Generating System Data and Model Guidelines

Determination and Report

Prepared by: Power System Planning and Development

Version: 1.0

Date: 29 February 2008
Executive Summary

This consultation was conducted in response to changes to the National Electricity Rules [1] that came into effect on 15 March 2007. Some of the changes brought about by this change included the replacement of Schedules S5.5.1 and S5.5.2 with a Generating System Design Data Sheet, a Generating System Setting Data Sheet and Generating System Model Guidelines that NEMMCO was required to develop under Rule S5.5.7 in accordance with the Rules consultation procedures.

NEMMCO is required by Rule S5.5.7 to develop and publish the Generating System Design Data Sheet, Generating System Setting Data Sheet and the Generating System Model Guidelines by 1 March 2008.

For the first stage of the consultation, three documents were prepared:

- an Issues Paper;
- draft Generating System Design and Setting Data Sheets (Data Sheets); and
- draft Generating System Model Guidelines (Model Guidelines).

Six valid submissions were received in response to the First Stage Notice of consultation from the following parties:

- ALSTOM (Switzerland) Ltd;
- Clean Energy Council;
- TransGrid;
- CitiPower / Powercor Australia;
- Suzlon Energy Australia Pty Ltd; and
- Roaring 40s.

Two valid submissions were received in response to the Second Stage Notice of consultation from the following parties:

- Vestas Australia;
- Clean Energy Council.

NEMMCO has revised the draft Data Sheets and draft Model Guidelines. The significant outcomes are:

For the Data Sheets:

- no additional generating system technologies have been added to the draft Data Sheets;
- changes and additions to symbol names;
- revision of some timing classifications (S, D, R1 and R2 classifications) for provision of information;
- correction to specification of fault current information;
- allowance for ‘R2’ parameters to be determined for a range of generating units through “type-tests”¹, under certain circumstances;
- a request for information regarding any assumptions used to determine fault current information;

¹ That is, a test carried out on a single unit as representative of the performance of all identical units.
• removal of the ‘R2’ classification for fault ride-through control schemes, where off-site tests or factory tests (i.e. ‘R1’ data) can be shown to be representative of the plant installed on-site;

• a reference to Data Sheet changes that may arise out of an approval by NEMMCO of an alternative model provided under Rule S5.2.4(c)(2); and

• additions, deletions and clarifications to specific data items.

**For the Model Guidelines:**

• removal of several accuracy requirements for the transient stability models that were identified as superfluous or which placed too much reliance on the accuracy of the power system model;

• removal of the need for medium and long term models, relying on the data provided with the Data Sheets to provide relevant information for these types of studies;

• removal of the need for subsynchronous resonance models, relying on the data provided with the Data Sheets to provide relevant information for these types of studies;

• removal of the need for harmonic model information;

• a decision by NEMMCO that there is insufficient evidence at this stage that electro-magnetic transient models are required by NEMMCO or Network Service Providers;

• a decision by NEMMCO that (summarised):
  - **generating unit** models are required for all generating systems. Other plant in the generating system must be modelled explicitly – these must be validated models;
  - where there is a significant computational burden by modelling each generating unit within a generating system, NEMMCO and the NSP would, in the first instance, scale the generating unit model by the number of similar generating units; and
  - a Generator may choose to apply to NEMMCO and the NSP to provide a model that aggregates the generating unit models within a generating system into a single “equivalent generating unit”. This would be provided in addition to the generating unit model – this model need not be validated, but must be confirmed against the generating unit model;

• replacement of the list of power system simulation software products held by NEMMCO (for which unencrypted model source code information must be provided under Rule S5.2.4(b)(6)) with a reference to NEMMCO’s website, where that list will reside; and

• a statement regarding the requirement for consistency between various forms of model information provided by a Generator or connection applicant, as required by the Data Sheets and Model Guidelines.
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1 Matter under consultation

Schedule 5.5 of the National Electricity Rules (Rules) covers the technical data that must be provided to support applications for connection to the national grid, and otherwise requested by a Network Service Provider (NSP) or NEMMCO under Rule S5.2.4(a). Clause S5.5.7 requires NEMMCO to develop and publish a Generating System Design Data Sheet, a Generating System Setting Data Sheet (Data Sheets) and Generating System Model Guidelines (Model Guidelines) as follows:

S5.5.7:

(a) NEMMCO must, subject to paragraph (b), develop and publish by 1 March 2008, in accordance with the Rules consultation procedures:

(1) a Generating System Design Data Sheet describing, for relevant technologies, the generating system design parameters of generating units and generating systems including plant configurations, impedances, time constants, non-linearities, ratings and capabilities, to be provided under clauses S5.2.4 and this schedule 5.5;

(2) a Generating System Setting Data Sheet describing, for relevant generation and control system technologies, the protection system and control system settings of generating units and generating systems including configurations, gains, time constants, delays, deadbands, non-linearities and limits, to be provided under clauses S5.2.4 and this schedule 5.5; and

(3) Generating System Model Guidelines describing, for relevant generation and control system technologies, NEMMCO’s requirements when developing mathematical models for generating units and generating systems, including the impact of their control systems and protection systems on power system security,

and there must be a Generating System Design Data Sheet, Generating System Setting Data Sheet and Generating System Model Guidelines in place at all times after that date.

The Data Sheets, developed in accordance with this Rule, replace Schedules 5.5.1 and 5.5.2 that were applicable prior to 15 March 2007.

Rule S5.5.7 also stipulates that:

(b) When developing and publishing the Generating System Design Data Sheet, Generating System Setting Data Sheet and Generating System Model Guidelines under paragraph (a), NEMMCO must have regard to the purpose of developing and publishing the sheets and guidelines which is to:

(1) allow generating units and generating systems to be mathematically modelled by NEMMCO in load flow and dynamic stability assessments 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) proposed access standards and performance standards of generating units and generating systems to be assessed; and

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

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

The category specified in Rule S5.5.7(b)(2) relates to the following data categories defined in Rule S5.5.2:
• ‘Standard Planning Data’ (S);
• ‘Detailed Planning Data’ (D); or
• ‘Registered Data’ (R1 pre-connection, R2 post-connection).
## The Consultation Process

Following is an outline of the consultation process.

<table>
<thead>
<tr>
<th>Process</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notice of First Stage of <em>Rules</em> Consultation issued</td>
<td>6 September 2007</td>
</tr>
<tr>
<td>Closing date for submissions received in response to the Notice of First Stage of <em>Rules</em> Consultation</td>
<td>18 October 2007</td>
</tr>
<tr>
<td>Closing date for submissions received in response to the Draft Determination and Report</td>
<td>22 January 2008</td>
</tr>
<tr>
<td>Publication of this Determination and Report</td>
<td>29 February 2008</td>
</tr>
</tbody>
</table>
3 Background to matter under consultation

This consultation is being conducted in response to Rule changes that came into effect on 15 March of 2007. As part of this Rule change, former Schedules S5.5.1 and S5.5.2 were deleted from the Rules, and have been replaced by the Data Sheets.

NEMMCO is required by Rule S5.5.7 to develop and publish the Data Sheets and the Model Guidelines by 1 March 2008.

3.1 Requirement for connection applicant to provide technical data

The Rules mandate the provision of the technical data covered by Schedule 5.5. Provision of data is required of Connection Applicants and on an ongoing basis by Generators:

- Rule 5.3.3(c)(3) requires an NSP to detail the list of technical data required to support an application to connect, which will generally be in the nature of the information set out in Schedule 5.5, but may be varied by the NSP as appropriate to suit the size and complexity of the facility to be connected.

- Rule 5.3.9 requires a Generator proposing to alter a connected generating system to provide technical information listed in the Data Sheets as well as the impact of the alteration on the generating system performance on the applicable access standards.

- Rule S5.2.4(a) requires that a Generator or any person negotiating a connection agreement must provide technical data specified in Schedule 5.5 on request by NEMMCO or an NSP (there are some qualifications to this requirement in Rules S5.5.5 and S5.5.6, relating to Generators who have generating systems comprising asynchronous generating units or generating systems of less than 30MW capacity).

- Rule S5.2.4(b) through (d) require that a Generator whose plant has a combined nameplate rating of 30MW or more must provide a dynamic model of the generating system, in the form of both functional block diagrams and source code. The model must be provided with the application to connect, or three months prior to commissioning (whichever is earlier), and must be updated following the completion of commissioning tests or other compliance tests, or when plant is altered.

- Rule S5.5.3 requires an NSP to initiate a periodic review of the data to ensure its continued accuracy and relevance.

3.2 Extent of Data Provision Requirements

Under Rule S5.2.4(a), NEMMCO or an NSP may request the provision by a Connection Applicant or Generator of all data specified in the Data Sheets, and the Connection Applicant or Generator must provide that data.

Rules S5.5.5 and S5.5.6 limit the application of this requirement as follows:

- Rule S5.5.5: Generators who have generating systems comprising asynchronous generating units are exempted from providing data the NSP considers not to be relevant to the asynchronous generation; and

- Rule S5.5.6: Embedded generating units or generating systems of less than or equal to 30MW capacity are required to submit less registered system planning data and less registered data than is indicated in the Data Sheets and Model Guidelines, but must provide the data if reasonably required by the NSP or NEMMCO.

Rule S5.2.4 establishes that dynamic models must be developed in accordance with the Model Guidelines, except where otherwise agreed with NEMMCO. Rule 5.7.6 provides that an NSP may
require occasional testing of a generating unit for the purpose of determining model parameters or to assess performance and that NEMMCO may direct an NSP to require testing if NEMMCO considers that existing information is inadequate to determine model parameters.
4 Consideration of consultation submissions

4.1 List of submissions received

*NEMMCO* received six submissions in response to the Notice of First Stage of *Rules* Consultation. Following is a list of respondents:

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Participant Type or Other Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALSTOM (Switzerland) Ltd</td>
<td>Interested Party</td>
</tr>
<tr>
<td>Clean Energy Council</td>
<td>Interested Party</td>
</tr>
<tr>
<td>TransGrid</td>
<td>Transmission Network Service Provider</td>
</tr>
<tr>
<td>CitiPower Pty &amp; Powercor Australia Pty Ltd (combined submission)</td>
<td>Market Customer, Distribution Network Service Provider, Special Participant Distribution Operator</td>
</tr>
<tr>
<td>CitiPower Pty &amp; Powercor Australia Pty Ltd (combined submission)</td>
<td>Distribution Network Service Provider, Special Participant Distribution Operator</td>
</tr>
<tr>
<td>Suzlon Energy Australia Pty Ltd</td>
<td>Interested Party</td>
</tr>
<tr>
<td>Roaring 40s</td>
<td>Generator</td>
</tr>
</tbody>
</table>

All of these submissions were published on *NEMMCO*’s website on the same date that the Draft Determination and Report was released.

Following is a list of respondents for the Second Stage of the consultation:

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Participant Type or Other Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vestas</td>
<td>Interested Party</td>
</tr>
<tr>
<td>Clean Energy Council</td>
<td>Interested Party</td>
</tr>
</tbody>
</table>

Both of these submissions were published on *NEMMCO*’s website on the same date that this Determination was released.

4.2 Meetings

Roaring 40s requested a meeting, which took place on 3 December 2007. The meeting clarified the issues raised in the Roaring 40s submission and discussed *NEMMCO*’s consideration of Roaring 40s' issues in Section 5.

There were no meetings requested from the Second Stage of the consultation.
5 Consideration of Submissions

The following Sections present the specific comments made in the submissions in terms of:

- Sections 5.1 to 5.24 – the issues raised in the Issues Paper (numbered and quoted from the Issues Paper);
- Section 6 – additional issues raised in the submissions; and
- Section 7 – further issues raised by NEMMCO.

In general, submissions have been allocated to the issues (1 to 24) they were specified as addressing. Where a general comment was made that was not assigned to a particular issue, NEMMCO placed the comment under the issues where it most reasonably fitted and, at times, to several issues.

The Clean Energy Council’s submission for the Second Stage of the consultation raised no major issues and hence is not specifically referenced below. That submission commented that the Council expects that the Data Sheets and Model Guidelines will evolve over time as systems change and technologies mature.

NEMMCO agrees that this is likely to be the case, and will carry our further Rules consultations to modify or expand the Data Sheets or Model Guidelines at appropriate times.

5.1 Need to change the format of the Data Sheets

### Issue 1

From NEMMCO’s perspective, the style and format of specification of plant parameters in the Data Sheets has worked adequately in the past. Is there a need to change the format? What format is recommended? Please provide reasons for, and the advantages of, any proposed format change.

#### Submissions:

Alstom: “Alstom does not see a need to change the draft format. However, providing symbols for each parameter would help when making references.”

TransGrid: “TransGrid agrees that the there is no need for a change in the format of the Data Sheets.”

#### NEMMCO’s consideration and decision

Neither Consulted Person saw a need to change the format of the Data Sheets. NEMMCO will retain the current style and format.

Alstom requested the provision of symbols for all parameters in the Data Sheets. Symbols have been used when these were seen to be either standard symbols, or at least typical symbols, used for the particular parameters described in the Data Sheets. Symbols have been added to the Data Sheets, where possible, to reflect Alstom’s request for additional parameter symbols.

5.2 Additional Technologies

### Issue 2

- Should any other technologies be explicitly addressed in these Data Sheets?
- In terms of those other technologies what evidence is there that would support their inclusion in the Data Sheets (e.g. existing installations or ones under development)?
5.2.1 Submissions:

**Suzlon:** “The following technology type is currently not represented in Table 1, so we would suggest the following row be inserted in the WIND section:

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Prime mover control</th>
<th>Type of generation</th>
<th>Grid interface</th>
<th>Power system control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>Pitch Controller and Variable Slip – Active Power Control</td>
<td>Asynchronous (variable rotor resistance)</td>
<td>Transformer</td>
<td>System voltage or reactive power control from reactive plant</td>
</tr>
</tbody>
</table>

“This is required to accommodate wind farms based on Suzlon’s S88 WTGs, with several projects installing this equipment currently under development.”

**CitiPower/Powercor:** “Wave and tidal generation should be included. There are trials underway in Australia, and it is a proven generation elsewhere so it would be beneficial to be included.”

**TransGrid:** “TransGrid is not aware of any other generating technology that needs to be explicitly addressed in the Data Sheets.”

5.2.2 NEMMCO’s consideration and decision

The Issues Paper suggested a number of technologies that could be included in the Data Sheets. Suzlon suggested an additional form of wind turbine generator be added to the table in the Data Sheets. Suzlon’s recommended addition will be made to the Data Sheets.

CitiPower/Powercor suggested the addition of tidal generation. Although there are tidal generation schemes in existence (one scheme has a capacity of 240MW), NEMMCO would prefer not to speculate on the type technology that would be used for the size of project that would warrant a dynamic model. When a project of significant size looks like coming to fruition, NEMMCO will need to establish the model and consult with the proponent. It is expected that the Data Sheets may already cover many aspects of this type of plant, assuming that conventional generator technology is used and depending on the type of turbine used.

The processes within the Data Sheets and the Rules allow for the possibility to provide information in an alternative form. If necessary, additional Data Sheets could be added following a Rules consultation.

At this time, NEMMCO will not include Data Sheets specific to tidal generation.

5.3 Effectiveness and Appropriateness of the Data Sheet Structure

**Issue 3**

- Is the structure of the draft Data Sheets effective and appropriate? If not what alternative structure would be effective and appropriate?
- Does the above list (section 4.3 [of the Issues Paper]) describe the modular structure appropriately?
- Has anything been missed in the list above? This should apply for a technology currently implemented in a generating system in the NEM, or emerging technologies that are likely to lead to generating systems of 30MW or more in the next 5 years.
- Is there any information listed under section 4.3 [of the Issues Paper] (or in the draft Data Sheets) that could not be obtained by a Connection Applicant or Generator? (Please be specific about what information, and when it might be available)
5.3.1 Submissions:

CitiPower/Powercor: “In general the requested information covers the protection requirements. It is suggested that:

- The different sheets for the different protection systems are all very similar and should be combined onto one sheet but with the different systems identified and described.
- There must be a schematic diagram submitted to show the different protection systems and what their inputs are and what they act upon (trips what).
- There must be a diagram of the earthing arrangement for the Power Station.
- There is no mention of parallel capacitor bank controls if one is installed for power factor or harmonic control. It is possible that a fixed bank and not an SVC could be installed.”

Roaring 40s: “The generator data sheets contain fields for generator pitch systems including Cp curves. It is noted that there is insignificant response from the pitch systems for the system events studies in the transient time frame. As such pitch system modelling is not necessary for modelling the response of wind farms to power system disturbances.

“The only circumstance under which pitch systems will move to a significant degree is when the wind speed changes. As wind speed is not a variable in power system models, there is no value in attempting to model the dynamic performance of pitch systems.

“It should also be noted that manufacturers seem quite sensitive about pitch system designs and more so about blade design. For this reason we expect string resistance to any requirement to provide such data.

“Given the lack of demonstrated need for this data, and the reluctance of suppliers to provide this data, we suggest that the information on pitch systems should be omitted from the generating system data sheets until a suitable case is made for their inclusion.”

TransGrid: “TransGrid believes that:

- The structure of the draft Data Sheets is effective and appropriate.
- The list in section 4.3 describes the modular structure appropriately.
- Generators would know whether the list is complete.
- Generators would know better whether any the information listed in section 4.3 could not be provided.”

The following submission was received during the Second Stage of the consultation:

Vestas: “It is acknowledged that some consideration was undertaken with the Draft Determination issued on December 2007 in relation to the topic of generator pitch systems. In reference to this topic it should be noted that generator pitch systems are not normally considered in the development of transient models as the time constant period for pitch system performance relevance is outside the boundaries of transient models and do not bear significant impact on the turbine performance. With this consideration in mind the question may turn to the relevance of such data.

“In relation to (viii) “auxiliary compensation equipment” there is an issue. Usually there is a current source dynamic inverter based reactive compensation system (rather than a “voltage source converter). It may be that a new section titled “current source dynamic inverter based compensation system” data could be put into the data sheet additionally to “voltage source converter.”

5.3.2 NEMMCO’s consideration and decision

TransGrid submits that the Data Sheet structure is effective and appropriate.

CitiPower/Powercor suggested that the protection system sheets should be combined due to their similarity. NEMMCO agrees that the format is similar, but prefers to keep some of them separate to emphasise the different specific categories of protection that need to be provided:

- specific generating unit protections:
typical synchronous generating unit protection systems, which include the types of protection systems required under Rule S5.2.5.10;

- asynchronous generating unit protection systems required under Rule S5.2.5.10;

- crowbar protections which are internal to some wind turbine and similar technologies that have power electronic controls; and

- other relevant protection systems.

Anti-islanding protection systems (referenced in Rule S5.2.5.8(c)) will be combined under “Other protection systems”, as this is sufficiently general to fit under that heading.

While generally agreeing with the Data Sheet structure, CitiPower/Powercor suggested the following additions:

(i) A schematic diagram of protection systems showing the input and the effect of the protection;

(ii) A diagram showing the earthing arrangements for a power station; and

(iii) A section regarding parallel capacitor banks,

Item (i) is considered to be already addressed by the Data Sheets with the reference to “Diagram” under the “Units” heading.

Item (iii) is addressed by Section 15.1 of the Data Sheets.

To satisfy item (ii), an additional requirement for earthing arrangement and impedances has been added to the single line diagram under Section 6 of the Data Sheets (“Generating system (Power Station)”). This is considered to meet the general requirements of Rule S5.5.7(b)(1) (“… to allow … generating systems to be mathematically modelled by NEMMCO in load flow and dynamic stability assessments…”), by allowing an assessment of zero sequence connections and impedances.

Roaring 40s and Vestas suggest that generator pitch systems are too slow to respond in transient timeframes. Roaring 40s further submits that there will be strong manufacturer reluctance to provide wind-speed/turbine pitch information.

