R1 Capability Assessment Guideline

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Approved for consultation by:

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Current version release details

Version	Effective date	Summary of changes
1	16 April 2025	Draft for consultation.

1. Introduction

In June 2024, the Australian Energy Market Commission (AEMC) published a rule on "Enhancing investment certainty in the R1 process". This "R1 Capability Assessment Guideline" (Guideline) describes the process for the *capability assessment*. The *capability assessment* is AEMO's assessment of the capability of a *generating system* (GS) or *integrated resource system* (IRS) to meet or exceed its *performance standards*, to be eligible to register as a *Generator* or *Integrated Resource Provider* (IRP) in the *National Electricity Market* (NEM). The *capability assessment* is undertaken in consultation with the *Network Service Provider* (NSP) in the period following the execution of the *connection agreement* and prior to registration. The term "R1" is colloquially used to describe this period[1].

The approach of the *capability assessment* to determine whether a *Generator* or IRP will be capable of meeting or exceeding its *performance standards*, is intended to give effect to the following principles:

- The connections process is consistent, predictable and improves investment certainty.
- The connections process is time-efficient and reduces costs, without compromising *power system security* and operability.
- The assessment requirements are pragmatic and fit for purpose.
- There is a collaborative approach between *Connection Applicant*, the NSP and AEMO.
- There is a collective commitment to problem-solving to facilitate outcomes.

The Guideline expands on aspects of the *capability assessment* approach, incorporating these principles.

1.1. Purpose and scope

The Guideline has been made under clause 2.1.3 of the National Electricity Rules (NER) and is to be used for the *capability assessment* in NER 5.3.7A. It is applied only for the purposes set out in the NER. The NER and the National Electricity Law (NEL) prevail over the Guideline to the extent of any inconsistency.

The Guideline covers the process for the *capability assessment*, including the following matters, as specified in NER 2.1.3(b)(6):

I. the data and information that the *Connection Applicant* must provide to AEMO and the NSP under NER 5.3.7A(c), being data and information:

   A. required under the NER (including schedule 5.2, 5.3 or 5.3a);

   B. in connection with the *performance standards*; or

   C. otherwise required for AEMO to assess whether the GS, IRS or *performance standards* have an adverse effect on *power system security* or the quality of supply for other *Network Users*;

[1] The term "R1" is from the data category for pre-connection registered data described in NER S5.5.2.

II. examples of the circumstances in which AEMO or the NSP may request additional data and information from the *Connection Applicant* under NER 5.3.7A(f), and if that request is made, examples of data and information the *Connection Applicant* may provide in response under NER 5.3.7A(h)(2) to satisfy AEMO and NSP;

III. How AEMO may assess, and the matters AEMO may consider in assessing:

A. the data and information provided by the *Connection Applicant* under NER 5.3.7A(c) or NER 5.3.7A(h)(2); and

B. whether the *generating system*, *integrated resource system* or *performance standards* has an adverse effect on *power system security* or the quality of *supply* for other *Network Users*, with reference to the relevant *access standards*; and

IV. any other matters AEMO considers relevant in describing the process for the *capability assessment*.

The Guideline also covers the circumstances under which AEMO will agree to terms and conditions in relation to registration, and the nature of those terms and conditions.

1.2. Definitions and interpretation

1.2.1. Glossary

Terms defined in the NEL and the NER have the same meanings in the Guideline unless otherwise specified in this Section 1.2.1. Terms defined in the NER are intended to be identified in the Guideline by italicising them, but failure to italicise a defined term does not affect its meaning.

In addition, the words, phrases, and abbreviations in the table below have the meanings set out opposite them when used in the Guideline.

Term	Definition
AAS	*Automatic access standard*
AEMC	Australian Energy Market Commission
AGC	Automatic generation control
AVR	Automatic voltage regulator
BESS	Battery energy storage system
Connection Applicant	A Connection Applicant seeking to register as a Generator or *Integrated Resource Provider*
CT	Current transformer
CUO	*Continuous uninterrupted operation*
ECM	*Energy conversion model*
EMS	Energy management system
FAT	Factory acceptance testing
FCAS	*Frequency control ancillary services*
FRT	Fault ride-through
GS	*Generating system*
IBR	Inverter-based resource
IRP	*Integrated Resource Provider*
IRS	*Integrated resource system*

Term	Definition
MAS	*Minimum access standard*
MFRT	Multiple fault ride-through
NEL	National Electricity Law
NEM	National Electricity Market
NEO	*National Electricity Objective*
NER	National Electricity Rules
NOFB	*Normal operating frequency band*
NOFEB	*Normal operating frequency excursion band*
NSP	*Network Service Provider*
OEM	Original equipment manufacturer
PFR	*Primary frequency response*
POD	Power oscillation damper
PPC	Power plant controller
PSCAD™/EMTDC™	Power Systems Computer Aided Design / Electromagnetic Transient with Direct Current
PSDS	Power system data sheets, refers to the *Power System Design Data Sheet* and the *Power System Setting Data Sheet*, referred to in S5.5.7
PSMG	*Power system modelling guideline*
PSS	Power system stabiliser
PSS®E	Power System Simulator for Engineering
PQM	Power quality meter
RoCoF	Rate of change of *frequency*
RUG	*Releasable user guide*
R1 data	Registered data (pre-connection) as described in NER S5.5.2.
SAT	Site acceptance testing
SCADA	Supervisory control and data acquisition
SSIAG	*System strength impact assessment guideline* published in accordance with NER 4.6.6
SLD	Single line diagram
SRAS	*System restart ancillary service*
S5.2.X.X	The performance standard applicable to the generating system or integrated resource system in question – "S5.2.5.X" refers to the clause in Schedule 5.2 of the NER from which the applicable performance standard is drawn
THD	Total harmonic distortion
UPS	Uninterruptible power supply
VCS	Voltage Control Strategy
VDS	Var Dispatch Scheduler
VT	Voltage transformer

1.3. Related documents

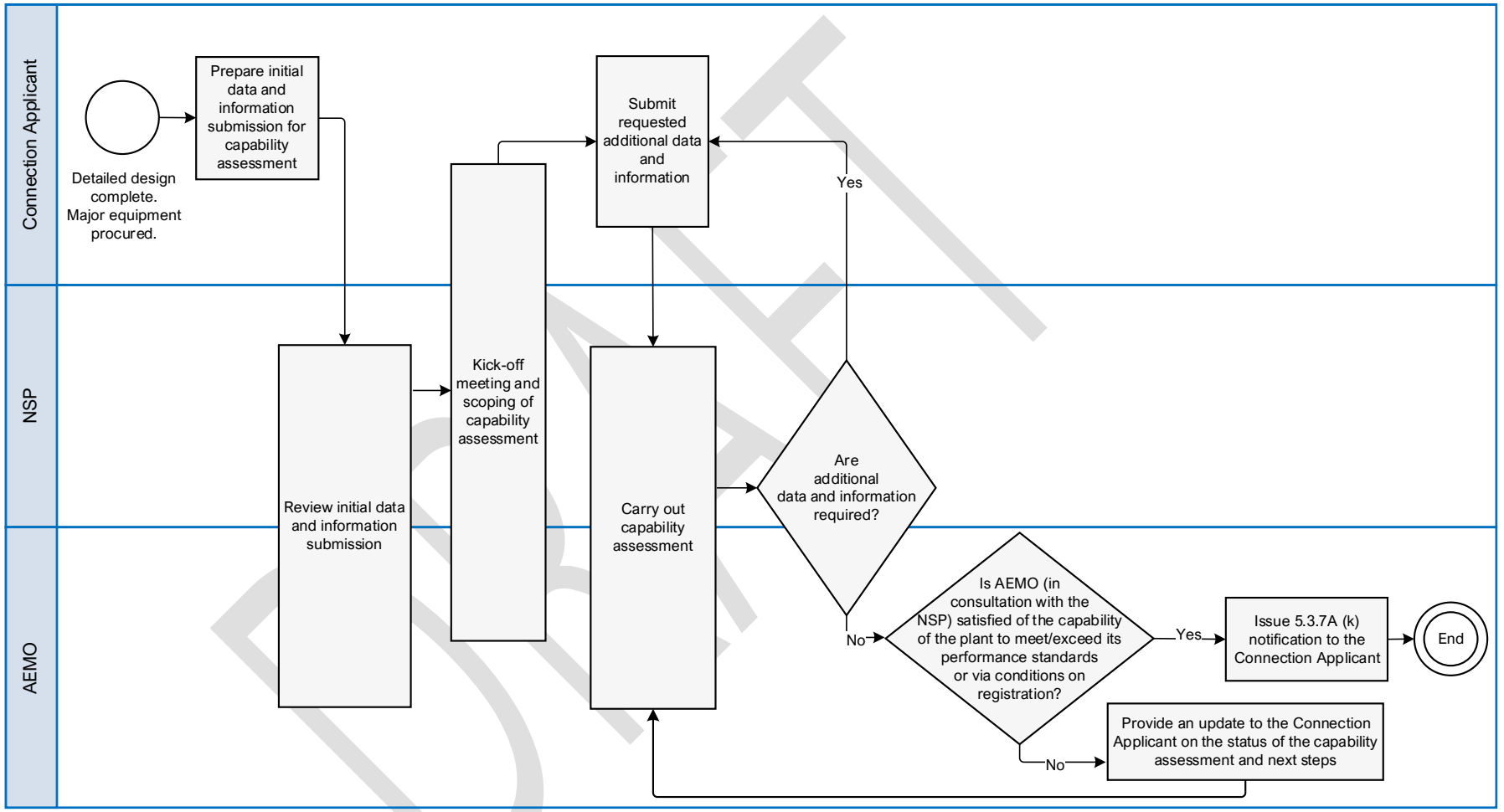
Title	Location
AEMO Market Registration Page	https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/registration

