GUIDELINES FOR ASSESSMENT OF GENERATOR PROPOSED PERFORMANCE STANDARDS

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Contents

1 Introduction

(a) These Guidelines provide an explanation of AEMO's approach to the assessment and acceptance of a Generator's proposed performance standards.

(b) These Guidelines are not intended to be a substitute for the National Electricity Rules (Rules).

(c) These Guidelines may be amended from time to time.

(d) If there is any inconsistency between these Guidelines and the Rules, the Rules will prevail to the extent of that inconsistency.

2 Purpose

These Guidelines are designed to assist Generators and Network Service Providers (NSPs) to understand AEMO's information requirements and the issues AEMO will consider when assessing a Generator's proposed performance standards.

These Guidelines do not:

- provide details of the scope of studies to be undertaken;
- list all studies required or the breadth of transmission system and generating system operating conditions to be considered; or
- describe acceptable commissioning practices or ways in which Generators can demonstrate compliance with their performance standards.

3 Application

These Guidelines apply to AEMO in its assessment of proposed performance standards.

4 Legal and Regulatory Framework

AEMO's functions are prescribed in the National Electricity Law (NEL) and the Rules. Performance standards are the standards of performance of generation plant that have either been taken to be an applicable standard in accordance with clause 5.3.4A(i) or registered by AEMO in accordance with clause 4.14 (n) of the Rules. In the context of the assessment of proposed performance standards AEMO's involvement is a product of its different functions, three of which are relevant.

4.1.1 System and Market Operator of the NEM

AEMO's involvement as power system and market operator is limited to AEMO advisory matters, which is principally a reference to those proposed performance standards that could have power system security implications.

4.1.2 Provider of Declared Network Functions

AEMO currently has declared network functions in Victoria. This means that the functions of a Transmission Network Service Provider (TNSP) have been allocated between AEMO (who owns no assets) and SP AusNet (as the owner of the main transmission network in Victoria). For relevant purposes, this allocation of the functions and responsibilities of Chapter 5 of the Rules is detailed in clauses 5.1.2(d) and 5.3.7A.

For a new generating system connection to the declared shared network in Victoria (DSN), and modifications to a generating system, all of the generator's proposed performance standards will be assessed and accepted by AEMO, acting as the connecting NSP in accordance with the Rules, in addition to its role as power system operator.

For a new generating system connection to a distribution network in Victoria, the generator initially negotiates with the connecting Distribution Network Service Provider (DNSP) and AEMO then assesses the proposed performance standards, taking into consideration their impact on the DSN and power system security.

4.1.3 Provider of Additional Advisory Functions

AEMO has also been appointed as provider of additional advisory functions in South Australia, and provides technical advice to the Essential Services Commission of South Australia (ESCOSA) on generation licences and other technical requirements. Specifically, AEMO provides advice on the reactive power obligations for new licences.

5 Related Policies and Procedures

These Guidelines should be read in conjunction with the following:1

- Guidelines for Shared Transmission Connections in Victoria
- Guidelines for Establishing Terminal Stations in Victoria
- Policy on the Active Management Connection Applications in Victoria
- Generating System Model Guidelines.

6 Access and performance standards

The Rules use a number of different terms when it addresses the standards of generation plant performance:

- Acceptable levels of performance in respect of technical requirements listed in Schedule 5.2 of the Rules are called access standards.
- The minimum access standard is the minimum technical level of performance allowed, that is, the minimum standard in respect of a technical requirement. All access standards have a minimum technical level of performance.
- The highest technical level of performance for most access standards is the automatic access standard. A Generator is not required to demonstrate capability in respect of a technical requirement in excess of the relevant automatic access standard.
- A negotiated access standard is a level of performance in between the minimum access standard and the automatic access standard applicable to a technical requirement. Negotiated access standards must be agreed with the connecting NSP and AEMO for AEMO advisory matters. In all cases, the generator should demonstrate that the negotiated access standard is as close as reasonably practicable to the automatic access standard.

In these Guidelines, where a Generator proposes a performance standard, it will be referred to as a 'proposed performance standard'.