NEMMCO’s review of the literature, including typical models shows this to be necessary (e.g. models provided for DlgSILENT’s Powerfactory software and Siemens Power Technologies Incorporated’s PSS/E software). Considering the speed of response of pitching, the impact on simulation accuracy may not be negligible after a fault. NEMMCO will retain the requirement for aerodynamic models and pitch controller models to be provided.

NEMMCO notes Vestas’ suggestion to add information requirements for current source converter devices and will adjust the Data Sheets accordingly.

5.4 Data Provision when Data Sheets are inappropriate

<table>
<thead>
<tr>
<th>Issue 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>How should the Data Sheets cater for the situation in which the plant technology does not fit well with the data sheet model?</td>
</tr>
</tbody>
</table>

5.4.1 Submissions:

TransGrid: “TransGrid has limited experience with alternative power sources and is therefore unable to make a suggestion.”

Clean Energy Council: (also covered under Issue 18, Section 5.18) “Given the evolving nature of many renewable energy generators, it will not always be practical to be fully prescriptive on the data required. Flexibility is very important in the provision of information where it may not be available, cannot be
determined accurately or is impractical to obtain, and the lack of information only has immaterial impacts on the modelled outcomes. Often when the information not available a conservative estimate can be made in model parameters, so that power system security is not compromised, and the proponent is still able to demonstrate compliance.”

The following submission was received during the Second Stage of the consultation:

**Vestas:** “In circumstances where the “plant technology” does not fit well with the data sheet model, the solution is not to seek NEMMCO’s written approval. Alternatively, a data sheet with typical information needs may be offered in the Data Sheet whereby new data may be entered and then submitted to NEMMCO. Flexibility is warranted here as new technologies may require different parameters to adequately describe performance.”

5.4.2 **NEMMCO’s consideration and decision**

The Clean Energy Council stresses the importance of flexibility around data provision, especially where technology is under rapid development. The provision of conservative data was suggested as a way of achieving a suitable outcome for both a proponent and NEMMCO. There are already mechanisms available for information to be provided in alternative forms, showing justification. If the impact can be shown to be immaterial, then there may be scope to allow some flexibility, although NEMMCO does not want to discount the significant effort that may be required to demonstrate this, particularly:

- over the possible range of conditions that the *generating system* may be required to operate, including, for example, *network plant outage* conditions and a range of different *contingency events*;
- the potential for conservative parameters to lead to pessimistic outcomes in some instances and optimistic outcomes in others; and
- in terms of the impacts that the inaccuracy may have on the determination of *network limits*, including stability limits.

The use of inaccurate parameters to show conservative performance can have unintended consequences over the full range of *power system* conditions. Good modelling accuracy of *generating systems* is an important aspect in ensuring that the *generating system* is not restricted in its operation and *network capability* is not degraded unnecessarily.

The Issues Paper presented two alternatives to allow non-standard information to be provided:

1. By application to NEMMCO to allow information to be provided in an alternative manner; and
2. Data Sheets that were in a generic form.

Vestas suggests that the *Generator* should be able to provide alternative information without specific written approval by NEMMCO, and proposes that a Data Sheet be provided that allows information to be provided flexibly (similar to the second option above). NEMMCO’s preference is to retain the proposal already in the Data Sheets (Option 1), as there is a concern that the generic sheets of Option 2 might be over-used. Option 1 also allows NEMMCO to monitor the appropriateness of the Data Sheets over time and, if necessary, adjust any Data Sheets that need to be updated. As the information provided in the Data Sheets is confidential, *Generators* would not be aware of the form of information provided by other *Generators* that have similar technology, without some involvement by NEMMCO. Therefore, a requirement for approval by NEMMCO would also allow the information to be provided consistently, both in terms of:

- the actual data requirements for similar technologies; and
- the level of detail provided over a range of technologies.

While Vestas’ comment is noted, NEMMCO sees no reason to change the requirements in the Data Sheets and the Model Guidelines in terms of the manner in which flexibility might be allowed.
5.5 Arrangement of Design and Setting Data

**Issue 5**

\[ \text{Is there any better way in which the required separation into Generating System Design Data Sheets and Generating System Setting Data Sheets could be presented in the Data Sheets, while still preserving the Rule concept of separate Data Sheets?} \]

5.5.1 Submissions:

**TransGrid:** “The proposed method of separating the Generating System Design Data Sheets, the Generating System Setting Data Sheets and the Generating System Setting Data Sheets appears to be satisfactory.”

5.5.2 NEMMCO’s consideration and decision

No suggestions for changing the form of presentation were submitted.

*NEMMCO* sees no need to change the form of presentation.

5.6 Scope of Studies for which the Data Sheets are used

**Issue 6**

\[ \text{Does this description cover the complete range of study types for which the Data Sheet information will be used (taking into account the purposes that must be considered under S5.5.7)?} \]

5.6.1 Submissions:

**Suzlon:** “Voltage fluctuation (flicker) studies are not currently covered by the descriptions provided.  "We also note that Fault Calculations are mentioned in the initial bullet points of page14, but have not been discussed in the detailed text of page15." [Page references are to pages 14 and 15 of the Issues Paper.]

**TransGrid:** “The list of the types of studies seems to be comprehensive.”

5.6.2 NEMMCO’s consideration and decision

The Issues Paper listed a range of types of studies, including their descriptions, that might be required by NEMMCO and NSPs, for which models might need to be provided.

Suzlon suggests the need for the inclusion of flicker studies and the need for a more thorough description of fault studies. *NEMMCO* acknowledges the need to perform flicker studies but understands that the model information specified in the Data Sheets provides sufficient detail to assess the impact of flicker on the power system using conventional analytical methods. What might not be included is the effect of flicker on power electronic devices, however, this would probably require electro-magnetic transient (EMT) analysis methods, for which *NEMMCO* currently sees no need to require such models (see Section 5.24). It is reasonable to expect that should such studies be required, this should be the responsibility of a Generator (and the generating unit or generating system supplier).

In relation to the comment regarding fault calculations, this was covered on page 15 of the Issues Paper: “Data for load flows and fault calculations are always required for network limit determination or assessment of performance standards”, *NEMMCO* sees no need to change the requirements in the Data Sheets and the Model Guidelines in terms of flicker and fault study requirements.
5.7 Impedance modelling within a Generating system

**Issue 7**

⇒ Modelling of impedances within generating systems distributed across wide areas or connected by high impedances is necessary but in other situations (e.g. most large synchronous generating plant) these impedances are negligible for loadflow analysis. What is an appropriate way of requesting the impedance data that reflects these differences?

5.7.1 Submissions:

**Suzlon:** "For wind farms, reticulation impedances should be included to a level that ensures accurate results. If the reticulation impedances are very small, they can be neglected. The minimum impedance that needs to be modelled depends on the particular case in question, and should be at the modeller's discretion."

**Roaring 40s:** “It is suggested that information should only need to be provided if a participant is not providing a generating system model that includes these components.”

5.7.2 NEMMCO's consideration and decision

Both submissions suggest that the internal generating system impedances need only be supplied if the accuracy of the modelling of the system is affected.

This suggests that in some cases, the data may be required. The Data Sheets already request branch impedance information to be included on single line diagrams. NEMMCO considers that some discretion could be allowed, however, and will adjust the Data Sheets so that the branch impedance information is only required where the branch impedance from the grid interface to the furthest plant item in the generating system could exceed 10% of the grid interface impedance.

5.8 Fault modelling for generators with power electronic grid interfaces

**Issue 8**

⇒ If the draft Data Sheet approach will not result in a measure of the fault current for generating units that interface with the grid partly or wholly via power electronics, what level of detail is required, or what model should be used?

5.8.1 Submissions:

**Suzlon:** “Detail of fault current limiters should also be required, including instantaneous amplitude versus time characteristic, and waveforms. The time resolution should be sufficient to define the characteristic.”

**CitiPower/Powercor:** “This section refers to ‘sub-transient reactive impedance’ of generating plant. This quantity is not clearly defined for asynchronous generators. Powercor suggests that the requirement be for data corresponding to fault currents as defined in AS 3851 -1991.”

**TransGrid:** “TransGrid has no comment on the model that should be used for generating systems that are connected via power electronics. However, for synchronous generating systems, the requested short-circuit infeed data at the connection point in section 6.1.1 of the Draft Data Sheets is very confusing for the following reasons:

- The Data Description begins with “Three phase short circuit infeed”, which usually means the infeed from the generator for a three-phase fault. However, individual values are requested for other types of fault, e.g. “line-line, line-line-ground, line-ground”. If the intention is for “Three phase short circuit infeed” to mean “the infeeds on the three phases for the following types of fault”, then a change of wording is required;
- The Data Description suggests “Symmetrical” means “3 phase” and “Asymmetrical” means other types of fault. This is incorrect. The standards referenced define a symmetrical fault current to
have no dc offset component and an asymmetrical fault current to contain a dc offset component, whether the fault is three phase or another type of fault; and

- For fault types at the connection point other than a three-phase fault, the infeed from a generator will depend on the sequence impedances that represent the rest of the network. A Generator will not know these network impedances and how they will vary over time. Provision of the negative sequence and zero-sequence impedance of the generating system is sufficient for the NSP or NEMMCO to calculate the generator infeeds for non-three-phase faults at the connection point."

The following submission was received during the Second Stage of the consultation:

**Vestas:** "It is believed that the data requirements within the Data Sheet for fault currents is sufficient and that no further models are required by Generators.

"NEMMCO states “fault behaviour of generation with power electronic interfaces is not yet completely understood’. NEMMCO has proposed a “peak making current” and a “RMS breaking current”. This information may not be known to the wind farm owner. The question that arises is for what purpose is this information valuable.

"NEMMCO has quoted international standard IEC60909-O:2001 is titled “short circuit currents in three phase a.c. systems part 0: calculation of current’. This standard details the cases for conventional equipment, and not power electronic equipment. Thusly, to assign values to the two parameters peak making current” and a “RMS breaking current” some assumptions will need to be made. Subsequently, NEMMCO should be advised of the assumptions so that it can assess whether a particular simulation study will be accurate or inaccurate."

**5.8.2 NEMMCO’s consideration and decision**

The submissions suggest that the data requested will not always provide the information that is required for this analysis.

The requirements in Section 6.1.1 of the Data Sheets have been altered to correct the references to symmetrical and asymmetrical faults. The language used is now consistent with the definitions in AS 3851 – 1991.

**NEMMCO** acknowledges the concern, shared by Suzlon and CitiPower/Powercor, that the description of impedances for fault limited generating units does not provide the correct fault current when the methods defined in AS 3851 – 1991 are applied. In the absence of any direction from the standard, **NEMMCO** has altered Section 6.1.1 of the Data Sheets to include a requirement for Generators (where the generating system fault response varies from that expected by the standard) to provide fault response traces for faults simulated at the connection point of the generating system. These waveforms are to be provided for each of the fault scenarios (single phase, three-phase and two phase). This data is to be supplied at the maximum output of the generating system (and any other of generating system output that could lead to higher currents).

In order for a Generator to calculate the values required by Section 6.1.1 of the Data Sheets, TransGrid rightly submits that there is a requirement for a Generator to be supplied with:

(a) Thevenin equivalent voltage and impedance for the sequence networks (excluding the generating system) as seen from the connection point; or

(b) the pre-existing, maximum short circuit current at the connection point and the voltage at which this occurs.

The Data Sheets have been revised to include this requirement and to specify the data received from the NSP as a cross-check mechanism.

**NEMMCO** maintains that this allows for certainty in the calculation of the generating system fault contribution without placing undue requirements on either the NSP or the Generator.

**NEMMCO** notes Vestas’ comment that the fault current information requested is sufficient and that models are not required. **NEMMCO** agrees that this should be the case under normal
circumstances, however, in relation to a model for ‘quasi steady state behaviour’ \(^2\) in the Model Guidelines, instead of a Generator being required to provide a model in every case, the Generator would only be required to provide further information on request by the NSP or NEMMCO. It is expected that this will be under unusual circumstances, as it is believed that the information requirements in the Data Sheets will cover the majority of circumstances.

In relation to the question raised by Vestas, the terms “peak making current” and “RMS breaking current” were terms used in the Issues Paper, although not adopted in the Data Sheets or Model Guidelines. The Data Sheets use the terminology in the IEC standard. The fault current information (of the type described in the Data Sheets) is necessary for both the initial design of the connection point plant and for assessing the impact at locations in the shared network, where fault levels may be critical. In the longer term, the information in the Data Sheets would be used to develop simple parameters to be used in loadflow-based programs for longer term continuous fault level assessments – for example, these types of assessments are used in "contingency analysis" tools used in NSP and NEMMCO control rooms, to assess whether fault currents might be excessive, should a fault occur. As mentioned above, the NSP or NEMMCO may need to carry out a special investigation and may require further information to incorporate into a more sophisticated model. It was preferred that this latter information were not specifically requested in the Data Sheets, as the requirement for it is likely to be rare and may vary on a case-by-case basis.

In relation to Vestas' comment regarding the information requested in the Data Sheets, NEMMCO agrees that if any assumptions were used in the derivation of the quantities, this information ought to be provided as well. The Data Sheets will be adjusted accordingly. It should be noted that a Generator or Connection Applicant may provide the information in the form of waveform information if the design or technology of the plant does not allow accurate fault current information in the standard form requested.

5.9 Format of Harmonic Information where an acceptable plant standard does not exist

<table>
<thead>
<tr>
<th>Issue 9</th>
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</thead>
<tbody>
<tr>
<td>⇒ In what form should harmonic information be provided by a Generator, where an acceptable plant standard does not exist?</td>
</tr>
<tr>
<td>⇒ Is the harmonic characteristic impedance information available, or is a harmonic model for harmonic resonance studies normally available?</td>
</tr>
</tbody>
</table>

5.9.1 Submissions:

**Suzlon**: “Data should be provided in the form defined by AS61400 Part 21. “The characteristics and studies are normally available.”

**Alstom**: “Harmonic information might not be available from a generator until after the post-connection stage of development without requiring extensive calculations and studies. Generally where no specific requirements from NSP are provided, the standards AS/NZS61000.3.8 or IEC61000-3-6 are applicable. We believe that harmonic information (individual harmonics up to the 50th harmonic) measured after connection to the grid (R2) would meet NSP’s needs sufficiently.”

**Roaring 40s**: “A response will be provided on this matter when a draft guideline is completed.”

**TransGrid**: “TransGrid has only come across a few generating systems that do not have acceptable plant standards on harmonic generation and is therefore unable to provide suggestions on a standard form of harmonic information exchange. In the near future, harmonic assessment of generating systems may be made in a consultative manner, with the generator and TransGrid sharing generating system harmonic

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\(^2\) See section 6.1.2 of the Model Guidelines
impedances, generating system harmonic current source levels, harmonic voltage contribution limits, and transmission system harmonic impedances. After a number of these assessments have been made, TransGrid would be in a better position to suggest standard forms of harmonic information exchange.

The following submission was received during the Second Stage of the consultation:

**Vestas:** “It is often the case that power quality reports, including harmonic testing, results are sufficient for modelling purposes. It is not normally the case that harmonic models are required. “It is questionable whether all the harmonics from the 2nd to the 50th are necessary. Furthermore, NEMMCO should provide details of the “presumed model” in order for parties other than wind farm owners to understand what are the assumptions of the “presumed model”? Also, there may be periods of time that the harmonics have validity, and there are other periods of time where the harmonics are not applicable. For example, the switching of the power electronic devices may occur at 60MHz, and this may appear as a harmonic at the wind turbine, but the same harmonic may not appear at the “connection point”. How will NEMMCO allow for this in the data sheets?”

### 5.9.2 NEMMCO’s consideration and decision

There does not appear to be a standard that specifies emission limits for harmonic injection to the power system from generating units for any generating technology. The submissions recommend two standards: one for synchronous generating units and one for wind generating units. Neither of these standards specify on-line harmonic emission standards although AS 1359.101 specifies a Telephone Harmonic Factor. This is not considered relevant since it is an off-line measurement and cannot be applied to asynchronous generating units.

In the absence of a standard, the requirements under Rule s5.2.5.2 must be satisfied by compliance with the limits specified by the relevant NSP. As Alstom points out, this is generally assessed after connection, by measurement. Suzlon indicates that there are standards that specify measurement techniques that should be used to measure the harmonic performance of the generating system. NEMMCO would expect that the NSP would require adherence to these standards or an agreed alternative approach for the provision of this data post-connection. As TransGrid submits, it is rare for there to be unacceptable plant performance with respect to harmonics and hence this post-connection approach is appropriate.

There are no requirements for harmonic information to be provided in the Data Sheets. If an NSP requires information for a specific study, this information would be sought separately, on a case-by-case basis.

### 5.10 Need for additional components in the Data Sheets

**Issue 10**

*Do the components listed in the draft Data Sheets cover all components that need to be modelled in order to capture response to the types of power system disturbances listed above, in the relevant timeframes? If not, what is missing and for what reasons?*

### 5.10.1 Submissions:

**Alstom:** “Stator resistance depends on temperature. Therefore, in the past indicated accurately in the data sheet stator resistance (RA) @95°C and expanded the data sheet with rotor resistance (RF) @95°C.

“The direct axis damper leakage time constant (TKD) is not elaborated during type testing. This parameter may be used in order to generate very detailed synch. machine models (Walton, A., "THE DEVELOPMENT AND ANALYSIS OF EQUIVALENT CIRCUITS FOR SYNCHRONOUS MACHINES", University of QLD). However, this parameter would not have any influence to the level of modeling for transient studies, where standardised models for synch. machines are used."
**TransGrid:** “The components listed in the draft Data Sheets cover all the components that need to be modelled for conventional generators. Limited experience with generators implementing new technologies means that TransGrid is unable to suggest what components are missing for these systems.”

### 5.10.2 NEMMCO’s consideration and decision

Alstom suggests that rotor resistance (RF) be added to the Data Sheets and that the temperature at which rotor and stator resistances are determined should also be noted in the Data Sheets. **NEMMCO** has adjusted the Data Sheets to include rotor resistance and to require the specification of the relevant temperature (normal or typical temperature) at which the rotor and stator resistances apply.

Alstom is concerned that the direct axis leakage time constant (TKD) is not elaborated during type testing. Further, the impact on modelling accuracy of this parameter is questioned. **NEMMCO** considers that TKD is still required in the Data Sheets, as:

- damper winding effects are normally included in typical models for synchronous generators. It would not appear to be applicable only in very detailed models as, for example, in the reference quoted above, TKD is an explicitly parameter in the operational equations in the simple second order and classical models. Also, a similar representation is included in Reference [2], which recommends such a model for power system stability analyses; and
- this parameter is specifically required in some model applications.

A duplicated reference to TKD was included in the draft Data Sheets; it has been removed.

### 5.11 Data Sheet Component Suitability for response to power system disturbance

#### Issue 11

- Do the components listed in the draft Data Sheets cover all components that need to be modelled in order to capture response to the types of power system disturbances listed above, in the relevant timeframes? If not, what is missing and for what reasons?
- Are there components for which models have been requested in the draft Data Sheets that are unnecessary under all circumstances to capture response to the types of power system disturbances listed above? For what reasons are they unnecessary?
- Are there better formats for providing the data that are easier to provide or more suitable for medium and long term dynamic studies than what is described in the Data Sheets?

#### 5.11.1 Submissions:

**Suzlon:** “We would note that the text at the bottom of page 19 “the slower voltage/reactive power controls implemented on wind farms” does not reflect wind farms which are being deployed with modern reactive plant e.g. STATCOM or DFIG controls

“Two additional categories should be added:

- STATCOM: duration and level of permissible overload, and the recovery period for continued normal service,
- Switched capacitors: discharge time after being switched out of service, prior to re-energisation.

“These items are both required as knowledge of availability of plant capabilities is required to achieve adequate modelling accuracy.”