Title	Location
AEMO Modelling Requirements	https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/network-connections/modelling-requirements
AEMO Network Connections Page	https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/network-connections
Commissioning requirements	https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/network-connections/transmission-and-distribution-in-the-nem/stage-6-completion
Communications systems failure guideline	https://aemo.com.au/-/media/files/electricity/nem/network_connections/stage-6/communication-system-failure-guideline.pdf?la=en
Energy Conversion Model (ECM) Guideline	https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/operational-forecasting/solar-and-wind-energy-forecasting
Guideline for preparing Local Black System Procedures	https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/power-system-operation
Guide to VAR Dispatch	https://aemo.com.au/-/media/files/electricity/nem/it-systems-and-change/2016/guide-to-var-dispatch.pdf?la=en
NER 5.3.9 Process Guideline	Link to come at a later date (currently under review)
Power System Model Guideline	https://aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/System-Security-Market-Frameworks-Review/2018/Power_Systems_Model_Guideline_PUBLISHED.pdf
Power System Operating Procedures	Link to come at a later date (currently under review)
Primary frequency response (PFR) requirements	https://aemo.com.au/en/initiatives/major-programs/nem-reform-program/nem-reform-program-initiatives/primary-frequency-response

2. Capability assessment process

Figure 1 sets out the high-level process for the *capability assessment*. The following subsections describe the process in more detail.

Figure 1 R1 capability assessment process



2.1. Submission of data and information

The *Connection Applicant* initiates the *capability assessment* by submitting the Capability Assessment Request Form[2] with supporting information to AEMO and the NSP[3]. Section 3.1 outlines the supporting information to be included with this request.

AEMO strongly recommends that where large alterations are proposed compared with the original design, the *Connection Applicant* discusses them with AEMO and the relevant NSP as soon as possible and allows sufficient time for evaluation of affected *performance standards*[4].

AEMO will acknowledge receipt of the submission within five *business days* of receiving the request for *capability assessment* and advise of any missing information[5]. Within five *business days* of receiving all required information, AEMO will confirm commencement of the *capability assessment*[6].

2.2. Kick-off meeting and scoping of capability assessment

2.2.1. Kick-off meeting

AEMO recommends a kick-off meeting between all parties (*Connection Applicant*, NSP and AEMO), after the NSP and AEMO have reviewed the initial data and information. This meeting can be used to establish an effective project management framework to foster a collaborative working arrangement, including:

- Relevant contact details and responsibilities.
- Communication protocols.
- Project milestones and anticipated timing.
- A common repository for information and process for version control.
- Arrangements for follow-up or regular meetings to track project progress and efficiently address any issues or clarifications required as they arise.
- Agreeing the approach for resolving matters that arise during the assessment process.

This meeting can also be used to commence discussion on the scope of the capability assessment including:

- Any additional data and information required for the *capability assessment*.
- Assessment scope split between the NSP and AEMO to avoid duplication of work.
- Key assessment activities and associated timing.

[2] Link for the Capability Assessment Request Form (under consultation) https://aemo.com.au/consultations/current-and-closed-consultations/registration-information-resource-and-guidelines

[3] NER 5.3.7A(b) and NER 5.3.7A(c).

[4] See AEMO's NER 5.3.9 Guideline for more information about the process described for alterations to GS or IRS.

[5] NER 5.3.7A(d).

[6] NER 5.3.7A(e)(2).

The NSP and AEMO will work with the *Connection Applicant* to identify key activities and associated timing. Timelines are subject to change if new issues or impacted *performance standards* are discovered.

2.2.2. Scoping of capability assessment

The extent of evidence and level of detail of studies and supporting documentation required to complete the *capability assessment* will depend on various factors, such as:

- The capacity of the GS/IRS.
- The complexity of the GS/IRS (for example, IRSs that include multiple *generation* technologies or loads).
- The potential impact of the GS/IRS on the *power system*, considering its *connection point* location in the *power system*.
- Conditions in relation to technical capabilities included in the 5.3.4A letter[7].
- The nature and extent of changes from the design considered prior to execution of the *connection agreement*.
- Relevant external changes not considered prior to the execution of the *connection agreement*.

The following details from the NSP and AEMO may also inform the scope of assessment:

- External change details: any change to network or connections (that is, other *Generator* or IRP or *Customer* connections), which could affect the ability of the GS/IRS to meet its *performance standards*, and which was not considered previously as part of the *connection application* assessment. Examples might include newly committed *generation*, or disconnection of *generation*, or changed *network* conditions.
- Known model or performance issues: any specific known issues related to the models of the GS/IRS or its controls/protection and relevant *network* control schemes (such as a special protection scheme) that were not considered at the time of *connection application* assessment. Examples might include a performance issue found in an operational *plant* of the same type, or a discrepancy found between a plant's model and actual performance for the same type of *plant*.

Scoping will consider potential impact on *power system security* and quality of *supply* to other *Network Users*. For example, smaller *plants* in parts of the *power system* that have high system strength (low system impedance) will have less impact on the *power system*. Conversely, large *plants* can have more impact, especially in parts of the *network* that have low system strength (high system impedance). A larger potential impact will generally lead to more extensive assessment and information requirements.

Where large changes are proposed, compared with the initial design, the assessment of affected *performance standards* will be considered as part of the process under NER 5.3.9. See

[7] A letter issued by AEMO to the NSP formalising AEMO's agreement to access standards as a result of NER 5.3.4A negotiations.

Section 4.22 for more information on the principles that apply when there are alterations to a GS/IRS.

The NSP and AEMO may agree to split the scope of the *capability assessment* to reduce the duration of the assessment phase. The NSP and AEMO will agree on a methodology and share the results.

A *Connection Applicant* may elect not to seek a kick-off meeting and initial scoping discussion. In this case, the NSP and AEMO will carry out the scoping of the *capability assessment* and advise the *Connection Applicant* of any additional information they are required to provide to finalise the *capability assessment*.

2.3. Additional data and information required to finalise the assessment

As an outcome of the scoping phase, AEMO (and the NSP as relevant) will advise the *Connection Applicant* in writing of any additional data and information they require to progress and finalise the *capability assessment*[8]. See Section 3.2 for more detail of the additional data and information that may be required.

2.4. Finalisation of the capability assessment

If the *capability assessment* is not complete within 60 days of the commencement date, AEMO will provide a status update, including a record of any outstanding information and next steps[9]. This would be a formal update, in addition to any regular project updates in project progress meetings.

If satisfied that the GS/IRS will meet or exceed its *performance standards*, within five *business days* of completing the *capability assessment*, AEMO will:

- Issue a notice to this effect to the *Connection Applicant*[10].
- Subject to the terms and conditions agreed with the *Connection Applicant*[11] (as outlined in Section 5 of this Guideline), issue a notice to the *Connection Applicant* with the agreed terms and conditions.

[8] NER 5.3.7A (f).

[9] NER 5.3.7A(j)(3).

[10] NER 5.3.7A(j)(1).

[11] NER 5.3.7A(j)(2).

3. Data and information requirements for capability assessment

The data and information requirements under this Guideline are divided into two main parts:

1. The initial data and information required to commence the *capability assessment*, which will be used to scope the *capability assessment*.
2. As an output of scoping, AEMO and the NSP may request additional information and evidence, including studies, to complete the *capability assessment*.

AEMO or the NSP may also request further data and information on matters arising from their review of the information and studies listed above and will provide written reasons with reference to relevant requirements[12].

3.1. Data and information submission

The initial data and information requirements focus on changes since the execution of the *connection agreement* and are used to scope any additional information and assessments required. This includes:

- Changes to address any conditions in a letter issued under NER 5.3.4A.
- Alterations to *plant*, compared with what was previously considered.
- The updated *plant* models incorporating the R1 pre-*connection* data (as described in NER S5.5.2) and supporting documentation, along with a description of the changes to *plant* models or settings that have been incorporated and any anticipated changes that are yet to be incorporated in the models or settings. See further information in Section 3.1.1.
- Any issues with the Original Equipment Manufacturer (OEM) models or *plant* control schemes that the *Connection Applicant* is aware of, which were not previously considered.