Proposed performance standards become agreed performance standards when both the connecting NSP and AEMO have reviewed and accepted them. The agreed performance

[1] Unless otherwise indicated, all AEMO publications are available on AEMO's website.

standards that are applied to a generator's generating system are legally recorded in the connection agreement for that generating system with the connecting NSP and with AEMO as part of the registration process.

7 When Is an Assessment by AEMO Required?

AEMO will assess proposed performance standards under the following circumstances:

- new generation connection;
- alteration of an existing generating system; and
- inconsistency or non-compliance of generating system with performance standards.

There may be other jurisdictional requirements a Generator must comply with, and these may necessitate further assessment by AEMO (in the case of South Australia) or an NSP.

7.1 New Connection (Clauses 5.3.1 - 5.3.7)

If proposed performance standards for a new connection are lower than the automatic access standard, both the connecting NSP and AEMO are involved in their assessment. If the generator is not already a Registered Participant, it will need to apply for registration in accordance with Chapter 2 of the Rules. Registration depends, amongst other things, on satisfying AEMO that the generator's generating system is capable of meeting or exceeding the proposed performance standards.

7.2 Alteration of an Existing Generating System (Clause 5.3.9)

If a Generator intends to alter a generating system, it may require an alteration to its performance standards, following a process that involves both the connecting NSP and AEMO. The scope of such a review is limited to the performance standards that are being altered. The generator will need to satisfy AEMO that the altered generating system is capable of meeting or exceeding the proposed performance standards. The generator should address all performance standards that are affected by the change to the generating system. Regardless of the age of the existing generating system, the version of the Rules that is current at the time of the alteration will be applied in the assessment of the proposed performance standards.

7.3 Inconsistency or Non-compliance with Performance Standards (Clauses 4.15, 5.4.2 and 5.4.4)

During operation of the generating system, it may become apparent that the performance standards cannot be (or are not being) met. This could be identified during commissioning, routine testing, normal operation of the generating system, or through altered manufacturer data. When such an inconsistency is discovered, the generator must advise the connecting NSP and AEMO of the situation.

If an inconsistency is identified prior to the connection of the generating system, this is dealt with by the process described in clause 5.4.2 of the Rules. If the non-compliance is identified after connection, it will be dealt with using the process described in clause 4.15 of the Rules.

8 AEMO Advisory Matters

While there is a requirement for AEMO to be satisfied that a Generator can achieve all of the proposed performance standards for its generating system, in its role as power system operator, AEMO is only required to be involved in the negotiation of certain proposed performance standards where they fall below the automatic access standard. These are access standards whose technical

requirements have the potential to affect AEMO's obligations for maintaining power system security under the Rules. These are the AEMO advisory matters, which are:

- S5.2.5.3 Generating unit response to frequency disturbances
- S5.2.5.4 Generating system response to voltage disturbances
- S5.2.5.5 Generating system response to disturbances following contingency events
- S5.2.5.7 Partial load rejection
- S5.2.5.8 Protection of generating systems from power system disturbances
- S5.2.5.9 Protection systems that impact on power system security
- S5.2.5.10 Protection to trip plant for unstable operation
- S5.2.5.11 Frequency control
- S5.2.5.12 Impact on network capability
- S5.2.5.13 Voltage and reactive power control
- S5.2.5.14 Active power control
- S5.2.6.1 Remote monitoring
- S5.2.6.2 Communications equipment

For those access standards that are not AEMO advisory matters, AEMO will still check that the proposed performance standards comply with the Rules and do not adversely affect power system security. If it is considered that the proposed performance standard would adversely affect power system security, AEMO will participate in the performance standard negotiation only if required by the connecting NSP.

9 Data and Model Obligations

Some access standards refer to the performance of a generating system following power system disturbances. As it is not desirable to apply actual disturbances of the magnitude specified in the Rules to the power system, the need for an accurate computer model of the generating system becomes critical. An accurate model enables adequate assessment of proposed performance standards using power system modelling software. Accurate models also allow AEMO and TNSPs to determine transmission network transfer capability with confidence.

The data and model obligations required from a Generator are detailed in clause S5.2.4 of the Rules. AEMO has published Generating System Model Guidelines (available at AEMO's website) that describe the requirements for the development of mathematical models of generating units and generating systems. This includes the accuracy of the representation of their impact on power system security.