**CitiPower/Powercor:** “Powercor understands that the medium and long term dynamic studies relate to overall system security e.g for trip of major generation, load or interconnection. The dynamic models for transient stability studies as currently provided in response to S5.2.4 do not generally apply for these studies and models may need to be defined in detail.”
“The requirement for medium term stability and long term stability models in addition to transient stability models is a substantial extension of current practice. The requirements for such models will need to be detailed and reflected in the data sheets.”

The following submission was received during the Second Stage of the consultation:

**Vestas:** “Please confirm what is meant by “medium” and “long” term? In the above report, “long term” is in note no. 10 of the report, and it states “long term” could be up to fifteen minutes. However, compare this with what is stated in the introduction paragraph of the “Generating System Model Guidelines Draft”, namely a range of five minutes to thirty minutes.

“Further, version 18 of the National Electricity Rules does not specifically define the period of time for “medium term dynamic studies”, nor does it define the time period for “long term dynamic studies”.

“There are “optimistic” scenarios which assume all the wind turbines in the wind farms “ride through” the faults. Conversely, there are “pessimistic” scenarios which assume the wind farm has no “dynamic volt ampere reactive” compensation and that there is only a “partial ride through” of the fault. Again, there are assumptions and these need to be stated explicitly to wind farm owners.”

### 5.11.2 NEMMCO’s consideration and decision

Suzlon’s comment is noted. The inclusion of “the slower voltage/reactive power controls implemented on wind farms” is a reflection of the wind farm-level control systems on some wind farms that coordinate reactive power output from the wind turbines and any other reactive power compensation plant to control:

- voltage at or near the connection point;
- the overall reactive power output from the wind farm;
- the dynamic reactive range of fast reactive power compensation devices, such as SVCs or STATCOMs; or
- some combination of the above.

The reference to these slower control systems was not intended to exclude or override the provision of information for the faster control of voltage or reactive power, as provided by devices such as SVCs or STATCOMs. Specific Data Sheets, including their controls, are included for these devices, when installed at wind farms. Both the fast and the slow control system responses may be relevant to the overall response of the wind farm to a power system disturbance.

Suzlon has suggested:

(i) specification of the duration and level of over-load of STATCOM devices, and the recovery period prior to resumption of normal service; and

(ii) the discharge time of capacitors and the lock out time prior to re-energisation.

**NEMMCO** considers that both recommendations are relevant and has modified the Data Sheets applicable to STATCOMs (Data Sheets Section 15.3.1) and capacitor banks (Data Sheets Section 15.1.1), accordingly.

In relation to the medium and long term timeframes, the following has been decided and incorporated into the Data Sheets and Model Guidelines:

- specific models for these timeframes are not required;
- the information provided in the Data Sheets is assumed to be sufficient to allow longer term modelling;
- information on control systems requested in the Data Sheets must include those control systems that can influence generating unit or generating system performance within a 10 minute timeframe; and
• models used for transient stability studies are required to be numerically stable to allow studies with a simulation time of up to 10 minutes.

Also, the Data Sheets request information on protection systems that could trip plant. While not stated explicitly in each relevant Data Sheet, there is a general requirement that information on time delays in these timeframes (up to 10 minutes) must be provided.3

In relation to the performance of a generating system under various disturbance conditions, these are negotiated as part of an application to connect according to the requirements in the Rules. The requirement to maintain continuous uninterrupted operation applies to the generating system and each of its generating units. That is, where a wind farm is required to ride through a disturbance, all wind turbines must do so. This is consistent with the approach of modelling the wind farm as a single entity. The provision of accurate information on control systems and protection systems for the longer timeframes, as described in the Data Sheets and Model Guidelines, should remove or at least reduce the disparities between the “optimistic” and “pessimistic” scenarios described in Vestas’ comments.

NEMMCO considers that the general request, currently in the Data Sheets, that ‘information on any control systems, protection systems and plant limits that may affect the performance of plant over a range of timeframes must be provided – i.e. from “instantaneous” performance to up to 10 minutes’ ought to be sufficient to allow NEMMCO and the NSP to develop an understanding of plant performance over a wide range of timeframes, without the need for the Generator or Connection Applicant to provide specific short, medium or long term simulation models. NEMMCO does not consider that a more explicit statement of assumptions is necessary.

5.12 Requirements for Sub-synchronous resonance models

<table>
<thead>
<tr>
<th>Issue 12</th>
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<tbody>
<tr>
<td>⇒ For what types of plant are there data relevant to subsynchronous resonance studies that should be described in the Data Sheets?</td>
</tr>
<tr>
<td>⇒ Is subsynchronous resonance an issue for wind farms or other new generation technologies? Are wind farms subject to high frequency modes, or is there any risk that controls within a wind farm would react to subsynchronous frequencies?</td>
</tr>
<tr>
<td>⇒ Are there any situations where full electromagnetic transient models might be required to properly investigate subsynchronous resonance phenomena?</td>
</tr>
</tbody>
</table>

5.12.1 Submissions:

**TransGrid:** “Significant subsynchronous oscillations in turbine-shaft systems of conventional generators can be stimulated by causes other than the use of series capacitors. Some large loads (particularly cycloconverters) draw power variations at subsynchronous frequencies that are supplied from generators. If these frequencies align with the frequencies of the torsional oscillation modes of these generator they can stimulate large oscillations of these torsional modes.

“TransGrid is unaware of whether subsynchronous resonance is an issue for wind farms. When the torque amplification process is analysed for conventional generators and series capacitors, an electromagnetic transient model of the generator(s) and the network is required.”

5.12.2 NEMMCO’s consideration and decision

TransGrid’s submission identifies the risk to synchronous generator turbine shaft systems posed by, for example, certain types of loads and other power system connections and phenomena.

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3 See section 5 of the Data Sheets.
Reference [3] suggests there could be subsynchronous resonance issues between wind turbines and, for example, series capacitors and HVDC links, and that detailed studies are necessary to assess this. It is assumed that this would require EMT-type analysis, however, it is not clear:

- whether this is a risk for any particular wind turbine technologies;
- whether there could be a risk of interactions between wind turbines (of any type) and synchronous generator turbine shaft systems; and
- what particular type of model is required for particular technologies – for example, are full EMT models of the control systems necessary or would a modal equivalent model be sufficient (i.e. a model based on modal frequencies and damping only)?

At this stage, NEMMCO considers that there is not sufficient evidence that a full EMT model of control systems and power electronic systems must be provided for these types of studies, and that the provision of the type of modal information already included in the Data Sheets (described under Data Sheets Section 14.1.1) would normally be sufficient. To allow for the possibility that EMT studies might be required under special circumstances, a note has been added that the Generator must reasonably endeavour to obtain an alternative form of data to allow NEMMCO or the relevant Network Service Provider to carry out specialised investigations.

The Data Sheets have been adjusted to clarify the requirements for shaft models. There is a residual concern that provision of this data for asynchronous generating units could be misleading in that there may be resonance issues that are inherent to the design of such plant but that are compensated for through the power electronic controls of the plant. A note has been added to the Data Sheets to clarify a Generator’s requirements in this instance. The note provides flexibility for alternative data provision to be agreed between NEMMCO, the Generator and the relevant NSP.

### 5.13 Timing designation of Data Sheets Data

#### Issue 13

⇒ In the draft Datasheets will the assignments of data categories (ie S = Standard Planning Data, D = Detailed Planning Data, R = Registered Data (R1 pre-connection, R2 post-connection) lead to the appropriate data being made available at the appropriate stage of the development? Do some of the data categories place an undue burden on Generators by the provision of data at that particular time? What is the precise nature of this burden and how might it be mitigated while minimising design risks?

⇒ Are any of the items listed as R2 data impractical to determine from test? If so, please give details. If the plant parameter could be determined by test, but there is a perceived risk in doing so, please include what those tests might be, and the risks associated with those tests.

#### 5.13.1 Submissions:

**Alstom:** “The datasheets now include 'Manufacturer and manufacture's type designation or product name'. This information is not available at the development stages of categories S and D since the generator may still be in the evaluation phase for his manufacturer/contractor. We also see no reason why this information would be useful for NSP or NEMMCO at the design stage. We propose to use only category R2 for these items.”

“Generator unit reactances and generator unit time constants are impractical to determine from tests on site. Test results may become inadequate and inaccurate since the test conditions never match standard guidelines. For type tested synchronous machines, the parameters from the type test reports should be admissible.”

**TransGrid:** “It is expected that Generators would know better than TransGrid the burden imposed by the categorizing of the different items of data and the practicality and risk of on-system tests to identify R2 data.”
Clean Energy Council: “The detail of information being requested in the draft guidelines is significantly greater than is in Annexure B of the existing generation registration application. It would seem that NEMMCO is requesting additional information in case it proves to be significant, without a demonstrated need. Often this information is irrelevant to the modelling results, and may not be available or difficult to obtain and impossible to verify. Some particular examples are pitch system info, blade Cp coefficients and medium/long term dynamic modelling info.

“The Clean Energy Council believes that the development of generating systems data sheets and model guidelines will be an ongoing task and is keen to work with NEMMCO to ensure that the data sheets and models meet the needs of NEMMCO without placing undue costs and risks on generation developers.”

The following submission was received during the Second Stage of the consultation:

Vestas: “Normally, the design of a particular wind farm relies on the data sheets and usual specifications of a generic wind farm of comparable magnitude to the one being designed. All such the data is provided by the manufacturers of the equipment comprising the wind farm. All this design stage data could be passed onto NEMMCO through the categories “S” and “D” and “R1”. However, some of this information may be classified as confidential by the manufacturer of the equipment.

“Are any of the items listed as “R2” data impractical to determine from test?”

“In response, some features of a wind farm cannot be derived from a test without application of a fault. For example, the fault ride through capability of the wind farm. That is, the fault ride through of the combined connection of the wind turbines, the dynamic volt ampere reactive unit, the static capacitors, the static inductors, and those sets of equipment not part of the wind farm but are part of the transmission line electricity grid (e.g. step up or step down power system voltage transformers, static capacitors, static inductors, and control equipment).

“Also, there are only “three months” between the end of commissioning and the submission of “R2” data. If the wind farm owner has installed “electrical monitoring equipment and electrical power monitoring analysers”, then after three months, some data will be captured and analysed. However, there is a concern that the data that was captured and analysed might not be enough to “satisfy” this requirement.”

5.13.2 NEMMCO’s consideration and decision

Alstom identifies that the manufacturer and manufacturer’s type designation or product name may not be known during the S or D phases. NEMMCO agrees that the requirement to provide this type of information is inappropriate during the early stages of development and has made adjustments throughout the Data Sheets to remove the S and D classifications. It is expected that this information would be available during the R1 and R2 phases. This information is intended to provide a register of information on plant designs that would only be useful should an issue arise with a particular type of plant. While not essential to an NSP or NEMMCO during the design stages of a generating system development, it may circumvent any delays or problems during or after commissioning where the NSP or NEMMCO is aware (from past experience) of particular aspects of the design that must be taken into account in the modelling, setting design or operation of the plant. After commissioning, if a problem arises that results in a change to a model, this information would be used to determine what other plant might require such a change.

Alstom further suggested that synchronous machine reactances and time constants are impractical to determine from site tests. Alstom submits that type test data from type test reports should be admissible. NEMMCO acknowledges Alstom’s concern regarding manufacturer specific information, however, NEMMCO does not consider that the determination of synchronous machine parameters to be impractical, and the determination of machine parameters by site tests has been carried out on many generating units throughout the NEM. NSP experience with tests suggested that matching test responses to the software products (e.g. Siemens Power Technology Incorporated’s PSS/E) often resulted in closer matches than applying manufacturers’ parameters.

4 The Rules refer to S data as “Standard Planning Data” and D data as “Detailed Planning Data”
5 The Rules define R1 data as: “prior to actual connection and provision of access, data derived from manufacturers’ data, detailed design calculations, works or site tests etc.”
6 The Rules define R2 data as: “after connection, data derived from on-system testing”
Alstom’s concern suggests that a review of current practices might be in order, but this cannot be carried out in the timeframe of this consultation.

In relation to type-testing:

- **NEMMCO** accepts that site tests to verify parameters for a single *generating unit* should be sufficiently representative for all *generating units for plant* that has the same design (e.g. synchronous machines with identical design and manufacture); and

- for *plant* that has settings applied (e.g. controllers, limiters, etc.), **NEMMCO** expects either:
  - o each *generating unit* must be tested; or
  - o where the controller is digital, the same software version and parameters must be identical.

**NEMMCO** has retained the R2 designation for synchronous machine reactances and time constants in the Data Sheets.

The Clean Energy Council has a concern that the detail of information has increased and that it appears that **NEMMCO** has requested the data in case it proves to be significant without a demonstrated need. This issue is covered in more detail in Section 5.14.2.

In relation to the Clean Energy Council’s comment that the information may be difficult to obtain, **NEMMCO** has generally requested information that exists or considers reasonably ought to exist. An exception to this may relate to the subsynchronous modal frequency information described in Section 5.12.2. In relation to the examples provided by the Clean Energy Council, the pitch system information and blade Cp coefficients are considered to be standard design information for wind turbines and ought to be available. **NEMMCO** agrees that these parameters might be difficult to verify and that the difficulty in verifying that data is likely to outweigh the benefit of obtaining a verified model. Therefore, the Data Sheets have been adjusted in relation to the wind turbine aerodynamic model and blade pitch controller model to require:

- only the power curve information (including the cut-in wind speed and the speed at which full power is attained) to be R2 data – i.e. “data derived from on-system testing”; and

- in general, the rest of the data to be D (Detailed Planning Data) and R1 data – i.e. “data derived from manufacturers' data, detailed design calculations, works or site tests” – this includes the functional block diagram settings, which were previously required to be R2 data.

At times, this Cp curve information is available in the form of equations. **NEMMCO** has adjusted the Section 12.4.1 of the Data Sheets to allow Cp curves to be provided in this alternative form.

The Clean Energy Council also offered to work with **NEMMCO** in the development of the Data Sheets as an on-going activity. **NEMMCO** acknowledges and welcomes the Clean Energy Council’s support.

In relation to Vestas’ issue regarding the fault ride-through capability of a wind farm, **NEMMCO** requires each *plant* item to be modelled explicitly. Tests are required to establish each ‘R2’ parameter and not necessarily an overall performance of the *generating system* (while the overall performance of a wind farm may be a *performance standards* compliance issue for a *Generator*, that is separate from the requirement to establish ‘R2’ parameters by test). Tests to establish ‘R2’ parameters for a *plant* item can, therefore, be independent of other *plant* items, most of which would not require the application of a fault.

Similarly, **NEMMCO** requires:

- wind turbine models to be provided (rather than a “wind farm” model); and

- the models resemble the physical design of the *plant*.

It is **NEMMCO**’s expectation, therefore, that the fault ride-through controls would be a component of that model. This is consistent with the form of the Data Sheets, where a Data Sheet is explicitly provided for ‘Fault Ride-Through Control Systems’ under the general section ‘Secondary Electrical
Control systems. NEMMCO acknowledges that it would seem unlikely that the performance of a fault ride-through control system can be fully tested without the application of a fault, however, this does not mean that the individual control system parameters cannot be confirmed by another means – for example, protection systems and control systems for other technologies (e.g. synchronous machine generating units) are often tested by signal injections into secondary circuits or by bench-testing.

In recognition that this might not be achievable in some circumstances, the Data Sheet relating to ‘Fault Ride-Through Control systems’ has been adjusted to allow for tests carried out off-site (i.e. a specific application of ‘R1’ data) to be used as a type-test, under specific representative circumstances, that is, where:

- the off-site test is the application of a fault;
- the fault applied is a 2 phase-ground or 3 phase fault, equivalent to the what the wind turbine might experience on site;
- the post-fault fault level is reasonably representative of, or lower than, the post-fault fault level that the wind turbine would experience on-site (assuming all turbines at the wind farm operated the same way);
- the wind turbine tested is identical to the ones being installed on-site;
- the wind turbine tested has identical settings to the ones being installed on-site, or the difference in settings can be translated into appropriate model parameter values for the wind turbine being installed on site; and
- the test and associated documentation clearly demonstrate the features and settings of the fault-ride through control system.

In relation to the requirement that the ‘R2’ data must be updated within 3 months of commissioning, this is a requirement of the Rules and beyond the scope of this consultation.

The installation of monitoring equipment may demonstrate compliance with performance standards in the longer term. However, as noted by Vestas, it is unlikely that sufficient information can be collected by this means within the 3-month timeframe to establish ‘R2’ parameters. NEMMCO has insufficient knowledge of the specific design of the wind turbines and their control systems to make any definitive comments in this regard – this issue emphasises the need for developing staged tests that can be carried out during commissioning to establish, in the first instance, those ‘R2’ parameters that are not part of the fault ride-through control systems, but also tests that can establish the parameters of the fault ride-through control systems. In the longer term, the adjustment to the Data Sheet for the fault ride-through control systems (i.e. allowing off-site type-tests under the circumstances described above) may be a viable option.

### 5.14 Changes in requirements of the Data Sheets

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<th>Issue 14</th>
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<tbody>
<tr>
<td>⇒ Are there any issues regarding the changes made to the Data Sheets for conventional steam driven synchronous machine generating units, or the requested information for other plants?</td>
</tr>
<tr>
<td>⇒ If the types of data requested are more readily available in alternative standard forms, then please provide this information and, where possible, provide examples or cite references.</td>
</tr>
</tbody>
</table>

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7 See section 11.1 of the Data Sheets.
5.14.1 Submissions:

**Suzlon:** “This level of detail seems beyond NEMMCO’s scope of its work overseeing system stability. Could NEMMCO explain the reason for requesting this data.”

**Clean Energy Council:** “The detail of information being requested in the draft guidelines is significantly greater than is in Annexure B of the existing generation registration application. It would seem that NEMMCO is requesting additional information in case it proves to be significant, without a demonstrated need. Often this information is irrelevant to the modelling results, and may not be available or difficult to obtain and impossible to verify. Some particular examples are pitch system info, blade Cp coefficients and medium/long term dynamic modelling info.”

The following submission was received during the Second Stage of the consultation:

**Vestas:** “Commonly, due to the advanced technological developments of wind turbine generators and dynamic volt ampere reactive units it will not always be realistic to be rigid on the data set needed to simulate such equipment. If the approach is to be inflexible, then conservative estimates to quantise particular parameters will be done.

“If the types of data requested are more readily available in alternative standard forms.”

“As stated, the sophisticated industrial improvements of wind turbine generators and dynamic volt ampere reactive units do not easily permit "standardisation" of such equipment. In more broad terms, manufacturers may not willingly want to "standardise" this type of equipment for confidential intellectual property reasons and also for commercial reasons. It can be said the power system simulation packages such PSS/E have presented in their “software user guides” various “block” diagrams. It may be the case that NEMMCO is depending on these “block” diagrams but the “block” diagrams do not appear in the National Electricity Rules. From the wind farm owner’s perspective, it would be advantageous to include these “block” diagrams in the National Electricity Rules.”

5.14.2 NEMMCO’s consideration and decision

Both Suzlon and the Clean Energy Council have concerns that the detail of information has increased. Suzlon suggests that the increased information requirement is beyond NEMMCO’s scope and the Clean Energy Council suggests that it appears that NEMMCO has requested the data in case it proves to be significant without a demonstrated need.

Rule S5.5.7(b) specifies the purposes for the data (see Section 1). In developing the Data Sheets, NEMMCO considered that they ought to be comprehensive and ought to include all of the data requirements for the full range of studies that might need to be carried out for a generating system’s access standards and performance standards assessments, and for power system stability studies. The risks in not being comprehensive are that:

- a request for information well after the generating system has been commissioned and in operation may impose an even more onerous burden for data provision than “up-front” provision of that information; and
- if the provision of that information is not mandated under the Rules, there may be some resistance by the Generator in providing that data at a later date.