The initial data and information required to commence the scoping assessment is listed in Appendix A.

3.1.1. Incorporation of R1 data in simulations for the capability assessment

AEMO and the NSPs have some flexibility about what type of data they require for the *capability assessment*, as described in this Guideline[13]. By default, the requirement is for models of the GS/IRS to be based on *plant* data derived from manufacturers' data, detailed design calculations, works or site tests (described as Registered Data (R1 pre-connection)[14]).

However, AEMO recognises that OEM test data (from factory acceptance testing (FAT)) is often not available until close to commissioning, particularly in the case of wind turbines. For example, in some cases, where wind farm construction and commissioning are staged, manufacturing of later turbines may not be completed by the time the earlier constructed ones are ready to be

[12] NER 5.3.7A (f) and NER 5.3.7A (g).

[13] And permitted by NER 5.3.7A(c)(1).

[14] In NER S5.5.2 and denoted by the data category "R1" in NER S5.5.

commissioned. In such circumstances it is impractical to incorporate FAT data into the models *for capability assessment*.

The *capability assessment* should use the best information available to model the *plant*, as this will give the best accuracy for assessment of compliance with *performance standards*. All relevant, known changes since execution of the *connection agreement* should be incorporated into the model used for the *capability assessment*. For example, detailed design calculations and manufacturer's type test data should be used for the *capability assessment* process, in the absence of FAT data. See Section 4.1 for the approach when it is not practicable to incorporate all R1 data into the models used for the *capability assessment*.

3.2. Additional information to finalise the capability assessment

Additional information and assessments may be required to complete the *capability assessment*. Appendix B lists the types of information that may be required, and broadly describes the purpose of the information that may be requested.

Any required additional information will be identified as an outcome of the scoping stage (as outlined in Section 2.2.2 of this Guideline), and may not include all the information listed in Appendix B.

AEMO and the NSP (as relevant) will provide additional detail for connection-specific information requests, for example, specific concerns AEMO and the NSP may have with reference to the relevant parts of the *performance standards*, or *power system* impacts, which give rise to those concerns[15]. As the *capability assessment* is carried out, depending on the findings of the assessment, AEMO and/or the NSP may request further clarifications and/or data and information. *Connection Applicants* may also request additional clarification of information requests[16].

3.2.1. Simulations to support the capability assessment

Simulation studies may be required to examine:

- Aspects of performance that have not been previously reviewed.
- Model changes where the impact of the change on *performance standard* compliance or the impact on the *power system* is not clear.

Spot checks, for larger *plant* or *plant* in sensitive locations, may be required to confirm that there is no adverse impact, even where no adverse impact is expected.

More extensive studies may be required to investigate the extent or impact of non-compliances, or where significant changes have been made (for example, to controller models or settings) since the *connection agreement* was made.

For example, a model might have been updated to resolve an issue in a voltage controller response, with no expected changes to the *active power* controls. Specific studies may be

[15] Other types of information are required ahead of registration, which are outside of the capability assessment. AEMO strongly recommends that Connection Applicants familiarise themselves with other registration requirements listed in the 'Related documents' section of this guideline.

[16] NER 5.3.7A (h).

required to confirm the changes address the previous issue and confirm *performance standard* compliance relevant to the voltage controller, and spot checks might be required to confirm *active power* controls are unaffected.

More extensive studies may also be required to investigate OEM model issues that have been observed elsewhere, and which might also arise in the connection under consideration.

In some cases, external changes might have been identified during the scoping phase which require studies to confirm that the *plant*'s compliance with its *performance standards* is unaffected.

Where there are significant changes to models or the plant design[17] (for example, changes in the number of inverters, OEM, plant technology) that have potential to impact system strength, a Full Assessment or Stability Assessment (electromagnetic transient wide area studies) might need to be repeated in part or full.

4. Assessment approach

This section describes the assessment approach for the *capability assessment*, in accordance with principles outlined in Section 1.1.

4.1. Approach where R1 data has not been included in models used for the capability assessment

As indicated in Section 3.1.1, it is desirable to incorporate all R1 data into the models used for *capability assessment*, but it may not always be practical to do so. In cases where some R1 data (including OEM FAT data) is not available, *Connection Applicants* are encouraged to discuss alternative approaches with AEMO and the NSP during the scoping phase.

Where R1 data is not used for simulations supporting the *capability assessment*, AEMO and the NSP may require sensitivity analysis around uncertainty in modelling inputs to determine the likelihood of a non-compliance and the potential impact should a non-compliance occur.

In cases where studies indicate that the impact on *power system security* or quality of *supply* for other *Network Users* could be material, AEMO may require conditions on registration that apply until the *plant* performance has been demonstrated to be satisfactory[18] through commissioning tests. These may also need to be supplemented with some additional simulations, where the performance relates to matters that cannot be tested (for example, for fault ride-through for deep voltage disturbance.) The exact form of terms and conditions will need to be agreed between AEMO and the *Connection Applicant* and may include elements described in Section 5 of this Guideline.

Alternatively, AEMO (in consultation with the NSP) may agree to certain spot check simulations to be undertaken with R1 data, including OEM data, once that data becomes available ahead of registration, to confirm compliance.

[17] This would be considered as part of the process under NER 5.3.9.

[18] Compliance is the expected outcome. Where there is non-compliance, but it is not material, it may be possible to agree to a change in performance standard to achieve compliance. However, the Generator/IRP would bear the risk of material non-compliance needing to be addressed through other mechanisms, and of the plant output potentially being constrained.

For *plant* which has less potential to impact the *power system security* or quality of *supply*, use of type test data and detailed design information may be sufficient to demonstrate that the *plant* will meet or exceed its *performance standards*.

The risk of non-compliance resulting from small impedance changes because of manufacturing tolerances and small changes to cabling to account for site conditions may be mitigated by allowing for reasonable tolerances at the *connection application* phase. If allowances have been made in previously agreed *performance standards*, the *Connection Applicant* should inform AEMO and the NSP of them at the time of the request for *capability assessment*, so they can be taken into consideration for scoping the required additional data and information and studies.

4.2. Treatment of performance standards changes resulting from alterations

It is very common for there to be alterations to *plant* pre-registration, compared with the initial design for which the *performance standards* were previously accepted, although in many cases differences are minor, resulting from manufacturing tolerances or changes to accommodate site conditions. Plant alterations that trigger the application of NER 5.3.9[19], will generally be assessed as part of the *capability assessment*.

Where change to performance due to an alteration is small and does not result in non-compliance with existing *performance standards* (such as minor changes attributable to manufacturing tolerances or to accommodate site conditions), a *Connection Applicant's* proposal to retain the existing relevant *performance standard* would usually be acceptable, as it would be considered consistent with promoting efficient investment outcomes in the NEM. Simulation studies may be required to confirm compliance and the level of performance change.

For large alterations, only those *performance standards* impacted by the alteration would be renegotiated. A *Connection Applicant* is not required to renegotiate *performance standards* not affected by the alteration. Impacted *performance standards* will be re-negotiated in accordance with principles outlined in the NER 5.3.9 Process Guideline[20]. In particular, the benefits of requiring a *performance standard* closer to the *automatic access standard* (AAS) will be weighed against the costs of demonstrating and achieving this performance.

Where a significant improvement to performance is a consequence of the alteration or is the purpose of the alteration, this should be reflected in an updated *performance standard*. Performance standards are a key input into AEMO's understanding of the power system's technical operating envelope. It is important for operational purposes that the actual plant capability is reflected in the *performance standards*. *For* example, if a developer decides to increase the size of a solar farm by adding more inverters and solar panels, the additional *active* and *reactive power* capability would be captured in the NER S5.2.5.1 *performance standard*.

If new *plant* has been added (for example, addition of a battery energy storage system (BESS) to a *generating system*) it is not expected that the performance of the existing *plant* will need to be re-negotiated beyond capturing the impact of the new *plant*[21]. A *plant* with existing *performance*

[19] NER 5.3.9(a) contains a set of criteria which determines the application of NER 5.3.9 to an alteration.

[20] See Section 5 of the NER 5.3.9 Process Guideline.

[21] See Section 4.2 of the NER 5.3.9 Process Guideline.

standards is not required to be upgraded to achieve higher *performance standards* where the need to renegotiate the standard is only because of the new *plant* that has been added to the connection.

4.3. Assessing adverse impacts on power system security supply and quality of supply

Performance standards would have been established originally at levels that did not have an adverse impact on *power system security* or quality of *supply* to other *Network Users*. However, alterations to *plant*, particularly large changes, could change the *plant*'s performance to the extent that there could be an adverse impact on *power system security* or quality of *supply* to other *Network Users*, which is not allowed[22]. For this reason, the impact on *power system security* and quality of *supply* to other *Network Users* will need to be assessed in greater detail for larger changes compared with smaller ones.