AEMO cannot assess any proposed performance standard until the generator's data and model obligations have been fulfilled and either a complete application to connect (clause 5.3.4) or an application to alter a generating system (clause 5.3.9) has been received. The required information includes, but is not limited to:

- model information in accordance with the Generating System Model Guidelines;
- completed Generating System Design and Setting Data Sheets; and
- a comprehensive design report that demonstrates how the generator will meet the proposed performance standards.

AEMO has published a checklist of information to be provided for the assessment of new connection applications and alterations to a generating system (available at AEMO's website) which provide additional information on the study and model requirements to be met by Generators when submitting their applications.

A Generator with a generating system that has a combined nameplate rating of 30 MW or greater is required under clause S5.2.4 to submit all of this information by the earlier of:

- the date of submission of the connection application;
- the date of a request to amend performance standards;
- three months before the proposed commissioning date of a new or altered generating system; or
- five business days before commissioning a generating system that was repaired due to failure.

Generators with generating systems that have a combined nameplate rating of less than 30 MW and a connection point on the distribution network have lesser data and model obligations (clause S5.5.6 of the Rules), however, AEMO still requires sufficient information to confirm that the generator can meet the proposed performance standards. Clause S5.5.6 requires the supply of additional data if it is reasonably required by the connecting NSP or AEMO.

AEMO will not conclude its assessment of any proposed performance standard until all information required has been supplied by the generator.

10 Assessment Methodology

When assessing generation connections, AEMO assesses each of the proposed performance standards against the technical requirements listed in Schedule 5.2 of the Rules. The fundamental principle in every assessment of each proposed performance standard is to demonstrate that it will not have a detrimental impact on power system security and quality of supply to other network users.

The Plant Model Reference Group (formerly the Inter-Regional Planning Committee's[2] Plant Modelling Working Group) prepared Excitation Control System Design Guidelines for the assessment of an excitation control system design, including settings and parameters, and details of the requirements for the preparation of a design report. These Excitation Control System Design Guidelines go into greater detail on study requirements relevant to clauses S5.2.5.5, S5.2.5.12 and S5.2.5.13 of the Rules. AEMO will supply these Excitation Control System Design Guidelines on request. NSPs may also have their own requirements for the assessment of these and other proposed performance standards.

Subject to being provided sufficient information to prove compliance, AEMO will always accept a proposed performance standard set at the automatic access standard for a technical requirement. In all other cases, AEMO will need to be satisfied that the levels of performance of a generating system:

- are considered not to have a detrimental effect on power system security and quality of supply;
- will not prevent either the connecting NSP or AEMO from meeting their obligations under the Rules; and

[2] The IRPC was an entity established by NEMMCO, prior to the formation of AEMO on 1 July 2009. It had a number of responsibilities, including coordinating and assessing inter-regional planning. To assist with these tasks, it established a number of working groups.

- are recorded in the connection agreement for that generating system.

The remainder of Section 10 provides guidance on AEMO's approach to assessment of proposed performance standards.

10.1 Reactive Power Capability (Clause S5.2.5.1)

These technical requirements consider the reactive power capability of a generating system at its connection point, which assists in the maintenance of a suitable power system voltage profile. The reactive power capability of a generating system is influenced by the voltage and reactive power control systems that are present and, therefore, aspects of this provision overlap with clause S5.2.5.13 (see Section 10.13).

Assessment of a proposed performance standard requires steady state load flow studies be completed to validate the reactive power capability of the generating system at the connection point over a range of power system conditions. In the case of a wind farm, the network model must include the cabling network that can have an effect on the reactive power range at the connection point. In addition, consideration needs to be given to the typical operating voltage at the connection point, the generation terminals, and the tapping range on any connection asset transformer. AEMO will consider the NSP's validation and will also require proof that the generating system can provide the stated reactive power range over the range of connection point voltages from 90–110% of nominal voltage. This proof can be in the form of a capability diagram, showing reactive power capability from 0–100% power output, over a generation terminal voltage range of 90–110% of normal voltage.