In developing the Data Sheets, NEMMCO has attempted to keep a similar level of detail relating to plant parameters for all technologies:

- using the pre-existing requirements (as required by Rule 11.10.5) for modelling of synchronous generating units as a reasonable basis for the level of detail necessary for all technologies;
- where new technologies have emerged (e.g. wind farms), using the types of data that technical literature recommends is appropriate for power system stability analysis, particularly in terms of dynamic model structures and parameters, and typical protection and control schemes;
- where new technologies may emerge (e.g. photovoltaic arrays), attempting to request information in a generic way, with the intention of making the requested information more specific once the technology becomes firmer in its design;
in recognition of the fact that generating systems for newer technologies are more flexible in their designs, requesting information in those specific areas that have emerged with those technologies – e.g. flexibility through the use of:

- specialised control systems, such as fault ride-through schemes;
- generating system level control schemes to coordinate voltage or reactive power from a large number of generating units; and
- the use of auxiliary compensation equipment such as switched capacitor banks, SVCs or STATCOMs; and

in recognition of the types of studies that may need to be carried out, requesting data relevant to those studies. In some cases, this recognises the particular characteristics of the new technology – e.g. for wind farms that can be spread over many kilometres (unlike conventional synchronous generating unit power stations), the request for branch impedances within a wind farm where this may be necessary for harmonic or other studies.

New information is requested for all technologies relating to, for example:

- generating system design (such as single line diagrams). Past experience has shown that this provides the best information on installed plant and plant configurations for power system studies;
- operational arrangements. Where operational arrangements might affect plant configurations and operating regimes, these are necessary for setting up realistic power system studies;
- model documentation. Recent models provided to NEMMCO, particularly for new technology (wind farms) have had specific requirements in terms of their application; and
- manufacturer and manufacturer’s type designation or product name, for the reasons specified in Section 5.13.2.

As mentioned in Section 5.13.2, in relation to the examples provided by the Clean Energy Council, the pitch system information and blade Cp coefficients are considered to be standard design information for wind turbines and ought to be available. In relation to the medium and long term modelling requirements, these relate mainly to the modelling of voltage stability. As mentioned in Section 6.3, the requirement is intended to relate to the provision of information on controllers and limitations that affect the generating system output in these timeframes, and not the provision of specific medium or long term models.

In relation to Vestas’ comments, NEMMCO acknowledges that, at times, technological developments will overtake particular Data Sheets, perhaps not for conventional technologies, but likely for developing renewable technologies. As noted by Vestas, inflexibility may lead to inappropriate estimates being made. The Data Sheets are flexible to the extent of allowing a Generator to apply to the NSP and NEMMCO to adjust or augment the data required by the Data Sheets, and the request must be accompanied by appropriate technical evidence.

The obligation to provide an accurate model is with the Generator. It is in the Generator’s interest to establish an appropriate model in order to:

- meet the accuracy requirements specified in the Model Guidelines;
- ensure that appropriate performance standards are established without the need for additional auxiliary support plant; and
- ensure that they are able to comply with those performance standards once in operation.

In relation to Vestas’ comment regarding the use of PSS/E models as references, the provision of these references is for information where the Generator or equipment supplier has access to this software. The only case where PSS/E was the sole reference is for the ‘Diesel and Gas
Reciprocating Engine’ Data Sheet⁸. Should the establishment of a suitable model be problematic for both the generator and equipment supplier, NEMMCO or the NSP may be able to provide some assistance or, where more substantial assistance is required, there are expert consultants that can provide that assistance.

NEMMCO recognises that there are likely to be benefits in publishing block diagrams, however, to supplement the text descriptions in the Data Sheets, and will consider supplementing the Data Sheets either through a separate consultation or by publication of supplementary information. As the Data Sheets and Model Guidelines must be published before 1 March 2008, there is insufficient time in this second stage to develop that supplementary material. At present, NEMMCO is not in a position to publish copyrighted material. Incorporation of such material into the Rules is a matter for the AEMC upon the application of an interested applicant for a Rule change.

NEMMCO does not see the need to adjust the Data Sheets in relation to this Issue.

5.15 Other Standards and Grid Codes to be used as references

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<tbody>
<tr>
<td>⇒ What other international standards or grid codes could be used as references?</td>
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<tr>
<td>⇒ Are there any parameters missing from the draft Data Sheets?</td>
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<tr>
<td>⇒ Please document any errors in the draft Data Sheets.</td>
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5.15.1 Submissions:

Suzlon: “We believe NEMMCO should make readily available all the documents which are used as references within its guidelines/data sheets. This could be achieved through providing on the NEMMCO website.

“Additional standards that should be referenced;

- o AS/NZS 61000.3.6 on harmonics
- o AS/NZS 61000.3.7. on voltage fluctuations
- o IEC61400 relating to all aspects of wind turbines
- o AS61400 Part 21 relating to power quality of wind turbines.”

Roaring 40s: “NEMMCO should take steps to inform themselves of international standards and seek to converge NEM requirements with international requirements, to the extent practical. It is suggested that NEMMCO should carry out a systematic body of work in this area rather than seek adhoc response as part of the consultation process.

“The importance of a small market such as Australia “staying in step” with international standard for generation plant has be clearly articulated in numerous NEM forums to date, and NEMMCO is encouraged to take the lead on this issue.”

TransGrid: “The following observations are made on the Draft Data Sheets:

1. In sections 8.1.1 of the draft Data Sheets the parameters GTZ2n and GTZ1n (i.e. the positive-sequence and negative-sequence impedance of each winding of the generator transformer) will always have the same value, so only one of these parameters would seem necessary.

2. Transformer saturation is usually not modelled in any of the types of studies for which the data is required. Therefore, it is not clear why the transformer saturation curve is included in the list in section 8.1.1 of the draft Data Sheets.

3. The parameter XL (stator leakage reactance) is included twice in section 9.1.1 of the draft Data Sheets.

⁸ See section 12.5 of the Data Sheets.
4. In dynamic system studies, the symbol H (in MWs/MVA) usually means the inertia constant of the synchronous generator plus its prime mover. In section 9.1.1 the symbol H is defined to mean “synchronous machine inertia constant (excluding prime mover inertia)”. This use of the one symbol to have two meanings is a potential source of confusion. If a separate inertia constant of the synchronous generator is required, then it needs to be defined by a separate symbol. It is not obvious how this synchronous generator inertia can be identified by on-system testing to find its R2 value.

5. The Potier reactance (XP) is not used in system simulations and does not have a unique definition. It seems not to be needed.

6. The zero-sequence reactance of a synchronous machine (included in the list in section 9.1.1) is most commonly not required for system studies because:
   a) The generator transformer most commonly has a delta winding on the generator side, which isolates the generator zero-sequence impedance from the system; and
   b) Synchronous generators are most commonly fitted with neutral earthing impedances with values that are far greater than the requested zero-sequence reactance of the generator itself.

7. In section 9.1.1, the parameter TKD is defined twice as “Direct axis damping leakage time constant”, while TKQ (i.e. the Quadrature axis damping leakage time constant”) is not included.

8. A suggestion is to add the open-circuit saturation curve (or at least the saturation parameters found from this curve at terminal voltage levels of 1.0 and 1.2 per unit) to the data listed in section 9.1.1.”

The following submission was received during the Second Stage of the consultation:

**Vestas**: “Some of the sources listed in Table 2 refer to the models available in the software package titled “PSS/E” and the software package titled “DiSILENT PowerFactory”. A wind farm owner may not be familiar with these software packages. Also, manufacturers of wind turbines and dynamic volt ampere reactive units may not be familiar with the two software packages. Further, each equipment manufacturer will have its own preferred simulation software for example the software package titled “MATLAB”. Consequently, the mathematical numerical models developed by equipment manufacturers may not be readily transferable to either PSS/E or DiSILENT PowerFactory, which are specially designed to perform electricity grid power system load flow calculations.”

**5.15.2 NEMMCO’s consideration and decision**

The Data Sheets specify standards and technical references in a number of cases. Suzlon suggested that NEMMCO should make reference documents available on its website, and made suggestions for some standards that may pertain to the provision of data. NEMMCO has referenced all of the relevant documents in the Data Sheets and Model Guidelines. All of the documents are copyright and some of them are purchasable (Australian or IEC Standards, for example), so NEMMCO might not be in a position to put them on its website. Instead, NEMMCO has included an attachment to the Data Sheets which has hyperlinks to the relevant websites.

Many of the references Suzlon identify are shown in Table 2 of the Issues Paper, which were taken from the references in the Data Sheets, as well as models available within Siemens Power Technologies Incorporated’s PSS/E software package (it is expected that other software packages will contain similar or identical models). Where no references are provided, the models are reasonably well established or there is no readily available model – in such cases, the description of the required information is expected to be sufficient.

Vestas comments that some wind farm owners and manufacturers may not be familiar with some of the software packages mentioned by NEMMCO. The provision of a model by a Generator in a software format suitable to NEMMCO is a requirement in Rule S5.2.4(b) – NEMMCO’s preferred software package is, currently, PSS/E. The software packages nominated by NEMMCO:

- are currently held by NEMMCO (at least one user licence);
- allow modelling of the entire power system; and
- are software products specifically designed for power system analysis.
MATLAB⁹ is not one of NEMMCO’s preferred products for power system analysis and, at present, NEMMCO is not considering expanding that list.

Roaring 40s advised the importance of NEMMCO’s being abreast of international practices and Australian regulations aligning with them. As part of this consultation NEMMCO has tried to obtain information on practices for which it was not aware. Roaring 40s’ request is reasonable and NEMMCO will continue to review international practices. NEMMCO considers there is value in aligning with international practices, to the extent that those practices meet the requirements of the NEM and the technical challenges of the national grid.

TransGrid made numerous comments regarding the details in the Data Sheets. In relation to these, NEMMCO has decided:

- Regarding item 1: The specific entry for GTZ2n has been deleted. The reference to GTZ2n has been merged with GTZ1n and a comment has been included to the effect that positive and negative sequence impedances are expected to be identical.

- Regarding item 2: The saturation curve data provision is retained. While this data may not normally be required for studies, if it is required to assess abnormal situations (e.g. ferroresonance or resonance conditions during black-start situations) it is preferred that the data be readily available. The saturation curve is typically available and is not considered an onerous data provision requirement for new plant.

- Regarding item 3: The duplicate entry for XL has been deleted.

- Regarding item 4: NEMMCO agrees and has changed the parameter name to “Hgen”. Also, in each instance of machine inertia (synchronous or asynchronous machine), a comment has been added to each R2 entry to the effect that, for testing purposes, the R2 value may be determined in combination with any relevant prime-mover inertia. Prime-mover inertia values have similar comments associated with their R2 references.

- Regarding item 5: The entry for Potier reactance has been removed.

- Regarding item 6: The entry for the zero sequence impedance has been retained. While TransGrid quotes common design practice for generating unit transformer configurations, this cannot be guaranteed into the future. It is considered that this information should exist and the provision of that information would not be onerous. This has pointed out inconsistencies in the requested zero sequence and negative sequence information. For example, while the text description referred to zero sequence impedance, the symbol remained as ‘X0’ (where ‘X’ is commonly used to denote a reactance) and the Units specified “% on MBASE and VT”, also suggesting a reactance value is required. To rectify this, the Data Sheet has been adjusted so that:
  - ‘X0’ has been changed to ‘Z0’ (the Data Description remaining as “Zero Sequence Impedance”);
  - a comment has been added to the Data description requiring the zero sequence impedance to include any neutral earthing impedance;
  - the Unit has been changed to “(a + jb) % on MBASE and VT”; and
  - the Data Description for “Negative sequence impedance” has been changed to “Negative sequence reactance”.

- Regarding item 7: The second reference to TKD has been deleted. The parameter TKD appears explicitly in the synchronous machine field-to-armature winding current transfer function (sG(s)). TKQ is not explicit in any of the synchronous machine equations and so NEMMCO has not included it in the Data Sheets.

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⁹ A software product of The Mathworks [http://www.mathworks.com/].
• Regarding item 8: The saturation parameters for terminal voltage levels of 1.0 and 1.2 per unit have been added.

5.16 Missing Details from the Model Guidelines

<table>
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<tbody>
<tr>
<td>⇒ Is there any type of information currently absent from the Model Guidelines that ought to be covered? (Please give details.)</td>
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</table>

5.16.1 Submission:

CitiPower/Powercor: “Powercor understands that the medium and long term dynamic studies relate to overall system security eg for trip of major generation, load or interconnection. The dynamic models for transient stability studies as currently provided in response to S5.2.4 do not generally apply for these studies and models may need to be defined in detail.”

TransGrid: “The model requirements in the Model Guideline appear to be quite comprehensive.”

The following submission was received during the Second Stage of the consultation:

Vestas: “As mentioned in Item 1 of the Key Concerns section of this letter, the option of alternative models (simplified models) was available under the present model guidelines. It appears that this option has been removed with the proposed guidelines and a very brief section within Clause 5 “Model Requirements” has been added in regards to Model Variation provisions. Due to the lack of specifics included in this section, it appears that it may be difficult for Generators to have suitable understanding of the requirements should this option be taken up.

“Vestas believe that the simplified model approach should remain a valid option.”

5.16.2 NEMMCO’s consideration and decision

CitiPower/Powercor request further details on the requirements for longer term models. The requirement for specific medium and long term models has been removed from the Model Guidelines. See Section 6.3.2 for NEMMCO’s consideration of this matter, and Sections 8 and 9 in the Model Guidelines.

NEMMCO notes TransGrid’s comment.

In relation to Vestas’ comment, a Generator or connection applicant can apply to NEMMCO to provide an alternative model under Rule S5.2.4(c)(2). This is described in more detail in section 6.17.

5.17 Further guidance on oscillatory stability modelling

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<th>Issue 17</th>
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<tbody>
<tr>
<td>⇒ Currently, guidelines for oscillatory stability models are covered by reference to those for transient stability models. Is this adequate, or is further guidance required? What is the reasoning to support further guidance?</td>
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<tr>
<td>⇒ Are there other types of modelling that need to be covered in the Model Guidelines? What is the reasoning to support other model types?</td>
</tr>
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</table>

5.17.1 Submissions:

Suzlon: “Use of transient models as the basis for oscillatory studies has proved to be adequate for wind farms installing Suzlon machines. We don’t believe further models are required.”
“The oscillatory modes can be extracted from Fourier transforms of transient stability time domain responses as well as from eigenvalue analysis.

“Therefore NEMMCO should only require eigenvalue models if the transient stability model cannot be used to extract the oscillatory modes.”

**TransGrid:** “It is expected that the use of linearised transient-stability models will be adequate from oscillatory stability models. The types of modelling defined in the Model Guidelines seem to cover the required range of studies.”

The following submission was received during the Second Stage of the consultation:

**Vestas:** “It is expected that transient models are the basis for oscillatory studies and eigen values can be derived from system linearization.”

### 5.17.2 NEMMCO’s consideration and decision

All of the submissions support the use of models used for transient stability studies for oscillatory stability studies. In relation to Suzlon’s comment regarding the extraction of oscillatory modes from time domain responses, this provides a limited amount of information. NEMMCO’s and TNSPs' experience has shown the approach is not entirely suitable for inter-area mode analyses and that eigenvalue analysis is preferred for oscillatory (small signal) stability assessments. For the purposes of including the relevant plant into eigenvalue analysis programs, therefore, linearised versions of the plant models would need to be derived from the functional block diagram information provided in the Data Sheets and from the functional block diagram information provided under Rule S5.2.4(b). These linearised models would be established by the NSP or NEMMCO, as required. With regard to models for oscillatory stability analysis, the Model Guidelines will be retained in its current form.

### 5.18 Allowance to vary the requirements for Model Performance

**Issue 18**

⇒ As there are particular obligations on registered participants to meet the requirements of the Model Guidelines is some allowance to vary the requirements appropriate, or should the Guidelines be prescriptive?\(^{10}\)

⇒ If a process to allow variation in the requirements is appropriate, what aspects ought to be built into that process? What are the benefits of those aspects?

⇒ If some flexibility ought to be built into the accuracy specifications (as opposed to allowing a process to negotiate an arrangement), how can trade-offs between accuracy requirements, or relaxation of those requirements, be built into the overall framework? Are there international practices where these matters have already been addressed?

⇒ Apart from accuracy issues, are there other areas of the Model Guidelines where some flexibility might be appropriate? How should flexibility be applied in that instance and what are the benefits?

### 5.18.1 Submissions:

**Suzlon:** “We agree that some allowance for varying requirements is required. The requirements cannot be made proscriptive for wind farms considering the stochastic nature of wind with variation in speed and direction. We would question the need for creating highly precise models of the response of a wind farm to wind speeds measured during testing, considering the winds that will drive the farm during the fault are inherently difficult to predict, and that this inaccuracy factor shall dominant the accuracy of overall network

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\(^{10}\) this was “proscriptive” in the Issues Paper. The word “prescriptive” was intended.
modelling. For this reason the outcomes of validation work should be considered in consultation with the NEMMCO, accounting for technology, site and testing specific factors.

“Additionally we believe the application of validation standards as contemplated by NEMMCO should be the subject of further investigation, with reference made to industry practices and research work being performed in established wind markets such as Europe.

“A distinction needs to be made to the use of dynamic models to predict system behavior for the contingencies defined in the NER and for simulation of actual events for validation of the models. The system behavior for the defined contingencies is evaluated for sustained high generation as an extreme case. This inherently defines the aerodynamic condition for the simulation.

“Simulation of actual events for validation of a wind farm model requires a model of the wind farm plant and of the aerodynamic conditions at the time of a system event. The dynamic nature of wind conditions places inherent limitations on the accuracy that can be achieved with simulation of events. This aspect will require further detailed study to define the approaches to validation of wind models including reference to validation requirements in countries with substantial wind penetration.”

Clean Energy Council: (also covered under Issue 4, Section 5.4) “Given the evolving nature of many renewable energy generators, it will not always be practical to be fully prescriptive on the data required. Flexibility is very important in the provision of information where it may not be available, cannot be determined accurately or is impractical to obtain, and the lack of information only has immaterial impacts on the modelled outcomes. Often when the information not available a conservative estimate can be made in model parameters, so that power system security is not compromised, and the proponent is still able to demonstrate compliance.”

TransGrid: “There would be a significant potential benefit (in terms of effective use of resources) if the required level of modelling accuracy was related to impacts on important aspects of system performance, such as:

- Damping of inter-area oscillation modes;
- Inter-regional transient-stability transfer limits;
- The closeness of local-mode damping constant to the -0.139 Np/s limit; and
- Fault ride-through capability.

“The application of this approach would result in significant level of flexibility in the requirements, with the more severe requirements (particularly on accuracy) being appropriately applied to those systems that can have a significant impact on system performance.

“The accuracy requirements listed in section 7.2 of the draft Model Guidelines appear to be difficult to achieve. Most oscillation modes involve more than one unit and factors (such as load behaviour) that are not part of the system being assessed. The draft Guidelines require only for that plant to be "associated" with a mode in the 0.1 – 5 Hz frequency band for the 10% accuracy requirement to be met. Errors in inter-area mode damping are usually much greater than 10%. Requirement 2 in section 7.2 would identify that discrepancy as an unacceptable level of accuracy for the model of a particular unit, where the model deficiency is most likely the accumulation of inaccuracies in other aspects of the system model.

“Because of the contributions from background disturbances, even the identification of the damping of a local-mode oscillation with a 10% measurement accuracy is usually very difficult. Therefore, obtaining difference between simulated and measured damping values of less than 10% will be extremely difficult.”

The following submission was received during the Second Stage of the consultation:

Vestas: “It is envisaged with the transient model accuracy that the tolerance accuracy must be within 5 degrees of the actual control system phase because of post fault conditions. If this is the case, would it not be preferable to implement an envelope amplitude dampening limitation?”

5.18.2 NEMMCO’s consideration and decision

There is reasonable support for allowing flexibility in the Model Guidelines.