Power system security

Power system security impacts may be assessed against the requirements in Chapter 4 of the NER for *power system security* and *satisfactory operating state*[23]. AEMO is required to operate the *power system* securely, such that it is in a satisfactory state, and in the event of a *credible contingency event* or *protected event*, returns to a satisfactory state after the event. Following a *contingency event*, AEMO must adjust the *power system* to return to a *secure operating state*, as soon as practicable, but within 30 minutes[24].

Satisfactory operating state[25] includes operating with:

- *Frequency* within *normal operating frequency band* (NOFB), except for brief excursions but within the *normal operating frequency excursion band* (NOFEB).
- Voltage magnitude within relevant limits[26].
- *Transmission* line loadings within ratings (accounting for emergency ratings).
- Other *plant* operating within relevant ratings (accounting for time dependency).
- Stable conditions.
- Network configuration such that circuit breakers can clear faults.

AEMO applies constraints to the operation of the *power system* reflecting stability and thermal network limits for *credible contingency events* or *protected events* and which, with other types of constraints, define a *technical envelope* for operation of the *power system*[27], within which system operation is secure.

[22] NER 5.3.4A(b) (2) and (3).

[23] NER 4.2.2, 4.2.4 and 4.2.6.

[24] NER 4.2.6 (b).

[25] See NER 4.2.2 and cross-referenced clauses for more detail.

[26] See S5.1.4 The limits depend on whether the connection point supply voltage meets AAS or a NAS.

[27] Which changes dynamically with power system conditions.

Broader principles for *power system security*[28] also include availability of *emergency frequency control schemes*, *system restart ancillary service* (SRAS), *inertia* and sufficient *three phase fault level* for system strength requirements.

A *plant's* performance has an adverse impact on *power system security* if it impedes AEMO's ability to maintain a *satisfactory operating state* and the secure operation of the *power system*. AEMO considers materiality when determining whether a plant has an adverse impact. Materiality is a term used to indicate the significance of a change. In this context it is considered in terms of the effect a plant's performance has on the operation of the *power system* for the various elements of *power system security*. For example, if the reactive power exported from a solar farm at night results in a 2% increase in voltage, this would be an adverse impact if it could prevent AEMO from operating a part of the *power system* below 110% of *normal voltage* or could prevent a *connection point* being operated within 5% of target voltage[29], otherwise it would not be considered an adverse impact on *power system security*. Appendix C provides further examples of adverse impacts on *power system security*.

Quality of supply

An adverse impact on quality of *supply* is indicated if the plant's quality of supply performance (including harmonic emissions, voltage disturbances (also known as flicker) or unbalance level) has changed to the extent that it is no longer suitable to connect (without changes) considering its impact to other Network Users.

The quality of supply at any *Network User*'s *connection point* is affected by contributions from all *plant* connected through the *network* to that point, with electrically closer *plant* tending to have a larger impact. The NSP manages quality of supply by making allocations for each *load*, GS or IRS, so that acceptable power quality is maintained across the *networ*k. The NSP targets a planning level at each location which includes the cumulative impacts from loads and *generation* of flicker and harmonics.

Quality of *supply* standards, unlike other *access standards*, reserve capability for future connections, through allocation of emission limits. An emission level above an allocation by itself is not likely to cause an adverse impact on other *Network Users.* However, there could be adverse impacts when combined impacts from all plant emissions cause the level of harmonics or flicker to exceed planning levels.

4.4. Treatment of non-compliances

Where a non-compliance is identified through the *capability assessment*, action will need to be taken to address the non-compliance. AEMO will work with the relevant NSP and the *Connection Applicant* to agree an efficient approach to achieve compliance.

AEMO or the NSP may request additional studies or evidence to establish the extent of the non-compliance and its impact on the *power system*.

[28] NER 4.2.6.

[29] Set in accordance with S5.1.4(c). There are some simplifications in this example. See Appendix C and the footnotes there for more detail on this requirement.

A non-compliance is material if the associated changed performance could change a decision about the *plant*'s suitability to connect to the *power system* considering its potential adverse impact on *power system security* or quality of *supply* to another *Network User*.

Where AEMO (in consultation with the NSP) assesses the non-compliance to have no adverse impact on the *power system security* or quality of *supply* to other *Network Users*, AEMO and the NSP may agree with the *Connection Applicant* to amend the *performance standard*[30] to achieve compliance, provided also that the performance is not less than the *minimum access standard* (MAS)[31].

For harmonics or flicker, where emissions are non-compliant (above the allocated emission limit) but less than planning levels, there may be some uncertainty around whether there is an adverse impact. This is because of the uncertainty around background contributions from other *plant*, and allowances for future *plant* that are inherent in the allocation of emission limits. In such circumstances, it may be acceptable to consider a condition on registration which requires verification of harmonics or flicker (as relevant) during commissioning, and rectification of any non-compliance. Depending on the outcome and whether the planning levels are exceeded, this might lead to a change in *performance standard*, a change to the *plant*, or a commercial arrangement between the GS/IRS and the NSP for rectification by the NSP.

Where the performance is below the MAS, or AEMO (in consultation with the NSP) assesses the non-compliance to have an adverse impact on *power system security* or quality of *supply*, a range of options may be considered to address the non-compliance. Options include (but are not limited to):

- *Control system or protection system* settings changes.
- Operational arrangements.
- Model changes.
- Firmware changes.
- *Plant* hardware changes.
- *Network* operational changes.
- *Network plant* changes.
- A combination of the changes listed above.

The agreed change must result in *plant* performance that AEMO (in consultation with the NSP) is satisfied will be compliant with its *performance standards*.

Appendix C sets out *power system security* and quality of *supply* requirements and examples of where AEMO considers that an individual non-compliance would be material because it would or could result in an adverse impact on *power system security* or on the quality of *supply* to a *Network User*. Where non-compliance(s) have impacts across more than one of these elements AEMO will need to consider the cumulative impact. In those circumstances, AEMO may determine

[30] Through NER 4.14(p) where the change is not related to a plant alteration, or NER 5.3.9 otherwise.

[31] The lower of the present MAS and the existing performance standard (NER 5.3.4A(b)(1A)).

the cumulative impact to be material even if no individual item, viewed in isolation, may be considered material.

5. Conditions on registration

Under NER 5.3.7A(k)(2), AEMO may issue a notice that it is satisfied that the GS or IRS can meet its *performance standards* subject to terms and conditions agreed with the *Connection Applicant*. This option may assist to expedite the registration of a GS or IRS.

AEMO is not obliged to, but may, agree terms and conditions on registration under provisions of NER Chapter 2[32]. The terms and conditions agreed to between AEMO and the *Connection Applicant*, under the *capability assessment* process[33], become the terms and conditions on registration.

5.1. Circumstances under which AEMO may agree to terms and conditions

AEMO may consider agreeing terms and conditions on registration in the following circumstances:

- The terms or conditions are related to a technical capability to meet a *performance standard*.
- The application of terms and conditions would advance the principles of this Guideline (as set out in Section 1.1)
- There is a clearly identified, credible pathway for the *Connection Applicant* to be able to demonstrate its *plant* will meet or exceed its *performance standards*.
- Under the terms and conditions on registration:
  - An inability to meet or exceed *performance standards* at this time will not have an adverse effect on *power system security* (including through reduction in the *technical envelope* for operation).
  - An inability to meet or exceed *performance standards* at this time will not have an adverse effect on the quality of *supply* to any other *Network User*.
- The use of the terms and conditions on registration is consistent with the *National Electricity Objective* (NEO)
- The terms and conditions incentivise the resolution of the relevant issue, in a reasonable timeframe considering the nature of the issue.

5.2. Nature of terms and conditions

Terms and conditions placed on registration must be implementable and compliant with the requirements of the NEL. This section provides a list of the nature of terms and conditions to which AEMO may agree.

The terms and conditions for registration may include:

[32] The relevant provisions of Chapter 2 are NER 2.1B.1(c) and NER 2.1B.2(b)(4).

[33] NER 5.3.7A(k)(2).