If the proposed performance standard is below the automatic access standard, this should be assessed by the NSP with regard to any requirements for the connection at the connection point. These requirements may vary according to power system fault level and loading in the vicinity of the connection point. For example, generation connecting in a lightly loaded area of the power system may be able to connect satisfactorily with less reactive power capability than those connecting in a more heavily loaded area that is subject to lower voltages and has a smaller reactive power margin. In some cases, active power output from the proposed generation may improve reactive power margins on the network without additional reactive power capability.

10.2 Quality of electricity generated (S5.2.5.2)

These technical requirements consider the quality of the electricity generated by a generating system at its connection point that can have a detrimental effect on other network users. Each connection point is assigned (by the connecting NSP) an automatic access standard for allowable levels of voltage fluctuation, harmonic voltage distortion and voltage unbalance. If the generator wishes to have a performance standard that is lower than the automatic access standard this will be a matter for negotiation with the connecting NSP.

For Victorian connections to the DSN, AEMO will allocate an automatic harmonic emission limit that is a proportion of the planning levels specified in AS61000.3.6 Australian Standard: Electromagnetic Compatibility, as calculated by a Stage 2 assessment. AEMO will also define a minimum negotiated harmonic emission limit that is allowable for that location while still ensuring that AEMO can meet the planning limits. The generator may be required to provide reports or other evidence to AEMO as to how its generating system will comply with the agreed levels.

If a proposed performance standard below the automatic access standard is accepted under clause S5.1.6 of the NER, the generator may be required to upgrade to the automatic access standard at a later date to accommodate new connections.

10.3 Generating unit response to frequency disturbance (Clause S5.2.5.3)

These technical requirements consider the response of the generating system, and each of its generating units, to frequency disturbances at the connection point, and the conditions for which they do (and do not) remain connected. As frequency disturbance is a possible outcome from a power system incident, some aspects of the requirements of clause S5.2.5.3 overlap with the requirements of clause S5.2.5.5 (see Section 10.5). There is also an overlap with the requirements of clause S5.2.5.8 (see Section 10.8) in that any over-frequency trip setting established under this clause must lie outside the frequency operating range specified in clause S5.2.5.3.

Assessment of a proposed performance standard requires the generator to provide for validation

- details of the frequency protection system, in particular, over-frequency and under-frequency protection element settings; and
- equipment specifications for its generating system, including auxiliaries that detail:
    - steady state frequency range operating capability; and
    - maximum rate of change of frequency operating capability.

The assessment will consider if any auxiliary plant needed to support the generating system can withstand the frequency disturbance. For example, if a synchronous generating unit requires key auxiliary loads to maintain operation (such as pumps or fans), evidence that these loads can maintain operation during the frequency disturbance should be provided.

If the proposed performance standard is below the automatic access standard, the following must also be addressed:

- The proposed performance standard must be as close as practicable to the automatic access standard while respecting the need to protect the generating system from damage;
- The frequency would be unlikely to fall below the lower bound of the operational frequency tolerance band as a result of over-frequency tripping of the generating units; and
- There would be no material adverse impact on quality of supply to other network users or to power system security.

10.4 Generating system response to voltage disturbance (S5.2.5.4)

These technical requirements consider the response of a generating system, and each of its generating units, to voltage disturbances at the connection point, and the conditions for which they do (and do not) remain connected. As voltage disturbance is a possible outcome from a power system incident, aspects of clause S5.2.5.4 overlap with the requirements of clause S5.2.5.5 (see Section 10.5). There is also an overlap with the requirements of clause S5.2.5.8 (see Section 10.8) in that any over-voltage or under-voltage trip setting established under this clause must lie outside the voltage operating range specified in clause S5.2.5.4.

Assessment requires that the generator provide the following information:

- details of the voltage protection system to be supplied, in particular, over-voltage, under-voltage and over-fluxing protection element settings;
- a curve (similar to that shown in Figure S5.1a.1 of the Rules) showing the range of voltages for which the generating system can ride through, time domain dynamic studies showing the generating system's ability to remain connected for that range of voltages, and a description as to whether the limiting voltage is determined by the protection system, or the generating system itself; and
- equipment specifications for its generating system, including auxiliaries that detail the voltage operating capability.