Suzlon comments on whether the requirements are appropriate for wind farms, due to the stochastic nature of the wind, and comments particularly in relation to:
(i) the need for creating precise models of the wind farm to wind speeds and conditions during testing, as the variations in the wind during any test would result in significant model uncertainties;

(ii) a distinction between the use of the dynamic model:
   a. to predict behaviour for the types of contingencies defined in the Rules (e.g. faults and other disturbances for the assessment of performance standards or the determination of power system limits). This normally assumes the wind farm is operating at sustained high generation conditions, as the worst case; and
   b. for model validation purposes following tests, which requires a model that is capable of simulating the wind farm plant and the actual aerodynamic conditions at the time of the test;

(iii) the need for NEMMCO to carry out further investigation in terms of international practices and research relating to model validation.

NEMMCO notes Suzlon’s concern under item (i). It is assumed that the possible reasons for this are that:

- the wind speed could not be measured with sufficient accuracy and at enough locations throughout the farm, so as to be able to derive an “equivalent” wind speed representative of the entire farm;
- the size of disturbance that could be applied to a wind farm is not sufficiently large to “swamp out” the effect of wind variations; and
- the number of tests that would be required to sufficiently reduce the uncertainty caused by the wind variations (e.g. by using an averaging approach) would be impractical.

Notwithstanding these, there is likely to be some scope for:

- wind measurements as part of the test, to ensure that tests with excessive wind gusts can be discarded. Suzlon also suggests that some of the variability could be accounted for by measurement of the wind strength and explicitly including a wind strength input in the wind turbine model (see Section 6.13);
- a thorough review, in consultation with NEMMCO and the relevant NSP, of the scope for tests that could be carried out. It is recommended that power system studies are performed, where possible, to ensure that the proposed test will result in a sufficiently large disturbance, without unduly affecting other network users; and
- multiple tests to be performed to average-out the effects of wind variations.

As described in more detail in Section 5.19, NEMMCO has a preference for an accurate wind turbine model to be derived, with wind farm validation tests used to confirm overall wind farm performance. While the influence of wind variations is likely to be more of an issue for individual wind turbines (compared with an entire generating system, for example), the Rules requirement to provide facilities for testing a generating unit’s control systems sufficient to establish their dynamic operational characteristics may improve this situation. It is considered that a turbine model can be determined more accurately than a wind farm model and may require fewer on-site tests to confirm the model. This should also address, in part, Suzlon’s issue regarding the distinction between the model uses (item (ii), above) – i.e. for system studies and for validation – as it is NEMMCO’s expectation that the turbine model should be capable of partial load operation and not just operation at full load.

NEMMCO also notes Suzlon’s comment under item (iii), regarding the need for NEMMCO to carry out further investigation of international practices and research relating to model validation. NEMMCO will endeavour to do so.
NEMMCO also notes the Clean Energy Council’s comments regarding the need for flexibility, particularly where the modelled outcomes are immaterial or a conservative model can be derived. In relation to this, there is scope for flexibility in these areas by application to NEMMCO, however, the burden would be on a Generator to demonstrate the immateriality of the model parameters. For example, this might be by appropriate sensitivity studies over a range of power system conditions and disturbances. In relation to a conservative model, NEMMCO’s preference is for accurate generating system models to ensure that network limits are not degraded. Therefore, NEMMCO is open to the provision of a conservative model only to the extent that the conservatism does not materially affect network limits and the model is consistently conservative under a range of power system conditions and disturbances. Once again, the burden would be on a Generator to demonstrate this.

TransGrid suggests that the level of accuracy required should be commensurate with the criticality of the model accuracy to power system stability analysis. The aim of the Model Guidelines is to provide a benchmark for testers and model developers to aim for in preparing models and validating them without the need for specific knowledge in relation to the power system phenomena identified. In spite of this, NEMMCO considers that there is some scope for TransGrid’s suggestion:

- on a case-by-case basis. For any particular generating system this would depend primarily on:
  - the location of the plant;
  - plant size;
  - the particular network limits that it affected, taking into account local network impacts as well as more remote network impacts such as interconnector stability limits; and
  - the materiality criteria used for those network limits.

The model should also be representative in relation to the generating system’s performance standards or, as the Clean Energy Council points out, it should at least be conservative in this regard. While such studies could be scoped and carried out by a party with the relevant skills and power system data, it is the materiality criteria that are currently unknown and would need to be established and agreed. If the model structure is known, the criteria could relate to particular parameter accuracies. Otherwise, performance based criteria would be required. It is expected that either:

- this assessment would precede any validation tests, to establish what parameter values or performance are critical and determine what tests are necessary; or
- if range of values for each parameter is known, then the materiality can be assessed through sensitivity studies; or

- globally, following an overall review of model accuracy requirements. This would essentially be a review of the performance requirements in the Model Guidelines, to target the performance requirements that are most critical to network limits and refine the threshold levels. It is expected that this would be determined by assessing the impact on network limits by adjustment of accuracy requirements for all generators.

With either of these two approaches, some care would need to be taken to ensure that simplifications to models that achieve the necessary accuracy requirements do not lead to additive errors in models of similar technology (i.e. systematic over- or under-estimation of network limits).

While not achievable in the timeframe available for this consultation, this is worthy of a review following the consultation. At this stage, NEMMCO notes TransGrid suggestion, but will not adjust the Model Guidelines, as this could be taken into account through the flexibility arrangements currently proposed in the Model Guidelines.

TransGrid also comments that some of the accuracy requirements in Section 7.2 of the Model Guidelines might be difficult to achieve. In particular, this relates to oscillatory modes that may be affected by errors in the power system model and background disturbances in the measurement.
Techniques are available to determine model parameters, without the need for a model of the power system, by measurement of high speed voltage and current waveforms and injection of the measured voltage into the model (e.g. see Reference [4]). These techniques are normally applied to time domain signals for assessment of the transient stability model. TransGrid also comments on a similar approach for long term monitoring that would establish generating system inter-area and local mode performance parameters (see Section 5.21), although it is not clear whether this would assist with parameter identification.

NEMMCO considers that it is reasonable to remove items 2 and 3 (relating to fitting of eigenvalues) from Section 7.2 of the Model Guidelines on the basis that they place too much reliance on the power system model, which currently shows significant discrepancies against measured inter-area mode damping. Until this is resolved or an alternative approach can be adopted, NEMMCO considers that the Model Guidelines should rely on accuracy requirements for control system modelling and any innovative approaches for testing (such as those of Reference [4] and TransGrid’s) to establish accurate model parameters.

In relation to Vestas' comments:

- the phase accuracy requirement for a control system\(^\text{11}\) relates to the linearised control system response over a defined bandwidth (e.g. as would be shown in a Bode plot); and
- an envelope limitation is incorporated in item 5(b) of section 7.2 of the Model Guidelines, describing the response during periods of oscillatory behaviour following a fault.

### 5.19 Generating Unit versus System Modelling

<table>
<thead>
<tr>
<th>Issue 19</th>
</tr>
</thead>
<tbody>
<tr>
<td>⇒ To maintain consistency between technologies, is it appropriate that all technologies provide models on a single generating unit basis? On what basis should the provision of aggregated models be permitted or even encouraged?</td>
</tr>
<tr>
<td>⇒ Do you have a preferred option (a, b or c)? Are there other options that ought to be considered? What are the advantages of your preferred option over the others?</td>
</tr>
<tr>
<td>⇒ NEMMCO has been advised that some wind farms cannot achieve the accuracy criteria in Wind Farm Model Guidelines and Checklist. If so, what amount of aggregation (e.g. number of turbines) could achieve those accuracy requirements? If option (c) is the preferred option, what other criteria should be used to determine an appropriate amount of aggregation?</td>
</tr>
</tbody>
</table>

### 5.19.1 Submissions:

**Suzlon:** “Data should be provided to sufficient detail to enable modelling of individual turbines. Therefore method a) is preferable as it involves less simplifying assumptions.

“Notwithstanding this, a modeller should exercise discretion as to the level of aggregation appropriate when conducting studies at other locations on the network. Currently for this purpose the NSP would need to determine the suitable level of aggregation. Aggregation should consider the significance of modelled disturbances to the system under study.”

**Roaring 40s:** “The consultation seeks views on whether modelling should be to generating unit level or generating system level. As it is impractical to use unit level models in large scale applications (as the large number of individual models would take too long to run), it is assumed that NEMMCO would use unit level models only for the purpose of developing aggregated system models. This being the case, the following is suggested as a practical frame work:

- participants can provide either unit level models or system level models;

\(^{11}\) See item 1 of section 7.2 of the Model Guidelines.
a participant that provides a generating system level model does not have to provide a generating unit model;

where a participant provides generating unit level data only, NEMMCO can develop a system level model from generating unit model provided; and

in developing this model, the following principles apply:-

- the participant should pay for the model development;
- the model must be developed in consultation with the participant; and
- the any participant must be able to request refinement or review of the model at any time.

“ISSUE: Should models represent discrete elements of the generating system?

“This question has strong linkages to the topic above. It is suggested that the answer that information should be provided when necessary to produce an accurate generating system model. In situations where the participant is providing a generating system model, this additional detail will not be necessary, however if NEMMCO is developing a generating system model from individual generator unit models, the participant must provide this information.”

TransGrid: “TransGrid has insufficient experience with generating systems that comprise a large number of individual generating units to have a preference in the modelling method.”

Clean Energy Council: “The detail of wind farm models should be limited to that necessary to correctly represent the interaction with the system. Options should be available for turbine models or generation system models that correctly model the interaction between the wind farm and the system.”

The following submission was received during the Second Stage of the consultation:

Vestas: “Manufacturers of wind turbines have mathematical numerical models of a single wind turbine. When confidentiality agreements are in place between the owner of the wind farm and the manufacturer of the wind turbine, then the manufacturer of the wind turbine can provide the mathematical numerical model of the wind turbine to the owner of the wind farm.

“Do you have a preferred option (a, b, or c)?

“Equipment manufacturers such as wind turbine manufacturers prefer option “a”.”

5.19.2 NEMMCO’s consideration and decision

NEMMCO presented several options in the Issues Paper for model provision, including the advantages and disadvantages of each:

(a) the provision of individual generating unit models;
(b) the provision of a single aggregated model for the entire generating system;
(c) a combined approach that models clusters of generating units.

Both Vestas and Suzlon prefer Option (a). NEMMCO notes Suzlon’s comment that the provision of information be sufficient for the modelling of an individual unit (Option (a)), but that some discretion is required in terms of aggregation of turbine models to a wind farm model.

Roaring 40s suggests that the option for provision of either a generating unit or generating system model should remain with the Generator.

On reflection, NEMMCO considers that a strict application of Option (b) – i.e. modelling generating system plant in a single model – is operationally impractical as it leads to uncertainty, and possibly invalidation of the model, when critical plant is out-of-service. Such plant might include, for example, a STATCOM that a generating system requires to meet a performance standard (e.g. for fault ride-through). NEMMCO considers that:

- it might be possible to aggregate identical (or, at least, very similar) plant items into a single model (e.g. all wind turbines in a wind farm); and
other plant items should be modelled explicitly (e.g. STATCOM, capacitor banks, transformers, etc.).

NEMMCO agrees with Suzlon that Option (a) would simplify the modelling assumptions and also that, with some discretion by the modeller, it may be possible, for example, to aggregate all of the wind turbines in a wind farm into a single “equivalent turbine” model.

NEMMCO also agrees with Roaring 40s that there ought to be an avenue for a Generator to provide an aggregated generating unit model if this would improve the overall modelling accuracy for the generating system. This would be appropriate particularly if a scaled-up single generating unit model were found to be excessively conservative. With this approach, it is not clear, however:

- if the model structure is different from the turbine model, what would be the basis for the revised structure;
- how the model parameters would be derived;
- whether the model would be robust; and
- how such a model would be validated.

Under Option (a), Roaring 40s recommended that, should any adjustments be made to a wind turbine model to represent the wind farm response more accurately, this must be done in cooperation with the Generator. As an adjustment to a model may affect a Generator’s performance standard in respect of that wind farm, NEMMCO prefers not to adjust the model unless this is done by the Generator, or the Generator recommends the changes, as the changes might have a commercial impact on the Generator (an overly conservative model might result in a restriction on the wind farm output in order to meet a performance standard, or an overly optimistic model might result in operation at a level that could trip the wind farm for a disturbance for which it should ride through, exposing the Generator to non-compliance with a performance standard). Similarly, from NEMMCO’s perspective, an overly conservative model might result in a degradation of network limits; an overly optimistic model might result in an incident that might compromise power system security.

On the basis of the submissions, NEMMCO considers that:

- Option (a) – i.e. provision of a single generating unit model and separate models for all other plant – be set as the requirement for model provision. This is the most straightforward approach and is consistent for all generation technologies. For wind farms, for example, this would include a single wind turbine model and models for other plant, as required;
- a single turbine model must be scaleable solely by setting its MVA rating to that of the combined number of turbines in the generating system. That is, the parameters applicable to the model must be in per-unit on the model MVA rating;
- if there is a significant computational burden by modelling each generating unit within a generating system, NEMMCO and the NSP would, in the first instance, scale the generating unit model by the number of similar generating units. This is unlikely for conventional synchronous machine technologies (except, perhaps, for diesel generation power stations), and is likely to apply to wind farms;
- a Generator may apply to NEMMCO and the NSP to provide a model that aggregates the generating unit models within a generating system into a single “equivalent generating unit”. This would be provided in addition to the generating unit model;
- if NEMMCO and the NSP accept the aggregated model, they may choose to use it for power system studies. If the aggregated generating unit model is found to be unsatisfactory, NEMMCO and the NSP may choose to revert to the “scaled-up” single turbine model;
the single generating unit model and other plant models in the generating system are the primary models for use by NEMMCO and the NSPs, these must be validated according to the ‘R2’ specifications in the Data Sheets;

provided a suitably validated generating unit model has been provided to NEMMCO and the NSP, the aggregated generating unit model need not be validated. This model could simply be confirmed analytically against the generating unit model taking, for example, appropriate levels of generating unit output diversity into account.

The above requirements have been included in Section 7.3 of the Model Guidelines.

NEMMCO notes the Clean Energy Council’s comment regarding the detail of the wind farm models and agrees that the level of detail should be appropriate for modelling power system interactions. See Section 5.14 for more detail on this issue.

5.20 More difficult aspects of accuracy requirements for models

<table>
<thead>
<tr>
<th>Issue 20</th>
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<tbody>
<tr>
<td>⇒ Are there any individual aspects of accuracy that are harder to achieve than others (in general, or for a particular technology)?</td>
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<tr>
<td>⇒ Are there international standards of accuracy against which to assess models?</td>
</tr>
<tr>
<td>⇒ Are there any specific aspects of the accuracy requirements that could be relaxed without materially affecting model performance (in terms of the generating system’s impact on the power system)? Please specify if this is general, or technology dependent?</td>
</tr>
<tr>
<td>⇒ To maintain consistency between technologies, is it reasonable to require the same accuracy requirements for different technologies? Should some technologies have different accuracy requirements? What technologies are they? Why should this be the case?</td>
</tr>
<tr>
<td>⇒ NEMMCO has been advised that some wind farms cannot achieve the accuracy criteria in Wind Farm Model Guidelines and Checklist. If so, what level of accuracy can be achieved for a single turbine? What level of accuracy can be achieved for a fully aggregated generating system (wind farm)?</td>
</tr>
<tr>
<td>⇒ Do the accuracy requirements properly reflect the level of accuracy required for each particular model type? Is there a need to review the accuracy requirements for the modelling of SVCs or Statcoms compared with, say, a governor model?</td>
</tr>
</tbody>
</table>

5.20.1 Submissions:

Suzlon: “During transient events, the aerodynamics conditions are particularly difficult to model accurately, with variance both for a specific turbine and across a wind farm. In the instance of turbines with only modest speed variability, this challenge is exacerbated. We would suggest the issue of appropriate accuracy requirements should be the subject of further investigation by NEMMCO.

“From our international experience, we would suggest there are no comparably stringent conditions applied in any other market. Notwithstanding the nature of the network NEMMCO is vested to oversee, we would suggest that other international markets pose equally challenging system security challenges.”

Alstom:

“The transient stability model and the associated parameter values must:

• be in functional block diagram format. In showing ‘functionality’, the model is expected to bear some resemblance to the physical design of the plant and controllers. The dynamic characteristics described within the functional block diagram must:
  o be described by Laplace (preferred) or Z-domain transfer functions wherever possible. The transfer function blocks and model parameters must be recognisable in terms of the
physical design of the plant and actual control system settings, to allow the Network Service Provider or NEMMCO to assess control system settings proposed by the Generator or Connection Applicant, or design new settings;"

[Excerpt from Section 7.1 “Functional Requirements” of Section 7 “Transient Stability Model Requirements and Oscillatory Stability Model Requirements” from the draft Generating System Model Guidelines]

“May not be possible because of propriety information, especially for the gas turbine control systems. Therefore simplified or standardized models shall be allowed.”

“1. For any control system models, the overall linear response over a frequency bandwidth of at least 0.1–5Hz must be within the following tolerances:
   o magnitude must be within 10% of the actual control system magnitude at any particular frequency; and
   o phase must be within 5 degrees of the actual control system phase at any particular frequency.

[Excerpt from Section 7.2 “Accuracy Requirements” of Section 7 “Transient Stability Model Requirements and Oscillatory Stability Model Requirements” from the draft Generating System Model Guidelines]

“The accuracy requirement for magnitude of 10% may not be achievable in transient cases due to measurement errors and equipment tolerances. We would propose to allow a tolerance of 15%.

“Same argument for phase angle tolerance.”

“To the best of our knowledge there are no international standards for assessing models.”

CitiPower/Powercor: “The first sentence states:-

‘The model must accurately represent the performance of the generating unit at its terminals. That is the model must respond accurately when compared to the actual generating unit response for the same disturbance.’

[Excerpt from Section 7.2 “Accuracy Requirements” of Section 7 “Transient Stability Model Requirements and Oscillatory Stability Model Requirements” from the draft Generating System Model Guidelines]

“The application of this requirement to wind generation will need further detailed study due to the variability of wind generation. The state of generation at the time of the event would generally be changing and highly variable for the different turbines of a wind farm. The wind can change in both speed and direction. Wind turbine models which assume constant wind or constant power may not be appropriate in conditions for which the wind is changing in speed and direction.

“However, validation of models compared with actual performance, requires a model of the actual aerodynamic conditions including changing wind speeds, changing wind direction and changing turbine yaw positions relative to the wind. Wind turbine models which assume constant wind or constant power may not be appropriate in conditions for which the wind is changing in speed and direction ie the aerodynamic power may not immediately change to the constant value for a changed wind speed.

“The application of these accuracy requirements to wind models needs further study.

“7.2.2 & 7.2.3 12
“The damping requirement here is defined in terms of eigenvalue real part. The NER defines damping as “the halving time of the least damped electromechanical mode of oscillation is not more than five seconds.” (S5.1.8)

“The requirement for damping should be expressed on a basis consistent with the NER. The dynamic responses provided to Powercor by intending generators are in the time domain and the NER definition of damping is readily ascertained. Powercor considers that the damping requirement for models should be consistent with the description in the NER and be expressed in the time-domain.

“7.2.6

The viability of a requirement for accuracy within 1% should be reviewed to achieve a practical level having regard to the accuracy of standard VTs, CTs and measurement transducers.

“7.2.7

This requirement raises the whole issue of the change in generation during a transient for wind generation. This issue will need further study.

“7.2.8

The viability of a requirement for accuracy within 0.5% should be reviewed to achieve a practical level having regard to regarding the accuracy of standard VTs, CTs and measurement transducers.”

Roaring 40s: “The accuracy requirements of generating units are practical. This leaves the question of as to the level of accuracy required for generating systems. It is suggested that NEMMCO should be flexible in this area by applying the following principle:

“The accuracy of the generating system model must be equivalent to the level of accuracy that would be achieved by deriving the generating system model from generating unit models that meet the accuracy guideline for generating units, and in any case, is adequate for assessing system security in the operational and planning time frames.”