- A maximum timeframe within which the *Generator* or IRP must satisfy AEMO that its *plant* can meet or exceed its *performance standards*.
- A milestone by which the *Generator* or IRP must satisfy AEMO that its *plant* can meet or exceed its *performance standards* (for example, a nominated hold point).
- A limit on the maximum capacity of the *plant* to *generate* or consume electricity.
- A limit on the *generation* or absorption of *reactive power*.
- A limit on the maximum number of *production units* that may be *connected* at any one time.
- A limit on the modes of operation of the *plant* and/or plant operational configurations.
- A limit on the types of market services that the *plant* is permitted to provide.
- That, if the technical envelope for secure *power system* operation is reduced by the *plant's* inability to meet its *performance standard*, the *plant* will be constrained ahead of other *Network Users* to minimise the impact on *power transfer capability* and other *Network Users*' operation.
- That, if the *plant's* inability to meet a *performance standard* causes an adverse impact on the quality of *supply* to another *Network User* (determined through measurement), the *plant* may be constrained, or the number of *production units* permitted to operate reduced to a level where there is no adverse impact.
- That, if the *plant's* performance causes a harmonics or flicker emissions planning level to be exceeded at the *connection point* (as determined through measurement), the *Generator* or IRP is required to either rectify its non-compliance or reimburse the NSP to rectify the non-compliance.
- That, if the plant's allocations for harmonics or flicker have been adjusted to address a non-compliance, and the emissions at the *connection point* exceed a planning level (assessed through measurement), the *Generator* or IRP is required to remediate their emissions or enter into a commercial operation with the NSP to rectify the exceedance in proportion to its contribution.
- The assessment process that will satisfy AEMO that the conditions on registration have been met and the party(s) responsible for this assessment.
- Payment of a fee to cover the cost anticipated to be incurred by AEMO and the NSP (where relevant) to confirm satisfaction of a condition on registration, where not otherwise addressed in the NER.

The terms and conditions may be applied in combination and may be tiered or linked to one another. This is to provide AEMO assurance that conditions on registration are being complied with and that AEMO remains satisfied of the capability of the *plant* to meet or exceed its *performance standards*. For example, a limit on the maximum capacity of the *plant* to *generate* or consume electricity may be lifted once an assessment process that will satisfy AEMO as to the conditions having been met has been completed.

5.3. Application of terms and conditions

The application of terms and conditions to registration must be agreed by AEMO. AEMO will only agree to the use of terms and conditions under the circumstances specified in Section 5.1.

AEMO retains discretion regarding whether to grant conditional registration. AEMO will adopt a careful and considered approach to agreeing to terms and conditions on registration where the implications of the application of terms and conditions might not be clear.

Examples where AEMO would consider agreeing to conditions on registration include:

- A delay in manufacturing of a harmonic filter, the effect of which can be managed through limiting the number of *production units* in service and monitoring the harmonic levels at the *connection point*, until such time as the filter is in service. The plant's operation may be further curtailed if the planning limits for harmonics at the *connection point* are exceeded.
- A firmware and model update, supported by a contractual commitment between the OEM and the developer, to fix a potential material non-compliance, for which the adverse power system security impact can be avoided by temporary restrictions to operation.
- A commissioning test at a specified output level (at a level that would not cause an adverse *power system security* impact), to confirm that an apparent material non-compliance is a modelling artifact. If the commissioning test does not confirm expected performance and the matter is not resolved during commissioning, it would be managed as a non-compliance in the usual way, including restrictions on operation as appropriate until resolved[34].

[34] Note, to agree to condition on registration in this case, AEMO would need reasonable confidence that there was a credible pathway to compliance – that is, demonstration through testing that the apparent non-compliance was only a modelling artifact – for example, through confirmation from the OEM.

Appendix A. Initial data and information requirements

Table 1 Initial data and information requirements

Type of information	Requirement
Resolution of conditions in 5.3.4A letter	Capture conditions in a 5.3.4A letter and any unresolved issues from the *connection application* that have been addressed. This would include: • A detailed description of how conditions and unresolved issues have been addressed including the corresponding changes for each item. Where relevant they should be supported with evidence such as simulation studies, OEM documentation, detailed design information and reports. • Identify and provide the updated relevant documents that are impacted.
Plant alterations and performance standard changes	Describe alterations to *plant* design since agreement of *performance standards*. • Describe the changes (and quantify where possible) and expected impact on the agreed *performance standards*, for example, cable impedance reduced by 5%, no change proposed to the *performance standards*. • Flag any alterations that have not been quantified at this stage. • Include a marked-up version of the *performance standards*.
Performance standards not previously assessed	Identify elements of *performance standards* that were not assessed during the *connection application* phase and provide an update of their status. For example, this is likely to include some protection and secondary systems related *performance standards* such as S52.5.8 and S5.2.5.9. It may also include run-back schemes and anti-island schemes in relation to S5.2.5.12.
Voltage control strategy (VCS)	Provide an updated voltage control strategy reflecting any updates to voltage control philosophy and additional detail on control, operational arrangements, special *protection schemes*, and details for wind free operation or *reactive power* at night where relevant. Highlight key changes since the agreement of *performance standards*.
Models of the GS/IRS including Registered Data (R1 pre-connection) and associated documentation	• Provide the models of the GS/IRS in PSS®E and PSCAD™/EMTDC™ format, incorporating the most up-to-date information available (See section 3.1.1 for more detail). The models should include any changes to address any outstanding modelling issues held over from the connection application phase or conditions in 5.3.4A letter[35]. • Provide the associated model documentation: – PSS®E Releasable User Guide (RUG). – PSCAD™/EMTDC™ User Guide. – PSS®E to PSCAD™/EMTDC™ parameter mapping sheet.
Dynamic model changes	Changes to dynamic models of the plant since agreement of *performance standards*. • Provide OEM information about the model changes including the model version history and change log. • Identify all model changes that could impact the *plant's performance standards*. Include a description of each change and how it will impact the agreed *performance standards*.

[35] The updated source code and block diagrams will also be required to be provided prior to registration.

Type of information	Requirement
Dynamic model outstanding changes	Identify any known changes that have not yet been incorporated into models or settings. For example, this might include some as-built quantities where not yet finalised (such as transformer impedances from FAT). Where possible, quantify the maximum extent of changes.
Dynamic models or firmware known issues	Identify any specific known issues related to the OEM models of the *plant* and controls or protection of the *plant* or known firmware issues, whether or not represented in the models that could affect its ability to meet the *performance standards* and were not considered at the time of *connection application* assessment.

Note: Except where specific documents are identified in the table above, the information can be provided as a technical note.

Appendix B. Additional Data and Information Requirements

B.1 Additional information that will generally be required

The information listed in Table 2 is required additional information, unless otherwise agreed with AEMO and NSP. NER S5.3 requirements only apply to IRS having load components other than auxiliary loads.

Table 2 General additional information requirements

Requirement	Performance standard	Purpose
Models and user guides **The following are required unless there are no changes to the models and user guides including complete Registered Data (R1 pre-connection provided in the initial data and information submission described in Appendix A, unless otherwise agreed[36, 37].** **Models:** • **Models of the GS/IRS in PSS®E and PSCAD™/EMTDC™ format. Includes load models for IRS where S5.3 applies.** • **The models should include:** – **Any changes to address any outstanding modelling issues identified by AEMO, or the NSP.** – **Updates for any outstanding changes identified in Appendix A.** **User guides of the GS/IRS models:** • **PSS®E Releasable User Guide.** • **PSCAD™/EMTDC™ User Guide.**	S5.2.5.3 S5.2.5.4 S5.2.5.5 S5.2.5.7 S5.2.5.8 S5.2.5.11 S5.2.5.12 S5.2.5.13 S5.2.5.14 S5.2.5.15 S5.2.5.16 S5.3.11[38]	The models and the corresponding user guides are required for simulation studies to demonstrate the capability of the GS/IRS to meet or exceeds its *performance standards*. Updates including R1 data are generally required, both for AEMO/NSP to confirm compliance with *performance standards* and for on-going use in AEMO's operation of the *power system*.
Auxiliary reactive power equipment design report (where applicable) **Design report for any auxiliary reactive *plant* (for example, capacitor, reactor, statcom or *synchronous condenser*).**	S5.2.5.1 S5.3.5 S5.2.5.4	*Reactive power* auxiliary plant will impact the *reactive power* capability of the *connection*, the reactive current injection at the *connection point* (relevant to S5.2.5.5), and may also impact stability of the *connection*. There may also be some

[36] Some factory test results may not be available at the start of the capability assessment. AEMO recommends the Connection Applicant discuss with AEMO and NSP the timing of data provision, to establish how models can be managed to achieve an efficient capability assessment process.

[37] See Section 4.1.

[38] Schedule 5.3 applies to load elements of IRS, other than auxiliary loads.