The assessment will consider if any auxiliary plant needed to support the generating system's performance can also withstand the voltage disturbance. For example, if a wind farm requires a static synchronous compensator (STATCOM) to meet its proposed performance standard, evidence of the STATCOM performance during the voltage disturbance should be provided.

Operational arrangements to meet the agreed levels of performance must be described in the proposed performance standard and included in the assessment.

Where a proposed performance standard is below the automatic access standard, the assessment must consider and list:

- the expected performance of the existing network and considered future transmission projects;
- the expected performance of existing generating system and other relevant projects3; and
- any corresponding performance standard (or where no performance standard has been registered, the relevant access standard) that allows the generating system to trip for voltage excursions in ranges specified in the automatic access standards.

AEMO can only accept the proposed performance standard where the following considerations are addressed:

- The proposed performance standard is as close as practicable to the automatic access standard while respecting the need to protect the generating system from damage. Negotiations should ensure that all of the available features of the generating system relevant to voltage control and disturbance ride-through are enabled and that any further improvement in performance would only be achieved at a significant additional cost to the generator. This is particularly relevant for wind farms where manufacturers typically offer a range of control system options on a particular turbine model.
- The generating system that would be tripped as a result of any voltage excursion within levels specified in the automatic access standard should not be more than 100 MW. A higher limit may be acceptable provided that there would be no adverse impact on network constraints, quality of supply to other network users or power system security. This limit will depend on the network conditions at the proposed connection point, including fault level, customer load, other nearby generation and proximity to transmission interconnections.
- There would be no material adverse impact on quality of supply to other network users or to power system security.

10.5 Generating system response to disturbances following contingency events (Clause S5.2.5.5)

These technical requirements consider the response of the generating system to all disturbances, including network faults, and credible contingency events. Aspects of this provision overlap with clauses S5.2.5.3 and S5.2.5.4 (see Sections 10.3 and 10.4).

Assessment of a proposed performance standard requires that time domain dynamic studies showing the generating system's (and each of its generating units) ability to remain connected for

[3] For the purposes of clause S5.2.5.4 of the NER, AEMO considers that "relevant projects" include the following as a minimum:

- committed generation projects, and
- generation projects that have a significant impact on the surrounding network and which, in the reasonable opinion of both the relevant NSP and AEMO, are likely to proceed – such projects would typically have advanced beyond the connection enquiry stage (clause 5.3.2 of the NER), but may not yet have reached the stage of finalising a connection agreement (clause 5.3.7).

the range of faults described in clause S5.2.5.5. Studies are expected to cover a range of operating conditions, including as a minimum:

- maximum power generation in the over-excited and under-excited regions;
- light, medium and high regional demand; and
- high and low level of interconnector transfer conditions.

There may be additional requirements for the generating system during and after the fault detailed in the proposed performance standard; these must be addressed in the studies. For example, where the automatic access standard is proposed, fault simulation studies should demonstrate the following generating system performance:

- Supply of pre-disturbance reactive current during the fault or, if greater, reactive current equal to 4% of maximum continuous current for each 1% reduction in the connection point voltage (e.g. for a 50% drop in connection point voltage, the generating unit should supply 200% of its rated current).
- The achievement of 95% of the pre-fault active power output within 100ms of fault clearance.

Operational arrangements required to meet the agreed level of performance, under both normal and abnormal network or generating system conditions, must be described in the proposed performance standard and included in the assessment. This may include, for example, control settings for generating unit terminal voltage or transformer tap changers. Any settings required to meet the proposed performance standard must be consistent with the requirements of all other access standards, particularly reactive capability under clause S5.2.5.1 of the Rules.

Where a proposed performance standard is below the automatic access standard, it must be set such that the system standards described in clause S5.1a of the Rules would be met with other relevant projects[4] at their agreed performance standard. Where a performance standard does not exist, a level of performance not greater than the automatic access standard is assumed for the relevant project.

The assessment must also consider the expected range of power system operating conditions and the expected performance of:

- existing networks and considered transmission projects (the access standards must be applicable both with and without the considered transmission projects, in any combination);
- existing generating system and other relevant projects; and
- control systems and protection systems, including auxiliary systems and automatic reclose equipment (any required modifications to control systems or protection systems should form part of the works to connect the generating system).