TransGrid: “There are a number of factors that will ensure that some of the individual aspects of accuracy will be harder to achieve than others. These include:

- The arbitrary choice of the different accuracy requirements;
- The influences of model inaccuracies of other generators and other system elements; and
- The uncertainties involved in the actual cause of the disturbance (e.g. for a fault, its location, its variation of resistance with time, the timings of circuit breaker openings on different phases at different locations).

For conventional generators, accuracy requirement 6 in section 7.2 of the draft Model Guidelines seems particularly hard to achieve. While the requirement takes into account the voltage magnitude at the connection point, uncertainties about the event, the models and other aspects of the system will influence the voltage angle variation at the connection point, which in turn will affect the response of the generator PSS and hence the generator terminal voltage.

TransGrid is unaware of any international standards against which to assess models.

There are numerous aspects of the accuracy requirements that could be relaxed without materially affecting the performance of the overall system model. Many of these relate to the size of the generator, while the technology of the generator will also influence the nature of the disturbance of its output following a particular system contingency.

- the final value at which the actual plant response would settle ±2% of the plant’s nameplate rating; or
- the final value at which the actual plant response would settle ±10% of the total change in the quantity during the transient period during and following the disturbance

8. Taking into account the level at which voltage settles at the connection point, the final voltage value of the plant within the generating system at which the model settles is within the more restrictive of:

- the final value at which the actual plant output would settle ±0.5% of the nominal voltage at that point; or
- the final value at which the generating unit would settle ±10% of the total change in the voltage during the transient period during and following the disturbance.”

[Excerpts from Section 7.2 “Accuracy Requirements” of Section 7 “Transient Stability Model Requirements and Oscillatory Stability Model Requirements” from the draft Generating System Model Guidelines]
“To maintain consistency between technologies, it is reasonable to base the accuracy requirements on a combination of the output rating of the generator and its location is the system.

“TransGrid has insufficient experience with wind farms to identify levels of accuracy that can be achieved with either a single turbine or a fully aggregated wind farm.

“The comparison between the level of accuracy required for models of SVCs and Statcoms compared with those for governors is a useful exercise. While an accurate governor model can be developed, if there are no FCAS requirements for its implementation, then the unit can be run in an operating mode where its effect following frequency changes will be quite unlike that predicted by the model. Having a governor model of great accuracy will therefore provide no guarantee of good agreement between actual and simulated behaviour for particular system events.”

The following submission was received during the Second Stage of the consultation:

**Vestas:** “Aerodynamic conditions are particularly difficult to model and variation of wind speed with WTG performance measurements other than power curve are unable to be tested in a meaningful manner.”

### 5.20.2 NEMMCO’s consideration and decision

*NEMMCO* notes Suzlon’s concerns regarding the appropriateness of the accuracy requirements for the models. Some of the changes made to the Model Guidelines attempt to address this. There is little international experience, however, in terms of standards that can be applied. Reference [4] suggests that reasonable model performance can be achieved for fixed speed turbines. It is not clear, however, the extent to which other turbine technologies might obtain similar model performance.

Both Vestas and Suzlon comment on the aerodynamic model accuracy requirements. The Data Sheets have been adjusted to address these concerns by removing the ‘R2’ requirement for the aerodynamic model parameters, except for the power curve. See section 5.13.2 for more information.

In relation to Alstom’s comment regarding allowing simplified and standardised models, *NEMMCO*’s and TNSPs’ experience is that generic models often have unsatisfactory performance, and further detail is required to achieve reasonable accuracy requirements. TransGrid has similar concerns (see Section 6.7). *NEMMCO* would need to understand the extent of the simplification before any further comment can be made. The flexibility allowed in the Model Guidelines would allow the materiality of the simplification to be assessed at an appropriate time. *NEMMCO* prefers to retain the requirements regarding the functional block diagram representing the physical plant structure.

Alstom also recommends that expanded tolerances ought to be allowed due to measurement errors and equipment tolerances. CitiPower/Powercor raised similar issues regarding voltage and current transformer errors. *NEMMCO* considers that the accuracy of voltage and current transformers and measurement systems should be well within the accuracy requirements, and it is similarly expected that calibrated equipment would be used for validation testing. Also, as the error is normally unknown, comparisons of measurement and simulated responses usually neglect measurement errors in the model assessment. Some of Alstom’s concern may be alleviated by the removal of items 6 and 8 of Section 7.2 of the Model Guidelines.

*NEMMCO* notes CitiPower/Powercor’s comments regarding wind variability. Variation in the wind on a turbine and across the farm can affect the wind farm significantly. If necessary, this can be taken in to account in a transient stability study as a random fluctuation in the wind farm output – it is currently not normally the case to do so, but it could be taken into account relatively easily. However, it is *NEMMCO*’s understanding that a disturbance from the grid side of the wind farm will impact all of the turbines in a similar way, resulting in a consistent response (see Reference [4]). Except where a wind farm fault ride-through control has taken control of the *plant* response, a wind farm fluctuation caused by variation in the wind can be superimposed on the fault response. *NEMMCO* will, however, continue to monitor research in this area. Other comments regarding model accuracy in the presence of wind variations are covered in Section 5.18.
Also, CitiPower/Powercor commented on specific accuracy requirements:

- 7.2.2 and 7.2.3 – these will be deleted – see Section 5.18 for more information;
- 7.2.6 (this was also raised by TransGrid) – the requirement was originally tightened in response to concerns that the response is dependent significantly on the response of the power system model, with the following allowance added: “Taking into account the voltage at the connection point”. However, this allowance creates a problem in that the voltage at the connection point and the voltage within the wind farm become highly inter-dependent and essentially makes the accuracy requirement redundant. This accuracy requirement will be deleted.
- 7.2.7 – this requirement is still considered to be valid – the allowance “Taking into account the voltage at the connection point” is considered to be reasonable in this case. In terms of wind variability and wind farm response to a disturbance, see the reasons mentioned in the previous dot point.
- 7.2.8 – this has been deleted for similar reasons to 7.2.6.

The accuracy of generating unit versus generating system models was raised by Roaring 40s. Comments similar to the wording suggested by Roaring 40s have been added to Section 7.3 of the Model Guidelines.

TransGrid raised a number of issues in relation to the specific accuracy requirements in the Model Guidelines, as well as suggesting that accuracy requirements should be based on the size of the plant and the location in the power system – TransGrid also suggested that the particular plant item might have different accuracy requirements. In relation to the specific issues with accuracy requirements, NEMMCO admits that the requirements are relatively arbitrary, partly due to a lack of industry experience in applying model accuracy criteria, and partly imposed by the requirement to produce the Data Sheets and Model Guidelines by 1 March 2008. Some allowance has been made through the flexibility arrangements with the Data Sheets and Model Guidelines, and it is expected that the accuracy requirements will evolve over time and further (and more recent) experience is obtained. The suggestion that the accuracy requirements should be based on the size of the plant and the location in the power system and even the plant type is worthy of consideration, although not within this consultation timeframe. More detail on NEMMCO’s consideration of this issue is provided in Section 5.18.

### 5.21 Staging of Tests rather than reliance on system incidents

<table>
<thead>
<tr>
<th>Issue 21</th>
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<tbody>
<tr>
<td>⇒ While a system incident provides some proof of an ability of the generating system to operate continuously during and following a disturbance, it only provides a single ‘test’ with which to determine a number of model parameters. This suggests that some staged tests are probably still required to properly validate a model.</td>
</tr>
<tr>
<td>⇒ Apart from using system disturbances to perform tests, are there other tests that could be used to perform validation tests successfully? Are there international practices in relation to validation test requirements? Do these apply for a range of generation technologies? If suitable tests can be staged, is it appropriate for NEMMCO to recommend such tests in the Model Guidelines?</td>
</tr>
<tr>
<td>⇒ NEMMCO is aware that there are measurement and analysis techniques that would allow validation test analysis without the need for a power system model. Have these types of approaches been used successfully in the NEM? Have they been carried out successfully internationally? Can you explain how the test was carried out and your level of satisfaction with the approach? Is it appropriate for NEMMCO to recommend such approaches in the Model Guidelines?</td>
</tr>
</tbody>
</table>
5.21.1 Submissions:

Suzlon:  “The tests that are available during normal operation (e.g. capacitor switching, line switching, and transformer tap changes) will only give small disturbances. Full validation of the model would require more severe tests consistent with the requirements for modelling.

“In regard to measurement and analysis techniques, a voltage time-series is measured at the POCC during the testing event. This series is then fed into a model consisting of the wind farm connected to a voltage controlled bus, thus representing the combined wind farm system response to the event.

“This approach has the advantage of not requiring the accurate modelling of the power system conditions external to the wind farm, and we would therefore consider this to be an appropriate approach for model validation.

“It should be noted that this method has the severe disadvantage of being inconsistent with the definition of contingency ride through under the NER S5.2.5.5. and can therefore not be used to indicate compliance with this Rule. It must further be noted that the wind farm may impose an impact on the voltage at the point of common coupling. This compromises the process of feeding the model with a voltage time series unless the point of common coupling is an infinitely strong bus, and so use of this methodology requires judgement during modelling work with consideration to the specifics of the connection point.

“Additional comment on Section 5.5 [of the Issues Paper]

“The accuracy of determination of system response to a disturbance requires the model of the power system to have the same level of accuracy as that required by the generation model. On the basis of the current simplified approach to load modelling, it is not clear if this condition is satisfied.

“This is of particular for issue for determination of system damping.”

TransGrid:  “To avoid imposing significant disturbances on its customers and to avoid the risk of imposing even greater disturbances, TransGrid has been reluctant to apply system faults to stimulate the substantial system disturbances required to test system dynamic models. Also, with the significant differences that presently exist between measured and calculated inter-area oscillation modal parameters, there is no basis for believing that the results of staged tests would be matched by the system model, as these parameters would make significant contributions in any staged disturbance.

“Other tests that can be done to identify the responses of individual generating units involve the identification of the frequency response obtained from long (e.g. 3-hour) samples of the variations of the real and reactive powers of generating units caused by system load changes and their randomly occurring effects on the voltage angles and voltage magnitudes at generator connection points. Continuously monitoring systems, with 50 Hz sampling rates, provide the inputs, and simple spectral analysis provides frequency response “fingerprints”. With this method, contributions from inter-area and local modes and inconsistencies between the responses of supposedly identical units are easily identified.”

The following submission was received during the Second Stage of the consultation:

Vestas:  “The actual fault ride through capability of a single wind turbine is studied by examining recorded measurements from an actual electricity grid system incident involving a single wind turbine. In the situation of a single wind turbine, it is straight forward to compare the actual measurements from a single wind turbine to simulation results from a single wind turbine equivalent mathematical numerical model. Manufacturers of wind turbine have a preference for this type of methodology. Undertaking staged tests do provide some evidence of performance but this is limited to the magnitude of the disturbance.”

5.21.2 NEMMCO’s consideration and decision

Suzlon queries the validity of staged tests for generating unit performance standard compliance assessment. Suzlon comments on a method that de-couples the accuracy requirement of the power system from the accuracy of the generating system model, and would appear to be similar to the one described in Reference [4]. This might remove some of the issues associated with reliance on the accuracy of the power system model, commented on by both Suzlon and TransGrid, although this may not be the case for all test requirements.
NEMMCO notes Suzlon’s concern regarding performance standard assessment, but the purpose of the tests are to validate the model (R2 data), not to prove compliance with performance standards.

Suzlon comments on the disturbances being relatively small, not exercising features necessary to model the entire plant. NEMMCO considers that the requirement to provide a validated generating unit model, rather than generating system model for wind farms may improve this situation, as will the recent requirement that generating units must have facilities for testing their control systems sufficient to establish their dynamic operational characteristics (Rule S5.2.5.13). Tests would still need to be devised to determine generating system control systems. NEMMCO understands that fault-throwing tests are carried out in Europe to establish wind turbine performance for large disturbances – provided these can be shown to be relevant to the plant being installed in the NEM (the same turbine type, the same or sufficiently similar control settings, and similar short circuit ratio conditions to those that would apply for the installed site) such tests could be used to establish large disturbance model parameters.

NEMMCO notes TransGrid’s comments regarding testing methods to establish inter-area and local mode damping contributions, providing information on inconsistencies between generating unit performances. It is hoped that this could be adapted to establish model parameters at some stage.

On the basis of these considerations, NEMMCO sees no reason to adjust the Data Sheets or Model Guidelines.

NEMMCO notes Vestas’ comments regarding comparisons of model and plant fault responses for a single turbine, and manufacturers’ preference for this approach. NEMMCO also agrees that the usefulness of staged tests depends on the magnitude of the disturbance. While an actual grid fault may provide useful information this also depends on the severity of the fault, and there may be considerable time (possibly years) before a fault of reasonable severity occurs for a particular wind farm.

As mentioned in section 5.13, reliance on naturally occurring faults may not result in sufficient (or any) information in the 3-month timeframe required under the Rules for determination of ‘R2’ parameters. NEMMCO’s preferred approach is described in that section.

5.22  Reliance on unit model for validation of Generating system Model

<table>
<thead>
<tr>
<th>Issue 22</th>
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<tbody>
<tr>
<td>⇒ Is it necessary for the party validating an aggregated model to have access to the detailed generating unit model (e.g. a wind turbine model)?</td>
</tr>
<tr>
<td>⇒ To what extent should an aggregate model of a generating system have the same control system structure as a single generating unit in that system?</td>
</tr>
<tr>
<td>⇒ For wind turbines, NEMMCO is aware that some manufacturers carry out fault-throwing tests on individual turbines. Could these be used as turbine type-tests for the purpose of model validation? Under what conditions would these types of tests be appropriate? (NEMMCO is aware, for example, that some of the tests are performed with significantly different fault levels to those that the wind farm would be subjected.) What test conditions should be required, should these types of tests be permissible?</td>
</tr>
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</table>

5.22.1  Submissions:

Suzlon: “It is necessary for the validating party to have access to the detailed model.
“The control systems of the two model forms must be consistent.
“Such tests though highly informative are not essential.”
CitiPower/Powercor: “Powercor considers that NEMMCO should have the responsibility for validating mathematical models of dynamic performance and for advising NSPs of the adequacy of such models.”

The following submission was received during the Second Stage of the consultation:

Vestas: “Equipment manufacturers such as wind turbine manufacturers prefer option “a”, and favour validation of option “a“.

5.22.2 NEMMCO’s consideration and decision

NEMMCO notes Suzlon comments that:

• the generating unit model is required to validate the generating system model; and
• the generating unit and generating system models should show consistent control system form.

See also NEMMCO’s consideration under Section 5.21.2.

NEMMCO notes CitiPower/Powercor’s comment that NEMMCO should have the responsibility for validating models and providing NSPs with advice on the adequacy of such models. NEMMCO considers that this is an issue associated with the Rules and is beyond the scope of this consultation.

On the basis of these considerations, NEMMCO sees no reason to adjust the Data Sheets or Model Guidelines.

NEMMCO notes Vestas’ preference. This is in line with Suzlon’s preference and NEMMCO’s decision.

5.23 Modelling Guidelines Documentation Adequacy

5.23.1 Submissions:

Suzlon: “The defined documentation is adequate on the basis that a system model is provided.”

TransGrid: “The specified documentation appears to be sufficient.”

5.23.2 NEMMCO’s consideration and decision

On the basis of these comments, NEMMCO sees no reason to adjust the Model Guidelines.

5.24 Need for EMT models

For the purposes of assessing the performance of a generating system utilising power electronic devices, is there a need for the NSP or NEMMCO to adopt EMT models? It is recognised that the Generator or the manufacturer might have a need for sophisticated and detailed models for their own design purposes, but do performance assessment studies need that level of sophistication and detail? Is there evidence of the materiality of the differences in the performances of the different modelling types? Is there evidence in the
form of international practices (overseas utilities, for example) that require EMT modelling to assess the capability of generating systems to ride through faults?

⇒ If EMT models are not required, is it reasonable that a single model can be used for the three purposes for the models, listed in Section 3? If not, what type of modelling is required? Is there evidence of the materiality of the differences in the performances of the different models? Is there evidence in the form of international practices (overseas utilities, for example) that require different models for similar purposes listed in Section 3?

⇒ Which (if any) technologies would require individual phase representation of models for transient stability assessments?

⇒ Are there other fundamental modelling issues that need to be addressed, that might change the way that particular generating technologies need to be modelled?

5.24.1 Submissions:

Suzlon: “The impact of unbalanced faults could be significant on machine performance. The adequacy of using three faults to simulate unbalanced faults has not been established.

“NEMMCO should facilitate further investigation as to appropriate approaches, and the significance of this effect for the assessment of system performance. The introduction of high speed power electronics emphasizes the need for this investigation.”

The following submission was received during the Second Stage of the consultation:

Vestas: “EMT is normally localised and not normally required, where the generator itself may not be relevant in a system study.”

5.24.2 NEMMCO's consideration and decision

NEMMCO agrees with Vestas’ comments regarding the use of the EMT model and that such a model would only be required occasionally for specialised studies.

NEMMCO notes Suzlon’s concern that the use of single-phase equivalent models does not always provide accurate response to unbalanced faults. This may be a reason for the use of EMT type models, under some circumstances.

At this stage, however, NEMMCO considers that there is insufficient evidence for NEMMCO or the NSPs requiring EMT models for their purposes, although acknowledges there may be a requirement for it in the future. NEMMCO will monitor this requirement and it may become the subject of a further consultation.

NEMMCO sees no reason to adjust the Data Sheets or Model Guidelines at this stage.
6 Other Issues

6.1 Generic Dynamic Models for Windfarms

6.1.1 Submissions

Clean Energy Council: “The wind industry is relatively new and manufactures are continually improving the design and performance of the wind turbines which means that performance data and dynamic models have been evolving over time. While there are a number of typical designs, manufacturers are spending huge amounts of resources developing their wind turbine systems and are most concerned that their intellectual property is protected. For more mature technologies such as thermal and hydro generators generic models have been developed, but at present no such models for wind turbines exist. However, work is progressing currently in the USA to create and validate a series of generic models for a number of the basic wind turbine designs. The Clean Energy Council would urge NEMMCO to participate in that process. The use of validated generic models should overcome some of the confidentiality issues raised by manufactures.”

6.1.2 NEMMCO's consideration and decision

NEMMCO looks forward to the development of the generic models. This may form a suitable generating system model that could be provided in addition to the generating unit model and might ultimately replace that model for power system studies. The suitability of these models will need to be assessed through comparison against the detailed generating unit models and any other validation test or power system disturbance evidence from installations.

6.2 Confidentiality

6.2.1 Submissions

Roaring 40s: “A key issue here is confidentiality. Although NEMMCO is currently required keep generator modelling information confidential, it is understood that there is still considerable nervousness among manufacturers around the practical workability of these arrangements, and a risk of future Rule change resulting in release of previously confidential information. It is suggested that NEMMCO could consider the options for improving trust in the confidentiality arrangements:

- release information on the system used by NEMMCO to ensure confidentiality including document tracking systems and access protocols;
- provide to information owners details of who has been given access to their information on request;
- initiate a Rule change that puts beyond doubt the principle that confidential information provided to NEMMCO can not be released by a subsequent Rule or procedural change without written consent of the owner of that information; and
- initiate a practice of entering confidentiality agreements with information providers unless this information is explicitly in the public domain.”

TransGrid: “Confidentiality - NEMMCO have taken the position that information contained in schedule 5.5.1 and schedule 5.5.2 of versions prior to and including 12 of the National Electricity Rules has become
confidential since the inception of version 13 of the Rules. The new confidentiality has been a frustrating development for many rule participants.

“The data sheets that are the subject of this consultation will replace the abovementioned schedules.