Requirement	Performance standard	Purpose
		interaction between *reactive power* equipment and the protection settings, which might affect the plant's ability to remain in *continuous uninterrupted operation*. The design report will confirm the reactive *plant* ratings and may inform the assessment on *reactive power* capability and *continuous uninterrupted operation* (CUO).
Harmonic filter design report (where applicable)	S5.2.5.2 S5.2.5.1 S5.3.5 S5.2.5.4 S5.2.5.5 S5.2.5.15[39]	The harmonic filter design report is primarily required to provide evidence supporting for compliance of the *plant* with harmonic emissions *performance standards* S5.2.5.2 and S5.3.8. Any changes to filter design may impact compliance for *reactive power capability* (S5.2.5.1, S5.3.5), the voltage disturbance response (S5.2.5.4) and contingency response (S5.2.5.5), particularly reactive current injection at the *connection point*. The harmonic filter design report can provide supporting evidence for compliance assessment against these clauses.
Protection design report • **Protection design report describing the *protection systems* within the *connection* and demonstrating protection coordination with the NSP's *network* protection.** • **(for S5.3.9, where relevant) evidence that substation can remain in *continuous uninterrupted operation* for voltage levels specified in the *system standards*. This would typically entail checking the equipment design against the protection (such as for V/f protection, over-voltage and under voltage).** • **(for S5.3.9, where relevant) provide for substations, details of the *protection systems* for individual *plant*, back-up arrangements, auxiliary DC supplies and instrumentation transformers, and evidence of insulation coordination with the NSP's *network*.**	S5.2.5.3 S5.2.5.4 S5.2.5.5 S5.2.5.7 S5.2.5.8 S5.2.5.9 S5.2.5.10 S5.3.9	The protection design report provides evidence that the protection design has the required level of redundancy and is consistent with the clearance times described in S5.2.5.9. It should also cover protection aspects related to stability (relevant for S5.2.5.10). Details in the protection report is also used to check that *plant* protection settings do not conflict with CUO requirements (considering requirements in S5.2.5.3 for frequency and rate of change of frequency (RoCoF) ride-through, S5.2.5.4 for voltage ride-through, S5.2.5.5 for contingency events, S5.2.5.7 for load events).
Supervisory control and data acquisition (SCADA) list **Agreed SCADA list with AEMO and NSP. The list should include, where relevant:** • **Measurement quantities and statuses from the connection point and within the *connection*** • **Var Dispatch System (VDS) signals** • ***Energy conversion model* signals** • **Status of runback schemes**	S5.2.6.1 S5.3.9	The information is required to confirm consistency between the SCADA list and the relevant *performance standard*.

[39] Withstand SCR assessment should be performed with filters and other auxiliary reactive plant in service.

Requirement	Performance standard	Purpose
• **Status of special protection schemes** • **Any other remote monitoring required by the NSP under S5.3.9 for a load**		

B.2 Additional information on detailed design, control and protection elements

The information listed in Table 3 on detailed control and design elements may be required for capability assessment. AEMO/NSP will advise which information is required, as part of the scope assessment.

Table 3 Additional information on detailed design, control and protection elements

Requirement	Performance standard	Purpose
Local limit implementation detail **Details of local limit controls based on temperature, unit availability, transformer status, other auxiliary plant availability.** **Where applicable, confirmation that local control limit outputs are connected to local limit SCADA signals.** **The information could be incorporated in a technical note or in the VCS.**	S5.2.5.1 S5.2.5.4	Local limits on *active power* may be implemented to maintain *reactive power* capability in a *plant* with distributed *production units* or IBR for various changes within the *connection*, so that during a voltage disturbance the *reactive power* capability is maintained in the range 90% - 110% of *normal voltage* at the *connection point* (for compliance with S5.2.5.4). The local limits are typically reflected in S5.2.5.1 *performance standard* wording.
***Reactive power* at night/wind free *reactive power*/ *synchronous condenser mode*/*reactive power* control mode change** **As relevant details on:** • ***Reactive power* at night arrangements (solar farms).** • **Wind-free mode control and operational details (wind farms).** • **Mode change to *synchronous condenser* mode (synchronous generators).** • **Control mode change to *reactive power* (where applicable).** **This information could be provided in a technical note or the VCS.**	S5.2.5.1	*Reactive power* at night / wind free operation / mode change for synchronous *plant* / control mode change to *reactive power* may be required to demonstrate meeting *reactive power* requirements when the plant is not actively producing or consuming (other than auxiliary load) *active power*.
Low power transition **Details of *plant* operational strategy for transition between low *active power* output and no output (and vice versa) including (as relevant):** • **Management of *reactive power* at low output and during transition.** • **Mode of operation changes.**	S5.2.5.1 S5.2.5.2	The *plant's* control actions when transitioning between low output and no output may cause a disturbance to the *power system*. Operational strategy details for low output/no output transition may be required to: • Confirm *reactive power* vs *active power* capability at low output consistent with the *performance standard* for S5.2.5.1.

Requirement	Performance standard	Purpose
• **Plant switching (such as filters, production units, *reactive power plant*).** **This information could be provided in a technical note or the VCS.**		• Confirm the smooth transition between low *active power* output and *reactive power* at night (for solar farms) or wind free operation (for wind farms). • Ensure the *plant* operates in a way that does not prevent the NSP from meeting the *system standards*.
Partial cloud shading algorithm (solar farms) **Details on how the solar farm avoids wind up of *active power* on inverters when other inverters are shaded.** **This information could be provided in a technical note or supported by the relevant OEM documentation.**	S5.2.5.4	Partial cloud shading algorithms may be required to demonstrate that a solar farm can maintain *active power* for a voltage disturbance during partial cloud shading of the solar farm. Wind-up of *active power* can lead to inability to comply with CUO requirements of S5.2.5.4 for a voltage dip.
Load current balancing (where applicable) **Design details of how load current balancing is achieved within the site.** **This information could be provided in a technical note.**	S5.3.6	If an IRS includes a load with single phase or unbalanced current components, AEMO or the NSP may require evidence of how load current balancing has been implemented within the *connection*. Inadequate load balancing may adversely impact other *Network Users* by causing equipment to overheat. The design details may be required to confirm compliance and no adverse impact on other *Network Users*.
Special protection scheme/runback scheme • **Special protection scheme or runback scheme implementation details.** • **Details of failsafe mechanisms if special protection scheme communications fail, or protection scheme is** disabled.	S5.2.5.12 S5.2.5.10 (for fail safe mechanism)	The *performance standards* may include a requirement to participate in a runback scheme or other special protection scheme. Details of these schemes are required to examine its impact on the *power system* and confirm compliance with the *performance standard*. Special protection schemes are usually put in place to avoid reductions to *technical envelope* of operation, and if they fail to operate, it can impact *power system security*. Fail safe mechanism are therefore usually included in the design and will also need to be reviewed.
Emergency over-frequency response • **Automatic *active power* reduction *facilities* /controls details for over-frequency.** • **Explanation of how over-frequency responsiveness has been implemented.** **The above information could be provided in a technical note. Alternatively, this may be demonstrated through simulations (See Appendix B Section B.4).**	S5.2.5.8	If the implementation is changed from that previously proposed as a part of the *connection application* (or was not assessed at that stage), further evidence to support compliance may be required. Also, details may be required to ensure that the implementation is consistent with PFR implementation agreed with AEMO.
Communications fail-safe implementation	S5.2.5.10	GS or IRS, particularly those with distributed *production units* and a central power plant controller may develop unstable operation if communications systems fail or some critical measurement is lost. The implementation of appropriate fail-safe measures to avoid unstable operation is part of compliance with S5.2.5.10.

Requirement	Performance standard	Purpose
Consistent with Communications System Failure Guideline[40], which may include between: • **Power Plant Controller (PPC) and *production units*** • **PPC and PPC meter** • **Production units and measurement unit** • **PPC and substation equipment** **This information could be provided in the communication design report. Operation of these fail-safe mechanisms may also (or alternatively) be tested during commissioning.**		
Fail-safe transfer systems (where required by the performance standard) **Confirmation of implementation of other fail-safe mechanisms such as:** • **PPC transfer between primary and secondary PPC.** • ***Synchronous machine* transfer between primary and secondary AVR/PSS.**	S5.2.5.10	The *performance standard* may include a requirement for duplication of key *control systems*, to avoid instability by transferring to a back-up controller in the event of failure or malfunction of the in-service controller. This requirement is usually applied for large *plants* where there can be a material impact on the *power system* from a trip or unstable operation. Confirmation of implementation would be typically required at this stage, with testing during commissioning.
Stability monitoring/protection • **Explanation of how requirements for instability detection and protection (as required by the performance standard) are implemented.** • **Evidence of pole slip protection** implementation (for *synchronous machines*) if required by the *performance standard*. • **Evidence of any other *protection system* to prevent machines from becoming unstable (such as loss of field protection).**	S5.2.5.10	Unless in-built in the *production units*, stability monitoring and protection is provided by additional equipment installed in the GS/IRS. AEMO and the NSP may require confirmation of installation and explanation of how the monitoring/protection equipment is set up to achieve the *performance standard*. *Synchronous machines* are typically equipped with pole slip protection to prevent unstable operation and damage to *plant* in the event of loss of synchronism. Loss of field protection is also commonly provided in synchronous plant to avoid instability and equipment damage. AEMO/NSP may require evidence that these systems have been implemented where required by the *performance standard*, and that the settings are appropriate to avoid adverse *power system security* impacts relating to stability.
Evidence to confirm capability to provide *frequency* response in conjunction with following *dispatch* instructions • **Explanation of how *frequency* responsiveness and *dispatch* have been implemented in the GS/IRS**	S5.2.5.11 S5.2.5.14	Requirements for *frequency* responsiveness under S5.2.5.11, (and PFR requirements), apply simultaneously with the requirements of S5.2.5.14.