The proposed performance standard must not cause other generating systems or loads to trip as a result of an event for which they would not have otherwise tripped.

10.6 Quality of electricity generated and continuous uninterrupted operation (Clause S5.2.5.6)

These technical requirements consider the quality of supply with respect to voltage fluctuations, harmonic voltage distortion and voltage unbalance at the connection point for which a generating system is required to remain connected.

[4] The definition of “relevant projects” applied for the assessment of Clause S5.2.5.4 of the Rules also applies for the assessment of Clause S5.2.5.5.

The generator must provide confirmation to the connecting NSP that their generating system can remain in continuous uninterrupted operation for the assigned levels of voltage fluctuation, harmonic voltage distortion and voltage unbalance at the connection point. The generator may be required to provide reports or evidence on how the generating system will remain in continuous uninterrupted operation for the assigned levels.

AEMO can only accept the proposed performance standard when a commitment from the generator detailing its ability to meet the proposed performance standard has been received and approved by the connecting NSP. A minimum access standard only has been specified for this requirement.

10.7 Partial load rejection (S5.2.5.7)

These technical requirements consider the ability of a synchronous generating system to remain connected during and following the loss of power system load. It does not apply to an asynchronous generating system. A load rejection event could be expected to result in power system frequency increasing, so aspects of this requirement overlap with clause S5.2.5.3 (see Section 10.3), but this clause is intended to ensure that generating system controls do not move in the wrong direction in response to a sudden frequency change. Therefore, aspects of clause S5.2.5.11 (see Section 10.11) must also be considered.

Assessment requires time domain dynamic studies showing the generating system's ability to remain connected for a load rejection event. These studies must include any active power control models. Modelling of the load rejection event should be appropriate to the generating unit technology. For example, for a large thermal synchronous generating unit it would be acceptable to have the generating system supplying load in isolation from the rest of the power system, and then stepping or ramping this load to simulate the partial load rejection.

Where a proposed performance standard is below the automatic access standard it must record the actual partial load rejection performance.

10.8 Protection of generating systems from power system disturbances (S5.2.5.8)

These technical requirements consider the performance of those protection systems that disconnect and prevent damage to a generating system from a power system disturbance.

Assessment requires details of the protection system to be supplied, in particular:

- a protection single line diagram (SLD), or SLDs, detailing all relevant protection AC circuits and circuit breaker tripping logic;
- a protection design report[5] that includes:
  - the derivation of individual protection element pickups and operating times;
  - confirmation that fault clearance trips specified in Table S5.1a.2 of the Rules can be achieved; and
  - assessment of the suitability of chosen protection current transformers; and
- confirmation of a coordinated design for the interface between the generating system and the connecting NSP's network by the provision of a letter from the connecting NSP.

[5] In addition to addressing the requirements of clause S5.2.5.8, the protection design report must also address the assessment needs for clauses S5.2.5.3, S5.2.5.4 and S5.3.5.9.

During the assessment, consideration should be given as to whether there is a requirement for a local or remote control scheme to automatically disconnect the generating system under an islanding condition.

AEMO can only accept the proposed performance standard when AEMO considers that it describes those conditions for which the generating system must, and must not, trip.

10.9 Protection systems that impact on power system security (S5.2.5.9)

These technical requirements consider the performance of those protection systems that prevent a fault in the generating system from causing a power system security incident.

Assessment requires that details of the protection system be provided. These details would already have been supplied for assessment under clause S5.2.5.8 (i.e. design report, SLDs and confirmation of a coordinated design, see Section 10.8).

10.10 Protection to trip plant for unstable operation (S5.2.5.10)

These technical requirements consider the performance of those protection systems that prevent an active power, reactive power, or voltage instability at the connection point, such as a pole slip for a synchronous generating unit.