“Will NEMMCO deem that all the information contained and described in the new data sheets will be confidential? It would be helpful for Rules participants if this was clearly answered. It would be unfortunate to unsuspectingly increase the frustration of the rule participants.

“On this note TransGrid would welcome the opportunity to discuss the full range of possible solutions (e.g. a Rule change request to the AEMC) with NEMMCO as soon as reasonably possible.”

Clean Energy Council: “As is well known; model confidentiality is a major issue to manufacturers and developers. As is discussed above, work is underway to develop generic models for wind turbines that will eventually form part of the IEEE library of models. This should mitigate some of the confidentiality issues and allow the requirement for the provision of source code to be relaxed. NEMMCO is urged to participate in the development of these generic models.”

The following submission was received during the Second Stage of this consultation:

Vestas (page 1): “As you can appreciate, mathematical numerical models contain highly confidential information that reveal the way in which the turbine has, after many years of research and development, been designed. If this confidential information was to be disclosed to a manufacturer’s competitor then there is a very real risk a competitor can copy techniques to the original manufacturer’s detriment. Nevertheless, manufacturers understand that owners of wind farms require these mathematical numerical models for the purpose of assisting with the design and testing the complete wind farm. Presently, the mathematical models being provided to wind farm owners are done so in a highly restricted and controlled environment, that is, they are provided to the owners after signing confidentiality deeds which restrict the release of the models.

Whilst there are confidentiality provisions in the National Electricity Rules which prohibit the release of certain information that is considered confidential, wind turbine manufacturers are not subject to those Rules and therefore the information supplied to NEMMCO would not be protected by the Rules.”

and…

Vestas (page 3): “Mathematical numerical models contain highly confidential information that wind turbine manufacturers do not want released to competitors, or more generally, to the public. Nevertheless, manufacturers understand that owners of wind farms require these mathematical numerical models for the purpose of assisting with the design and testing the complete wind farm. Presently, the mathematical models being provided to wind farm owners are done so in a highly restricted and controlled environment, for instance, subsequent to the signing of confidentiality deeds which restrict the release of the models to anyone other than the owners of the wind farms.”

and…

Vestas (page 8): *(a) Confidentiality

“Equipment manufacturers cannot risk their confidential information being disseminated to entities that may use that information to the manufacturer’s detriment. Whilst this could be addressed by the introduction of a new Rule that has the effect of restricting the release of intellectual property to manufacturer’s competitors, there is nothing to say that sometime in the future, another Rule is introduced that changes this. It is far preferable that manufacturers be permitted to provided ‘middle ground’ information to NEMMCO: that is, information that is sufficiently adequate to satisfy NEMMCO’s requirements, without confidential information being disclosed.

“(b) New method for controlled release of information

“It may be necessary to include in the National Electricity Rules specific guidelines or rules that control the way information is released. This system should comprise a document system that records who received the document with a time and date stamp.

“Also, there ought to be certain protocols (both in software and hardware forms) that prevent internal employees of NEMMCO receiving specifically confidential information.

“Notification to equipment manufacturers that a particular entity has applied to receive some or all of a manufacturers confidential information should also be provided.”
6.2.2 NEMMCO’s consideration and decision

NEMMCO notes the concerns regarding the confidentiality of model data and design information. Confidentiality is a matter that is addressed by the Rules and is beyond the scope of this consultation.

It is difficult for NEMMCO to judge what the expression “middle ground” in Vestas’ submission might mean, or the implications of any “middle ground” information on the overall power system model accuracy. In establishing the Data Sheets and Model Guidelines, the Rules defined several purposes of those documents, which are to (S5.5.7(b)):

“(1) allow generating units and generating systems to be mathematically modelled by NEMMCO in load flow and dynamic stability assessments 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) proposed access standards and performance standards of generating units and generating systems to be assessed; and

(iii) settings of control systems and protection systems of generating units, generating systems and networks to be assessed and quantified for maximum practical performance of the power system; …”

The requirements for models in the Data Sheets and Model Guidelines have been based on these principles. These would require the best available models that are suitable for loadflow and dynamic stability studies. The models requested have generally been based on those normally indicated in the literature as being appropriate.

Any new method of disclosure suggested by Vestas is more properly the subject of a Rule change proposal for the AEMC’s consideration.

6.3 Long time frame modelling

6.3.1 Submissions

Roaring 40s: “Development of medium and long term modelling of wind turbines is not a well developed area of understanding and should be considered as an area of academic research. As such it is not appropriate for it to be included in the NEMMCO guideline.

“It is understood that accepted industry practice for modelling power systems in this time frame are hybrid steady state / short term transient models, with heuristic treatment in changes in load, wind conditions, central dispatch and operation actions.

“It is beholden on NEMMCO to clearly build the case as to why it is necessary, or indeed desirable to engage in medium and long term dynamic modelling if it is believed that placing this impost on industry justified at a later point in time.”

Clean Energy Council: “The guidelines contain requirements over modelling medium and long timeframes. This raises the issue of wind variability in that time, in particular for validation of models against the recorded response to system events. The guidelines give no indication of how this variability should / could be included in the modelling.”

6.3.2 NEMMCO’s consideration and decision

Given the ability for transient stability models to be used for extended periods and suitable information regarding critical medium term and long term control systems, protection systems and limits, NEMMCO considers that medium and long term influences can be taken into account without necessarily modelling them.
NEMMCO considers that the requirement to provide models the sole purpose of which is long term and medium term power system studies is unnecessary. NEMMCO has adjusted the Data Sheets and Model Guidelines as follows:

- the requirement for specific models be removed from the Model Guidelines;
- models provided for transient stability studies must be numerically stable in the software packages for which they were provided, to allow studies for up to 10 minutes; and
- information must be provided in the Data Sheets on medium and long term control systems, protection systems, limits, etc. that is relevant for timeframes of up to 10 minutes.

See Section 5 of the Data Sheets and Sections 8 and 9 of the draft Model Guidelines.13

NEMMCO notes the Clean Energy Council’s concern regarding wind variability. This is considered in more detail in Section 5.18.

6.4 Model Description Wind Variability Effects

6.4.1 Submissions

Suzlon:

"9.1 Functional Requirements

The long term dynamic model must define the long term electromechanical and control system performance of the generating system under steady state and disturbance conditions and on time scales that may be arbitrarily long (typically up to 30 minutes).

- For generation with an inherently variable energy source, be capable of representing all credible variations in source strength. For wind generating units, such variations would include wind gusts, ramps, and variations in prevailing wind speed and direction consistent with an underlying wind speed distribution.”

[Excerpt from Section 9.2 “Functional Requirements” of Section 9 “Long Term Dynamic Model Requirements” from the draft Generating System Model Guidelines]

"Wind variability will have a significant impact on the accuracy of modelling that can be achieved in practice in this time domain. While it can be argued that wind speeds are approximately constant during a ten second transient study, this is not the case over a thirty minute period.

"As such we would suggest NEMMCO needs to conduct further investigation into appropriate standardized forms of representing wind conditions. It would be ideal if the worst case wind time-series could be established. This might take the form of a time series representing the worst case upwards or downwards variation that is likely to be encountered during a (say) seven year return period."

CitiPower/Powercor: "The third dot point on p11 states:-

"In the case of generating units with an inherently variable power source, where the variability of the source is not specifically the subject of the study, the model may assume the source strength remains constant throughout the simulation study."

[Excerpt from Section 7.1 “Functional Requirements” of Section 7 “Transient Stability Model Requirements and Oscillatory Stability Model Requirements” from the draft Generating System Model Guidelines]

"This raises the very serious issue of how to approach the analysis involving multiple wind farms, which can be distributed over a large geographic areas. The assumption of coincident and sustained maximum output from each wind farm would be the most severe case. However in view of the high variability of generation observed for wind farms connected to the Powercor system, such an approach could lead to an unnecessary limitation on the connection of generation and unnecessary costs for system reinforcement. Powercor suggests that further study proceed to investigate statistical approaches to this issue to provide a justifiable approach to assessing the capability of a network to connect variable generation (in particular wind) consistent with the security of system operation and the capability of the network lines and plant.”

13 the sections have been merged into a single section 8 “Medium and Long Term Dynamic Model Requirements” in the final Model Guidelines.
6.4.2 NEMMCO's consideration and decision

In relation to Suzlon and CitiPower/Power’s comments regarding potential investigations relating to wind variability and diversity, NEMMCO considers that these are beyond the scope of this consultation.

6.5 Accuracy of wind turbine models under changing wind conditions

6.5.1 Submissions

Suzlon: “In general we wish to comment that wind variability needs to be considered when defining modelling accuracy requirements, and also during the assessment of corresponding validation testing. Additionally we believe further consideration needs to be given as to the appropriate level accuracy for wind farm models. Irrespective of the accuracy achieved in validation of a generating system’s model, operation of the overall system model has limited accuracy due to the unpredictable mean value and random fluctuations in the wind input during system events.”

and

“7.2 Accuracy Requirements

“The model must accurately represent the performance of the generating unit at its terminals. That is, the model must respond accurately when compared to the actual generating unit response for the same disturbance.”

[Excerpt from Section 7.2 “Accuracy Requirements” of Section 7 “Transient Stability Model Requirements and Oscillatory Stability Model Requirements” from the draft Generating System Model Guidelines]

“Accuracy requirements, and the assessment of their validation, needs to account for model parameters which are inherently variable and therefore beyond the control of the testing setup. In the case of wind farms, wind variability forms a significant factor in the ability to replicate test measurements using a model simulation. Despite best practise endeavours to minimise errors in the validation procedure, such as by feeding measured wind data into the subject model, it needs to be considered that wind measurement across the scope of wind farm, or even a single wind turbine, introduces a limiting factor in the representation of the actual test conditions. Wind variation in speed and direction across both the wind farm and across time, poses a significant factor in the accurate functionality of a generator model.

“The impact of wind variability manifests itself even in short time frame test scenarios performed on a single wind turbine. During ride-through studies the sweep of the rotor blades traverses significant angular distance. As such spatial wind variability is introduced as a complicating factor, beyond wind variability already considered in NEMMCO’s consultation documentation over time such as introduced by gusting or ramping. Accepted acquisition of wind data consists of a single point of data collected by appropriately located measuring equipment. This is at best then approximation of the overall driving force on an aggregate generating unit considering the length modern wind turbine blades, and the resulting rotor sweep. The objective of validating pre- and post- fault generator parameters has thus been complicated when considering that the driving torque applied to the generator has varied through the course of the event. There does not appear to be an acceptable method available which resolves this issue, and so inaccuracies have been introduced into testing setup which need to be accounted for when defining validation accuracy criteria.

“These challenges are further compounded as the modelling/measurement duration is lengthened due to the increasing blade sweep.

“Beyond the shortest of testing durations, wind direction also introduces a challenging factor. Within the thirty second timeframe being contemplated, changed direction will result in yawing of individual wind turbines to align better into the wind. Each turbine undertakes this action individually, dependent on the wind direction detected at its own monitoring equipment. There is necessarily a time delay between wind direction change and completion of the yawing action, during which the resultant torque applied to the generator is compromised. This introduces a further modelling challenge during validation process, particularly when considering the complete wind farm installation.”

6.5.2 NEMMCO’s consideration and decision

NEMMCO notes Suzlon’s concerns regarding determination of models in the presence of wind variations and comments on this in Section 5.18.2. While it is recognised that wind technologies
might face a greater modelling challenge due to wind variations during tests, NEMMCO prefers to keep the accuracy requirements as they are until some further experience is gained with on-site validation testing of wind turbines.

6.6 Definition of Damping

6.6.1 Submissions

Suzlon:

"2. Over a frequency range of 0.1–5Hz, the damping of oscillatory modes associated with the modelled plant (i.e. the eigenvalue real part for a particular eigenvalue, measured in terms of the active power, reactive power and voltage at the terminals of the plant) must be within 10% of the actual response of the plant."

[Excerpt from Section 7.2 “Accuracy Requirements” of Section 7 “Transient Stability Model Requirements and Oscillatory Stability Model Requirements” from the draft Generating System Model Guidelines.]

"The NER defines damping in the time domain, with reference to the halving time of oscillations. We believe these requirements should remain consistent with the NER rather than move to frequency domain."

CitiPower/Powercor:

"The damping requirement here is defined in terms of eigenvalue real part. The NER defines damping as 'the halving time of the least damped electromechanical mode of oscillation is not more than five seconds.' (S5.1.8)

"The requirement for damping should be expressed on a basis consistent with the NER. The dynamic responses provided to Powercor by intending generators are in the time domain and the NER definition of damping is readily ascertained. Powercor considers that the damping requirement for models should be consistent with the description in the NER and be expressed in the time-domain."

CitiPower/Powercor's comment refers to:

"2. Over a frequency range of 0.1–5Hz, the damping of oscillatory modes associated with the modelled plant (i.e. the eigenvalue real part for a particular eigenvalue, measured in terms of the active power, reactive power and voltage at the terminals of the plant) must be within 10% of the actual response of the plant."

"3. Over a frequency range of 0.1–5Hz, frequencies of oscillatory modes associated with the modelled plant (i.e. the eigenvalue imaginary part for a particular eigenvalue, measured in terms of the active power, reactive power and voltage at the terminals of the plant) must be within 10% of the actual response of the plant."

[Excerpt from Section 7.2 “Accuracy Requirements” of Section 7 “Transient Stability Model Requirements and Oscillatory Stability Model Requirements” from the draft Generating System Model Guidelines.]

6.6.2 NEMMCO's consideration and decision

In relation to the above comments, it should be noted that NEMMCO has removed the relevant accuracy requirements from the Model Guidelines.

6.7 IEEE Standard Models

6.7.1 Submissions

TransGrid: "Design Data Sheets requires IEEE Standard type voltage regulator and PSS models if applicable. The Generating System Model Guidelines 6th September 2007, Section 7.1 provides extensive requirements for the model, including a requirement "the model is expected to bear some resemblance to the physical design of the plant and controllers. The invitation to provide IEEE standard models may undermine the intention that explicit plant and controller models are required, so that the confidence level in model performance is maintained. I would suggest the reference to IEEE Standard models is removed or expanded to make it clear that at some stage in the project explicit models are required and reworking due to model changes are minimised. The model validation process would be enhance if explicit models are provided. During the commissioning phase, the validation process requires measured controller data to be passed through the model and the plant and model responses directly compared. An IEEE equivalent model
would be more difficult to validate, especially if significant difference in plant and model response were observed.”

### 6.7.2 NEMMCO’s consideration and decision

*NEMMCO* agrees with TransGrid’s comments and will remove the references to IEEE standard models from the Data Sheets.

### 6.8 Model time-step requirements

#### 6.8.1 Submissions

**Roaring 40s:** “The guideline proposes a minimum integration time step of 2mS. It is assumed that this is seeking to minimise the convergence time of the models. The following experiences are give guidance in this matter:-

- technologies involving power electronics (including DFIGs) will need a shorter time step to achieve robust operation;
- substantial effort would be required to produce models that are stable for longer time steps. These models would have to include integration with shorter time steps within the model, so slowing down the model and negating any anticipated speed advantages; and
- existing models on the Australian system require a time step of around 0.5mS, so there would be no way of taking advantage of faster models while these remain on the system. There are no plans to change these models in the foreseeable future.

“It is suggested that a practical and effective solution would be to add additional processors to applications that run these models.”

#### 6.8.2 NEMMCO’s consideration and decision

*NEMMCO* notes Roaring 40s’ comment. *NEMMCO* considers that there needs to be a minimum standard so that simulations remain practical for electro-mechanical mode (transient stability) simulation. *NEMMCO* already runs studies with time step sizes down to 1msec, and so considers the request reasonable. The requirement in the Model Guidelines will be adjusted.

### 6.9 Grandfathering of modelling standards

#### 6.9.1 Submissions

**Roaring 40s:** “It should be made clear that the new guidelines only apply to new generators connecting to the system, and that there is no requirement for existing generators to provide modelling in accordance with this guideline. Further, it is also needs to be made clear that changes to generating systems that result in a requirement to modify models must be made in accordance with the generating system model guidelines in force at the time of registration. This will ensure that the new guidelines will not act as a disincentive to ongoing improvement of existing models.

“To put this issue into perspective, construction and verification of a robust generation system model will typically cost in excess of $300k.”

#### 6.9.2 NEMMCO’s consideration and decision

*NEMMCO* is unable to comment on this. This is an issue associated with the *Rules* and is beyond the scope of this consultation.
6.10 Incomplete sections of the Generating System Model Guidelines

6.10.1 Submissions

Roaring 40s: “ISSUE: Sub-Synchronous Resonance Model Requirements, Harmonic Model Requirements …

“It is noted that the draft guideline is marked “to be completed” for these issues. It is anticipated that a completed draft will be fully developed through a complete, two stage consultation process.”

6.10.2 NEMMCO’s consideration and decision

Specific models are not required for these (see Sections 5.9 and 5.12), and there is only a requirement for information in the Data Sheets. The sections marked “To be completed” have been removed for these sections. This includes the accuracy requirements for the loadflow and short circuit data, which is generally S, D and R1 data.

6.11 Sub-transient Reactance for fault analysis

6.11.1 Submissions

Suzlon:

“6.1.2 Quasi-Steady State Behaviour

More specifically, the model must be able to faithfully represent the plant, including:

• for use in a load flow program, parameters suitable for calculating the RMS AC (symmetrical components) fault current information and equivalent X/R ratios, including:
  o the resistance (R) and sub-transient reactive impedance (X) components of each relevant plant item within the generating system, up to the connection point; and …”

[Excerpt from Section 6.1.2 “Quasi-Steady State Behaviour” of Section 6 “Load Flow and Short Circuit Model Requirements” from the draft Generating System Model Guidelines]

“The specification of sub-transient reactance for calculation of fault currents is not consistent with the level of detail indicated in the Data Sheets, item 6.1.1. Subtransient reactance is derived from the fault current values for the generator alone. We suggest the reference to subtransient reactance should be replaced by reference to the quantities included in the Data Sheets which are consistent with the approach of the quoted Standard AS 3851.”

6.11.2 NEMMCO’s consideration and decision

NEMMCO considers this to be a reasonable request and will adjust the Model Guideline in accordance with the information requested in the Data Sheets.

6.12 Inclusion of TSAT in the Model Guidelines

6.12.1 Submissions

Suzlon:

“7.1 Functional Requirements

• be capable of being implemented in standard power system stability software packages, such as Siemens Power Technology Incorporated’s PSS/E, or DiGSIENT’s Powerfactory;

[Excerpt from Section 7.1 “Functional Requirements” of Section 7 “Transient Stability Model Requirements and Oscillatory Stability Model Requirements” from the draft Generating System Model Guidelines]

“We believe TSTAT should have included in this list, as it had been referenced in the list of appropriate modelling software packages given at the start of section 5.1.2.”
CitiPower/Powercor: “The list of software in this section (refer top of page 11) should include TSAT for consistency with Section 5.1.2 (refer page 8).”

This comment refers to:

“Information to be provided with the transient stability, medium term stability and long-term stability models must include:

- model source code. The source code must be unencrypted for at least one of the following software simulation products, to allow NEMMCO to convert the model for use with other software packages. Suitable software packages are:
  - PSS/E (a product of Siemens PTI (Power Technologies International)) in the form of FLECS code (preferred);
  - Powerfactory (a product of DIgSILENT GmbH) in unencrypted layered model block diagram format; or
  - TSAT (a product of Powertech Labs Inc.) in User Defined Model form (the source code of any dynamically linked blocks (DLB) must also be provided).”

[Excerpt from Page 8 of the draft Generating System Model Guidelines]

6.12.2 NEMMCO’s consideration and decision

NEMMCO considers this to be a reasonable request and will adjust the Model Guideline in accordance with the information requested in the Data Sheets.