[40] At https://aemo.com.au/-/media/files/electricity/nem/network_connections/stage-6/communication-system-failure-guideline.pdf.

Requirement	Performance standard	Purpose
		Evidence may be required to demonstrate that the PFR is implemented as an offset to a ramp required under S5.2.5.14, for *dispatch* response, considering the *frequency* as it varies across the *dispatch* interval.
Active power control • **Confirm active power is capable of linearly ramping from one dispatch level to another over a dispatch interval.** • **Unless the GS/IRS is on AGC, evidence to confirm implementation of a dynamic ramp rate.**	S5.2.5.14	For scheduled and semi-scheduled *plant*, evidence (or simulations) is required to demonstrate compliance with this *performance standard* if the *plant*/ model or controller settings affecting *active power* has/have changed or the implementation has not previously been assessed. Note that: • If the system uses AGC for dispatch implementation it will receive dispatch signals through SCADA throughout the *dispatch* interval. • Alternatively, the plant may receive a single dispatch instruction per interval, which will arrive a variable time after the start of the dispatch interval. • In the latter case the ramp rate needs to be adjusted to achieve the target dispatch at the end of the interval considering the remaining time as well as the output level change.

B.3 Additional supporting documentation

Additional supporting documentation listed in Table 4 may be required for capability assessment, particularly for larger plant or in cases where the plant's performance may have a material impact on the power system operation for the associated performance standard. AEMO/NSP will advise which information is required, as part of the scope assessment.

Table 4 Additional supporting documentation

Requirement	Performance standard	Purpose
Hardware in Loop (HIL) tests **HIL test results for FRT and MFRT**	S5.2.5.5	HIL tests, if available, provide supporting evidence for fault ride-through capability. Tests set up for site-specific system impedance will be of most value.
OEM documentation on unbalance **As relevant details on:** • **Unbalance specification data from OEM of production units and other reactive power auxiliary plant.** • **Other OEM documentation (for example, OEM documentation indicating compliance to a relevant standard).**	S5.2.5.2	OEM documentation may provide evidence to confirm that the *production units* will not have unbalanced operation beyond limits imposed in the *performance standard*.

Requirement	Performance standard	Purpose
Electromagnetic compatibility **Evidence of electromagnetic compatibility (EMC) levels such as**: • **Equipment certification for the** production units. • **Factory test results for EMC.** • **OEM statement of EMC compliance for the *production units*.**	S5.2.5.6	Certification evidence, test results for EMC are ways to provide evidence of compliance. OEM statement of compliance also provides some (lesser) level of evidence. Evidence may be required if not previously provided prior to *connection agreement* finalisation.
OEM documentation on equipment level protection **OEM datasheet on the types of protection implemented in the plant and the implementation in model settings.**	S5.2.5.8 S5.2.5.16	OEM documentation may be required to explain the types of protection and their implementation on the plant, where this has not previously been provided as part of the *connection application*. This could be used as evidence to support that the *plant* does not have any protection like vector shift protection that could trip the plant for phase angle shift of 20 degrees or less.
Anti-islanding scheme, synchronisation facilities or reclose blocking (as required) **Evidence to confirm implementation of anti-islanding scheme where required by the performance standards.** **For an IRS where S5.3.9 is applicable, with a substation that has a generating unit connected, evidence to confirm that the substation has the required synchronisation facilities or reclose blocking as relevant.**	S5.2.5.8 S5.3.9	Anti-islanding schemes are typically required for plant that is incapable of operating in an island, including grid following IBR GS or IRS. Evidence of the implementation arrangements may be required to confirm their effectiveness and that the settings do not give rise to conditions that could cause damage to other *plant* within the island. Where *generation* capable of islanded operation is included in load facilities it will require synchronisation facilities if designed to stay *connected* when the power to an islanded system is reconnected to the grid, or to have reclose blocking to prevent out-of-phase connection of the islanded grid with the *power system*. Evidence about the implementation may be required to ensure the facilities are do not cause equipment damage or adverse impact on the quality of *supply* of other *Network Users*, during *power system* reconnections after loss of *supply*.
OEM documentation on instability detection/protection equipment and associated implementation details **For example, OEM data sheets on stability monitors or relays.**	S5.2.5.10	The OEM information about the instability detection/protection may provide evidence of the functionality of the equipment and its suitability for use. The information may be used in conjunction with details of implementation (see Appendix B.2) to confirm compliance.
Proportional frequency response to provide frequency control ancillary services (FCAS) **Confirmation of necessary facilities to achieve compliance.**	S5.2.5.11	The AAS of S5.2.5.11 requires capability to provide proportional response to frequency disturbances (without reference to stable energy input conditions). To achieve this a plant with variable renewable energy sources may need to have additional facilities such as an energy forecasting system. Confirmation of how the plant achieves its capability to provide proportional frequency responsive behaviour may be required to confirm compliance with this performance standard.
Schematics showing protection detail **Single line diagram (showing plant as constructed) showing protection relays and associated current transformer (CT)/voltage transformer (VT) locations.**	S5.2.5.9 S5.3.9	The schematic provides additional confirmation that *protection systems* have been implemented consistent with the *performance standard* and the protection design report.

Requirement	Performance standard	Purpose
Schematics showing measurement and monitor locations and confirmation of how these facilities maintain their supply during disturbances • **Single line diagram (showing plant as constructed)** showing test facilities and monitor locations, along with VT and CT connections for these measurements. • **Evidence or explanation of how supply to these facilities is maintained during disturbances.**	S5.2.5.13	The AAS of S5.2.5.13 requires permanently installed facilities for testing. This typically entails monitoring equipment located at the *connection point* and electrically nearest and furthest *production units,* and possibly also at the medium voltage collector system bus. The 'as constructed' schematics provide information on locations and of implementation of these *facilities*. The monitors need to remain in service during *power system* disturbances, which may require additional equipment (such as a UPS). Evidence that the monitoring devices will remain in operation may be required to demonstrate compliance.

B.4 Simulation studies to support the capability assessment

Simulation studies may be required from the *Connection Applicant* to support the capability assessment application (for example, where there are changes in the GS/IRS compared with the initial design, to consider external changes since the *connection application*). The nature of the simulation studies will be similar to that of the *connection application* stage[41]. AEMO and the NSP will advise the required simulation studies as an outcome of the scoping assessment and as the capability assessment progresses, if further clarification or evidence is required.

In addition to studies by the *Connection Applicant*, there might be a need for wide-area PSCAD™/EMTDC™ simulations to be undertaken by the NSP or AEMO, if there are material changes to the controllers (or models) or settings, or to the *plant*, which could impact the ability of the *plant* to remain in CUO and *adequately damped* for normal operation or *contingency events*, including under low system strength conditions.

[41] Refer to the AEMO Access Standard Assessment Guide at https://aemo.com.au/-/media/Files/Electricity/NEM/Network_Connections/Access-Standard-Assessment-Guide-20190131.pdf for examples of simulation studies that may be required from the Connection Applicant.

Appendix C. Assessment of adverse impacts on Power System Security and Quality of Supply

NER Reference	Power system security or quality of supply element	Description of requirement	Examples of conditions that AEMO considers would reflect an adverse impact	Relevant access standard
NER 4.2.2 Satisfactory Operating state, in conjunction with: • **S5.1.4 Magnitude of power frequency voltage.** • **S5.1.4a Power frequency voltage.**	**Voltage magnitude**	• Except as a consequence of a *contingency event*, voltage magnitudes on energised busbars at any *switchyard* or *substation* of the *power system* must be maintained: – For a *connection point*, between 95% and 105% of target voltage[42] and – Between 90% and 110% of *normal voltage*. • (For a *satisfactory operating state*) all other *plant* forming part of or impacting on the *power system* must be operated within the relevant operating ratings (accounting for time dependency, in the case of emergency ratings) as defined by the relevant NSP in accordance with S5.1.	• The proposed operation of the *plant*, in absence of a *contingency event*, would, in some reasonably anticipated conditions, prevent a *connection point* being operated between 95% and 105% of target voltage, a *substation* or *switchyard*, or a *connection point* from being maintained within 90% and 110% of *normal voltage*, considering the realistic cumulative impacts from nearby GS and IRS. • The *plant's* operation, following a *credible contingency event* or *protected event* causes or exacerbates an overvoltage beyond the magnitudes and durations described in the *system standards*, considering reasonably anticipated cumulative impacts of nearby GS, IRS and *network* dynamic plant (from existing and *considered projects* or committed projects). • In *power system* conditions without a *contingency event* or following a *credible contingency event*[43], the *plant's* operation could result in other *plant* or *network* elements in the *power system* operating outside their voltage ratings (considering time-dependency of voltage ride-through requirements in the *system standard* S5.1a.4 and S5.2.5.4). • Operation of the *plant* (for example, switching of an element within the *plant*, or energisation of a	S5.2.5.1 S5.2.5.4 S5.2.5.13

[42] Where set in accordance with S5.1.4(c) for the MAS. The AAS references S5.1a.4, which specifies except as a consequence of a contingency event, not varying more than 10% above or below its normal voltage. Nevertheless, the transmission NSP (TNSP) must design its transmission system consistent with the voltage magnitude specified in S5.1a.4. It is common for distribution NSPs (DNSPs) to have additional state-based requirements to operate their networks within tighter tolerances.