6.13 Inclusion of wind strength as an input to a wind turbine model

6.13.1 Submissions

Suzlon:

“We assume by inclusion of the word “may”, NEMMCO accepts it is also appropriate to use more detailed representation of the ‘power source’ as input into the model. An obvious example being to input wind data actually measured during the testing event. This shall be an important factor in achieving acceptable agreement between simulation and measurement, particularly in the realm of longer time study periods.

“NEMMCO have stipulated that the transient model be appropriate for periods of up to 30 seconds. When considering that during this period the power source of a wind turbine and wind farm can undergo large variation in the form of wind gusting, ramping and direction changes, appropriate representation of this parameter within the modelling becomes paramount. This poses a significant challenge to achieving validation of models, and needs to be considered appropriately based on the specifics of a generating system, test setups and test results.”

6.13.2 NEMMCO’s consideration and decision

The inclusion of a wind input for the model is at the option of the person developing the model. NEMMCO encourages this if it assists in improving model accuracy in the presence of wind variations.

The issue of including wind variations in a study was commented on in Section 5.20.2 (with reference to a submission made by CitiPower/Powercor).

NEMMCO sees no need to adjust the Data Sheets or Model Guidelines as a result of this issue.
6.14 Final settling value of the model after a disturbance

6.14.1 Submissions

Suzlon:

"8. Taking into account the level at which voltage settles at the connection point, the final voltage value of the plant within the generating system at which the model settles is within the more restrictive of:

- the final value at which the actual plant output would settle ±0.5% of the nominal voltage at that point; or
- the final value at which the generating unit would settle ±10% of the total change in the voltage during the transient period during and following the disturbance."

[Excerpt from Section 7.2 “Accuracy Requirements” of Section 7 “Transient Stability Model Requirements and Oscillatory Stability Model Requirements” from the draft Generating System Model Guidelines.]

“The term ‘final value’ is an applicable concept for traditional generation such as steam or hydro generators, however it creates difficulties for wind where the power source may have varied over the course of the event. The concept of “final value” is only meaningful in system with no time varying quantities, which settles after a disturbance. Wind power plants do not fall into this category: they are powered by wind-speeds which vary continuously and randomly. Thus their outputs will never settle on a single value.

“We believe the validation requirements do not account for this aspect.”

6.14.2 NEMMCO’s consideration and decision

While the accuracy requirement referenced will be deleted, the issue is also applicable to item 7 of Section 7.2 of the Model Guidelines, which remains. NEMMCO considers this is a reasonable comment and will adjust the Model Guidelines to include an allowance to take supply source variations into account.

6.15 Final settling value in medium and long term studies

6.15.1 Submissions

Suzlon:

"8.1 Functional Requirements

- have a bandwidth of at least 0.001Hz to 1Hz (for that part of the response that is linear) and settle to the correct final value for the applicable power system conditions and applied disturbance(s)."

[Excerpt from Section 8.1 “Functional Requirements” of Section 8 “Medium Term Dynamic Model Requirements” from the draft Generating System Model Guidelines]

“The interpretation of ‘final value’ needs to be better developed in the scope of drifting system conditions over the medium term duration defined.”

6.15.2 NEMMCO’s consideration and decision

The requirement for medium and long term models has been removed from the Model Guidelines (see Section 6.3).

6.16 Accuracy requirements in medium and long term studies

6.16.1 Submissions

Suzlon:

"8.2 Accuracy Requirements

To Be Completed. "

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"In the case of wind farms, accuracy requirements will need to account for the variability of wind across the time frame being considered in the Medium Term analysis. Aspects previously detailed in this submission stemming from the variability of the power source are significantly increased in the scope of 10 minute modelling."

6.16.2 NEMMCO's consideration and decision

The requirement for medium and long term models has been removed from the Model Guidelines (see Section 6.3).

6.17 Provision of an alternative model

6.17.1 Submissions


"Clause 7.1, as it currently stands, proposes that the transient stability model and associated parameter values must be in a functional block diagram format. In showing 'functionality', the model is expected to bear some resemblance to the physical design of the plant and controllers. Moreover, the transfer function blocks and model parameters are required to be recognisable in terms of the physical design of the plant and actual control system settings.

"In order to achieve this requirement, the wind turbine manufacturer is required to reveal the mathematical numerical models which, as stated above, are highly confidential in nature. Vestas appreciates that NEMMCO needs to gain an understanding of how the model represents the design of the components and the plant, however, this information can still be provided in an alternative form that will, on the one hand, ensure NEMMCO gains an understanding of how the model represents the design, and on the other hand, the information will not, in itself, reveal the confidential information a wind turbine manufacturer is otherwise concerned will be revealed to a competitor.

"The information that Vestas submits ought to be adequate in achieving this goal includes provision of:

(a) a simplified model (which has the same accuracy, as referred to in paragraph 7, page 9 of the ‘Wind Farm Model Guidelines Checklist: Version 1.0’);

(b) a derivation report; and

(c) a functional block diagram.

"In summary, therefore, as the Rules presently stand, Generators have the opportunity to provide alternative models to NEMMCO. This is advantageous to wind manufacturers as they are able to provide alternative information that, on the one hand, will satisfy NEMMCO's requirements in demonstrating the viability of the plant and components in question, and on the other, give comfort to the manufacturers that their confidential information is not being disclosed as the 'alternative' information provided does not contain their design/technological secrets that has taken manufacturers many years to develop. This option should be maintained in the Rules and not be deleted."

6.17.2 NEMMCO consideration and decision

A Generator or connection applicant may request to provide an alternative model, as suggested by Vestas, through Rule S5.2.4(c)(2). Such a model:

- applies only to the information provided under Rule S5.2.4(b);
- does not conform with the Model Guidelines; and
- must be agreed with NEMMCO.

Vestas recommends the type of information that could accompany an application for an alternative model. NEMMCO would consider this when reviewing an application made under Rule
S5.2.4(c)(2). It is not clear the extent to which a particular alternative model might conceal confidential information, or how this might be done. It is also not clear how detailed the derivation report referred to by Vestas would be, or the extent it would need to reveal that confidential information in order to show how the model was derived.

The provision of such an alternative model is under a process that is separate from the Model Guidelines. Also, NEMMCO cannot know the form of the models that might be presented to it, or what issues may arise when assessing an alternative model. Therefore, NEMMCO prefers to:

- deal with an application to provide an alternative model on a case-by-case basis; and
- not put specific requirements for such a model in the Model Guidelines.

Alternatively, should a Generator or connection applicant wish to make a variation request under the Model Guidelines, then section 5 of the Model Guidelines contains a description of the information that must be provided and the issues that the NSP and NEMMCO must consider in assessing the request.

It should be noted that the allowance for variations described in:

- the Model Guidelines is for an inability of a model to meet technical requirements, such as the accuracy requirements; and
- the Data Sheets is for situations where a Data Sheet may not adequately describe a particular technology.

Given the intended purpose of a variation request for the Model Guidelines, NEMMCO considers that the process described in the Model Guidelines forms a reasonable basis for its assessment and a change to the Model Guidelines in this regard is not justified. Should an application relate to variations that fundamentally change the nature of the model or the Model Guideline requirements, then the application should be made under S5.2.4(c)(2).

The provision of an alternative model of the type described by Vestas, or one that is provided for some other reason, raises issues associated with the data that ought to be provided in the Data Sheets. The allowance for a variation in the Data Sheets was intended to cater for deficiencies in the Data Sheets, rather than, for example, for a Generator or connection applicant to conceal confidential information. However, in accepting an alternative model, NEMMCO recognises that there may also be consequent requirements for variations to the Data Sheets. Once again, as the form of an alternative model and the reasons for which it may be offered cannot be known by NEMMCO until an application is made, similar issues arise for variation requests for the Data Sheets.

Due to the uncertainties associated with alternative models applied for under Rule S5.2.4(c)(2), rather than provide specific requirements for variation requests in the Data Sheets:

- the Data Sheets have been adjusted to recognise that variations may come out of the approval for an alternative model; and
- the Data Sheet variations must be agreed as part of that approval.

6.18 R2 testing of parameters

6.18.1 Submissions

Vestas: "2. R2 Testing of Parameters

"We understand the rationale behind R2 testing is to demonstrate that the model provided by the Connection Applicant at or about the time of being granted an application and entering into a Connection Agreement reflects the performance of the actual wind farm after its completion. In light of the fact that there are some parameters that are required to be tested at the R2 stage are not detailed in the model, we are concerned that NEMMCO will require an update of the model to reflect the results of all the R2 tests and that this cannot
be achieved. This is primarily because not all parameters that are tested at R2 stage are relevant to the transient model validation. Therefore it should be made clear that the only parameters that should have a relevance to the development of the model are the ones that should be amended.”

6.18.2 NEMMCO consideration and decision

Schedule 5.5 of the Rules specifies ‘R2’ data as “after connection, data derived from on-system testing (R2)” – this derives the settings of control and protection systems and parameters of other plant, as installed.

The information described in the Data Sheets describes the model that NEMMCO expects to be provided by a Generator or Connection Applicant, in terms of the level of detail necessary over various stages of design and development. For most technologies, it is expected that the model required to be provided under Rule S5.2.4(b) reflects the level of detail and parameters in the Data Sheets. The ‘S’, ‘D’, ‘R1’ and ‘R2’ classifications (as described in Schedule 5.5 of the Rules) describe the timing when certain information is expected to be available. Information with multiple classifications is expected to be updated at the appropriate times.

It is recognised that at the time of an application to connect (‘D’ data), in some cases, a plant’s model might not be fully developed due to a lack of detailed design information. As the detailed design and testing is carried out, it is expected that the model would be improved and model parameters updated (‘R1’ data), prior to connection. At that time, it is expected that the model should be fully developed to the level of detail expected in the Data Sheets. The parameters based on factory tests and detailed design are expected to be sufficiently accurate to allow to connect safely. Once the plant is installed, parameters classified as ‘R2’ are derived by on-site tests, to provide a final confirmation.

It is expected that all of the parameters required in the Data Sheets are included in the model and, in particular, the ‘R2’ parameters. Where there is a technical reason why plant cannot be represented by the relevant Data Sheets, the Generator or Connection Applicant can apply to the NSP and NEMMCO for appropriate modifications. NEMMCO expects that the alternative information to be of an equivalent level of detail as is required for other technologies.

At this stage, NEMMCO does not see a need for modification to the Data Sheets or Model Guidelines on the basis of this issue.

6.19 Repetition of tests

6.19.1 Submissions

Vestas: “3. Repetition of Tests

“We are concerned NEMMCO will insist on some tests being carried out twice, notwithstanding that a particular component in question has already passed the first test. Some components, for instance, generators, are tested in the factory. A certificate is produced by the manufacturer to confirm that the generator has satisfied particular testing requirements. If the tests that the manufacturer conducts on its equipment fall within the R2 test requirement, NEMMCO should not insist on the same test being conducted at site, as this will result in an unnecessary waste of resources.”

6.19.2 NEMMCO consideration and decision

The parameters that are classified as ‘R2’ are required to be determined by test after connection. The purpose of the tests is to ensure that the models match the plant, as delivered. In general, those parameters that are classified as ‘R2’:

- are considered to be significant in terms for the modelling of the plant;
- they can be tested; and
• in the case of control systems, they are for plant that may have settings that can be adjusted.

Vestas has commented on components such as asynchronous machines. Alstom made similar comments on the testing of synchronous machines, which has been addressed in section 5.13.2. NEMMCO commented on page 27 that NSP experience with tests on synchronous machines suggested that matching test responses to the software products (e.g. Siemens Power Technology Incorporated’s PSS/E) often resulted in closer matches than applying manufacturers’ parameters. NEMMCO has insufficient practical evidence that this is not the case also for asynchronous machine parameters and models. Until some practical experience can show that accurate responses can be obtained using manufacturers’ parameters for asynchronous machines, NEMMCO prefers to retain the ‘R2’ requirement for all machine parameters – synchronous and asynchronous.

While testing is still required, the possibility of “type-testing”14 may reduce the impact of this requirement. NEMMCO’s comments on page 27 regarding type-testing were not reflected in the draft Data Sheets published with the Draft Determination and Report. Retaining the ‘R2’ requirement, unqualified, in the Data Sheets may still imply that each generating unit must be tested. A general statement has been added to the Data Sheets to reflect NEMMCO’s position on type-testing.

6.20 Combined models

6.20.1 Submissions

Vestas: “To foster confidence in fault ride through solutions of manufacturers of wind turbines, and combined wind turbine and dynamic volt ampere reactive units, detailed mathematical numerical models are obligatory. An organisation separate from the wind turbine manufacturer and the owner of the wind farm may be able to unite mathematically the mathematical numerical models of a single wind turbine (supplied by the manufacturer of the wind turbine), and the mathematical numerical model of the DVAR units (distributed by the manufacturer of the DVAR units). After that, this new site specific mathematical numerical model may be passed on to NEMMCO.”

6.20.2 NEMMCO consideration and decision

NEMMCO’s requirement is for models to resemble the physical design of the plant and controllers. The combination of plant into a single model may be problematic, particularly operationally, when plant items can be operated independently – e.g. in the example above, where reactive power support plant is installed, such as a DVAR15. Having such a model, it becomes unclear how the model is to be adjusted when the plant is out of service, there are unusual switching arrangements within the generating system (e.g. where buses can be split), where plant can be operated in different control modes, or where NEMMCO is advised when the plant or a particular control setting has been changed. In this last case, this also avoids NEMMCO or the NSP requiring re-validation of the entire combined model when a small part of the plant has been changed.

Therefore, NEMMCO requires each plant item to be modelled explicitly. At this stage, NEMMCO does not see a need for modification to the Data Sheets or Model Guidelines on the basis of this issue.

14 That is, a test carried out on a single unit as representative of the performance of all identical units.
15 This is American Superconductor’s device name for a voltage source converter dynamic reactive power support device.
6.21 Validation Tests

6.21.1 Submissions

Vestas: “In relation to validation testing, a representative from NEMMCO made a presentation at the Auswind 2007 conference. In the presentation it was stated (in slide no. 19) that “for validation tests: (i) there are no established methods in the National Electricity Market; (ii) some features (e.g. fault ride through) cannot be derived from a test without application of a fault”. With the introduction of the proposed Generating System Model Guidelines and the subsequent replacement of the validation guideline document issued by NEMMCO in March 2006, it is presumed that wind farm owners will require to develop their own procedure for “validation” which may provide for varied methodologies and potentially misinterpretation of quality and level of testing. It may be prudent that some guidelines be provided for validation purposes.

“It should also be noted that in the development of models, to accurately represent the performance of wind turbines, that certain elements of the components may have varying degrees of importance in relation to the overall performance of the model and certain or all conditions when referring the generating units terminals or generating system terminals. In light of this it may not be appropriate to undertake all the necessary testing to confirm component parameters as part of the R2 validation testing when such parameters do not play any or little impact on the model performance.”

6.21.2 NEMMCO consideration and decision

At this stage, NEMMCO is not considering developing guidelines that describe recommended tests. The obligation for testing, and developing specific tests and test procedures that are required to confirm models and derive ‘R2’ parameters from test, is on the Generator, probably in consultation with the manufacturer. NEMMCO is not provided sufficient information on plant design, operation and test points within a plant to be able to make informed decisions on procedures that could be adopted.

Should an industry body, such as the Clean Energy Council, National Generator Forum or other similar body, wish to develop such guidelines, NEMMCO would support the initiative by providing technical and operational advice.
7 Issues raised by NEMMCO

7.1 The list of generating units to which information applies

Alstom’s submission (see 5.13.1) has also brought to NEMMCO’s attention an issue with the Data Sheets regarding instances where they require information only during the early design stages (S and D stages of data provision), but which might change at the detailed design stage (R1) or after commissioning (R2). This applies, for example, to information regarding “the list of generating units to which this information applies”. An example from Section 8.1 of the draft Data Sheets is shown below:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Data Description</th>
<th>Units</th>
<th>Data Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>If this is a generating unit transformer, the list of generating units to which this information applies.</td>
<td>Text</td>
<td>S, D</td>
</tr>
</tbody>
</table>

This particular table entry was added to the Data Sheets to avoid the need for multiple Data Sheets being provided for a generating system with many identical generating units. This is particularly true of wind farms, and this particular table entry appears throughout the Data Sheets. As the issue that designs or data might change at any phase of a generating system’s development, the need to update this information applies whenever information is requested for that Data Sheet. In order to rectify this, for each occurrence of “the list of generating units to which this information applies”, NEMMCO has specified this to be required for each of the phases S, D, R1 and R2.

For example, the table entry above was changed to the following, with the relevant change circled (the addition of “R1, R2”):

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Data Description</th>
<th>Units</th>
<th>Data Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>If this is a generating unit transformer, the list of generating units to which this information applies.</td>
<td>Text</td>
<td>S, D (R1, R2)</td>
</tr>
</tbody>
</table>
7.2 Synchronous machine impedances

In reviewing the synchronous machine data in Section 9.1.1 of the Data Sheets, NEMMCO noticed that the synchronous machine reactances did not specify whether they ought to be saturated or unsaturated reactances. NEMMCO has adjusted the entries to require unsaturated reactances to be provided.

7.3 Asynchronous machine Torque/Speed and equivalent circuit information

It is normally the case that asynchronous generator equivalent circuit information is normally provided when impedance data is given. The requirement to provide equivalent circuit information has been added to Sections 9.2.1, 9.3.1 and 9.4.1 of the Data Sheets.

Sections 9.2.1 and 9.3.1 of the Data Sheets have also been adjusted to request Speed (slip) versus torque (power) curves.

Both of these changes have been added to clarify the values that are supplied in the Data Sheet so that all parties are working on the same assumptions, in the absence of a widely accepted standard.

7.4 Missing timing classifications

In reviewing the Data Sheets, several entries did not have timing classifications (i.e. S, D, R1 and R2). Classifications have been added for:

- RL and XL (Line Drop Compensation or reactive power droop settings) in Section 8.1.2 of the Data Sheets. Classifications D and R1 have been added.
- Active power operating range of the generating unit when the PSS is in operation in Section 10.1.2 of the Data Sheets. Classifications D and R1 have been added.

7.5 Specifying Software Product Versions

The Model Guidelines currently list particular power system simulation software products that are suitable to NEMMCO for the provision of unencrypted model source code information, required to be provided by a Generator under Rule S5.2.4(b)(6).

As software versions change regularly, and these may be relevant to the provision of the source code information, NEMMCO prefers not to include this software list in the Model Guidelines. A recent request for the version number of the software used by NEMMCO has highlighted this issue. This avoids the need for an update to the Model Guidelines, either under Rule S5.5.7(d) as a minor or administrative change or following a consultation under the Rules each time the software version changes.

NEMMCO will put the list on its website and a reference to the address in the Model Guidelines.

7.6 Clarification of relationship between Data Sheets and Model Guidelines

The term ‘model’ is used in a number of ways and there can be some confusion in relation to what is meant at different times. Information required for the modelling of power system plant for load flow and dynamic stability assessments of the power system is required in a number of forms and it is expected that the model information is consistent. For example, NEMMCO expects that there is consistency between:

- parameter values required by the Data Sheets;
- functional block diagram information required by the Data Sheets;
• functional block diagram information, required to be provided under Rule S5.2.4(b)(5); and
• model source code information, required to be provided under Rule S5.2.4(b)(6).

The Model Guidelines have been adjusted to reflect NEMMCO’s requirements in relation to this consistency (see section 5 of the Model Guidelines).
8 Determination

NEMMCO determines the Data Sheets and Model Guidelines in the form contained in:

- **Schedule A**: in the case of the *Generating System Design Data Sheets and Generating System Setting Data Sheets*.
- **Schedule B**: in the case of the *Generating System Model Guidelines*. 
9 References


Schedules

- **Schedule A**: *Generating System Design Data Sheets and Generating System Setting Data Sheets*, 29 February 2008. This is a separate attachment available on the NEMMCO website.

- **Schedule B**: *Generating System Model Guidelines*, 29 February 2008. This is a separate attachment available on the NEMMCO website.