[43] The power system is normally operated in a secure state. This may include outages of network elements, but the power system should return to a satisfactory operating state after a credible contingency. If, in absence of the plant, the voltages are outside the requirements of the system standards, or outside the system standards following a credible contingency event, this would not be a valid test condition. The condition must be caused by the plant's operation.

NER Reference	Power system security or quality of supply element	Description of requirement	Examples of conditions that AEMO considers would reflect an adverse impact	Relevant access standard
			transformer) causes a voltage step change of more than 5% of *nominal voltage*.	
NER 4.2.2 *Satisfactory Operating state*, in conjunction with: • **NER S5.1.8 Stability.**	**Stable operation**	• The conditions of the *power system* are stable in accordance with requirements designated in or under clause S5.1.8 of schedule 5.1.	• The *plant's* operation is or can become unstable or not *adequately damped* for a defined condition of the *plant*, the instability or poor damping is or could be ongoing, and there is no mechanism to abate it promptly. • The *plant* becomes unstable during or following a *credible contingency event* or *protected event* causing the *power system* to lose synchronism. • The *plant* becomes unstable during or following a *credible contingency event*, and its performance adversely affects or could adversely affect the performance of another *Network User's plant* (such as causing another plant to trip or have unstable or poorly damped operation). • The plant's voltage control behaviour prevents or could prevent stable voltage control of the *power system* from being maintained following a *credible contingency event* or *protected event* (compared with not having the *plant* in service). • The *plant* contributes to oscillations [against other *plant* in the *power system*] which have average halving time more than 5 seconds. • The operation of the *plant* results in or could result in a reduction in the *technical envelope* of the *power system*, resulting in a reduction in *power transfer capability*, beyond what is documented in its *performance standard* under the NER. • The *plant's* stable operation under defined *power system* conditions relies on the operation of a special protection scheme or runback scheme that will not be implemented at proposed registration date. • The *plant* will not have implemented the means to detect instability as required by is *performance standard* under NER S5.2.5.10 by the time of registration.	S5.2.5.5 S.2.5.13 S5.2.5.12 S5.2.5.10

NER Reference	Power system security or quality of supply element	Description of requirement	Examples of conditions that AEMO considers would reflect an adverse impact	Relevant access standard
NER 4.2.4 Secure operating state and power system security	**Recovery after a contingency event**	• Return to a *satisfactory operating state* following a *credible contingency event* or *protected event*	• The *plant's* operation following a *credible contingency event* significantly impedes or prevents the *power system's* return to the normal operating voltage range (90 -110%). • The *plant* will not have verbal communications systems in place, to receive a verbal direction from the system operator, by the time of registration.	S5.2.5.5 S5.2.6.2
NER 4.2.2 Satisfactory operating state	**Frequency excursions**	• Operation within the NOFB apart from brief excursions outside the NOFB but within the NOFEB	• The *plant's active power* recovery following a *contingency event* adversely affects the *power system's* capability to remain within the NOFB, considering is individual impact and the cumulative impact including other *plant* that could be affected by the same *contingency event*. • The plant's tripping adversely affects the *power system's* capability to remain within the NOFEB (considering initial operating *frequency* at a boundary of NOFB). • The plant's inability to follow a *dispatch* instruction could adversely affect the *power system's* capability to remain within the NOFB. • The *plant* is required to participate in an *emergency frequency control scheme* to restore the *power system* to a *satisfactory operating* state following a *protected event* or to reduce the risk of cascading outages, but the *plant's* participation has not been implemented.	S5.2.5.3 S5.2.5.8
NER 4.2.2 Satisfactory operating state	**Fault level**	• Operate within the fault withstand rating of plant	• The *plant's* operation could cause the fault withstand rating of nearby *plant* to be exceeded, considering existing fault levels and contributions of other committed projects and existing *network* and *considered projects*. • The *plant's* equipment ratings are inadequate to clear a fault at a fault level that could occur on the *power system*, considering existing fault levels and contributions of other committed projects.	S5.2.8
NER 4.2.2 Satisfactory operating state	**Overloading of network elements**	• Operation of the *power system* within ratings	• The *plant's* inability to follow a *dispatch* instruction could cause a *network* element to trip for operation beyond its current rating.	S5.2.5.14

NER Reference	Power system security or quality of supply element	Description of requirement	Examples of conditions that AEMO considers would reflect an adverse impact	Relevant access standard
	Stable operation	• Voltage stability	• The *plant's* (aggressive[44]) *frequency* response could cause a *network* element to trip for operation beyond its current ratings, voltage collapse or inadvertent operation of a special protection scheme[45].	S5.2.5.12
NER 4.2.6 General principles for maintaining power system security	**Recovery following a contingency event**	• Return the *power system* to a secure state as soon as practical and within 30 minutes	The *plant's* response to a *contingency event* (including a 3-phase fault), could contribute to a cascading event or otherwise impede restoration of the *power system* to a secure state.	S5.2.5.5
NER S5.1a.6 Voltage waveform distortion	**Harmonic distortion**	• Harmonic voltage distortion level of supply should be less than the "compatibility levels" defined in Table 1 of Australian Standard AS/NZS 61000.3.6:2001. • To facilitate the application of this standard NSPs must establish "planning levels" for their *networks* as provided for in the Australian Standard.	The *plant's* harmonic emissions[46] could result in harmonics exceeding compatibility levels on the *network*, or the planning level at the *connection point* considering background harmonics (may be associated with specific *network* configurations).	S5.2.5.2 S5.3.8

[44] Would only need to be considered if proposed droop was much lower than the droop required under the Primary Frequency Response Requirements, when the plant was not dispatched for a frequency control ancillary services (**FCAS**) service that required it.

[45] This is a potential S5.2.5.12 non-compliance from use of aggressive frequency droop settings if they result in a reduction in *power transfer capability* because higher safety margins on network constraint formulations were required to manage the issue.

[46] Note there is considerable uncertainty around harmonic voltages on the power system. A potential non-compliance could be dealt with using a condition on registration.

NER Reference	Power system security or quality of supply element	Description of requirement	Examples of conditions that AEMO considers would reflect an adverse impact	Relevant access standard
NER S5.1a.5 Voltage fluctuations	**Voltage fluctuations**	• The voltage fluctuation level of supply should be less than the "compatibility levels" set out in Table 1 of Australian Standard AS/NZS 61000.3.7:2001. • To facilitate the application of this standard NSPs must establish "planning levels" for their networks as provided for in the Australian Standard.	Operation of the *plant* could cause voltage fluctuation levels in the network to exceed "Compatibility Levels" defined in Table 1 of AS/NZS 61000.3.7, or the voltage or the planning level defined by the NSP at the *connection point* (may be associated with specific *network* configuration).	S5.2.5.2 S5.3.7
NER S5.1a.7 Voltage unbalance	**Voltage unbalance**	• Except as consequence of a *contingency event*, the average voltage unbalance, measured at a *connection point*, should not vary by more than the amount set out in column 2 of Table S5.1a.1, when determined over a 30-minute averaging period. • As consequence of a *credible contingency event* or *protected event*, the average voltage unbalance, measured at a *connection point*, should not vary by more than the amount set out in column 3 of Table S5.1a.1, when determined over a 30-minute averaging period. • The average voltage unbalance, measured at a *connection point*, should not vary by more than the amount set out in column 4 of Table S5.1a.1 for the relevant nominal supply voltage, when determined over a 10-minute averaging period. • The average voltage unbalance, measured at a *connection point*, should not vary more often than once per hour by more than the amount set out in column 5 of Table S5.1a.1 for the relevant nominal supply voltage, when determined over a 1-minute averaging period.	Unbalanced operation of the *plant* could cause average voltage unbalance measured at the *connection point* to exceed levels set out in columns 2, 3, 4 and 5 of the NER Table S5.1a.1 for the corresponding system conditions described in NER S5.1a.7 and the corresponding nominal supply voltage.	S5.2.5.2 S5.3.6