Assessment requires details of the protection system, as supplied for assessment of clause S5.2.5.8 (i.e. design report and SLDs, see Section 10.8). The design report should explain the derivation of settings that, in the case of instability at the connection point, may require time domain dynamic studies. In the case of a pole slip, this would be an RX plot of the impedance seen by the pole slip protection relay during the fault/contingency conditions specified in clause S5.2.5.5, superimposed on the protection relay operating characteristic. In conducting its assessment, the connecting NSP or AEMO may require that a protection system be installed to prevent consequential tripping or damage to other generating units, the network, or the facilities of other network users or prevent unstable operation that has an adverse impact on power system security.

Where a proposed performance standard is below the automatic access standard, agreement must be reached by all parties for the protection system to trip any other part of the generating system in order to stop the instability.

10.11 Frequency control (S5.2.5.11)

These technical requirements consider the performance of the frequency control system and the ability of the generating system to increase or decrease its active power output in response to a power system frequency event. Some aspects of this provision overlaps with clause S5.2.5.7 (see Section 10.7).

Assessment requires:

- details of the control system to be supplied, in particular, operating modes (e.g. does it switch to isochronous mode when the generating system is in islanded operation?), topology, control system time constants6, droop settings and operating dead bands; and
- time domain dynamic studies showing the active power response for changes in power system frequency.

Consideration must be given to ensure any market ancillary services to be provided by the generating system do not exceed those which would be consistent with the proposed performance standard.

[6] Note that if time constants associated with control systems are relatively small, it may be necessary to conduct an analysis to ensure the governing response is adequately damped.

Where a proposed performance standard is below the automatic access standard it must have been demonstrated that the increase and decrease in active power transfer is as close as practicable to the automatic access standard. It must also include the agreed values for maximum and minimum operating levels.

AEMO can only accept the proposed performance standard when it has been demonstrated that the control system used for frequency control is adequately damped.

10.12 Impact on network capability (S5.2.5.12)

These technical requirements consider the impact of the generating system on inter-regional, and intra-regional transfer capability. As small-signal stability can restrict inter-regional transfer, and is of particular concern for AEMO, aspects of this provision overlap with clause S5.2.5.13 (see Section 10.13). Network capability is influenced by the excitation system design, in particular the design of power system stabilisers (PSSs).

Assessment requires steady state load flow and time domain dynamic studies showing the impact of the generating system on key inter-regional and intra-regional transfer limits. TNSPs can provide advice as to the key limitations to be considered for a given inter-regional or intra-regional transfer, be it a voltage or transient stability limit, or a thermal limitation. As NSPs are responsible for providing advice as to how AEMO is to operate their networks, and are familiar with modelling assumptions used to derive network operating limits, the assessment is often undertaken by the connecting NSP. Assessment also requires frequency domain (small-signal) studies showing the impact of the generating system on key inter-area modes.

Studies are expected to cover a range of operating conditions, including, as a minimum:

- maximum power generation in the over-excited and under-excited region;
- light, medium and high regional demand; and

high and low level of interconnector transfer conditions.

Where a proposed performance standard is below the automatic access standard, the assessment must consider:

- the expected performance of:
  - existing networks and considered transmission projects;
  - existing generating systems and other relevant projects7; and
  - control systems and protection systems, including auxiliary systems and automatic reclose equipment;
- the expected range of power system operating conditions;
- whether a control system could minimise any reduction in power transfer capability; and
- whether operational arrangements are necessary to ensure that the generating system is operated to meet at least the minimum access standard under abnormal network and generating system conditions, so that power system security can be maintained.

Where a proposed performance standard is below the automatic access standard and a control system to minimise a reduction in power transfer capability has been included, the generating system capabilities, control systems and operational arrangements to be maintained by the Generator are to be detailed in the performance standard.

[7] The definition of “relevant projects” as applied for the assessment of clause S5.2.5.4, also applies for clause S5.2.5.12.

10.13 Voltage and reactive power control (S5.2.5.13)

These technical requirements consider the performance of the voltage control system, and the ability of the generating system to increase or decrease its reactive power output in response to a power system incident. Aspects of this provision overlap with clauses S5.2.5.1 and S5.2.5.12 (see Sections 10.1 and 10.12).

Assessment requires details of the voltage and reactive control system to be supplied, time domain dynamic studies that demonstrate the adequacy of the voltage and reactive control system(s) and are consistent with typical commissioning tests, and frequency domain (small-signal) studies.

For a synchronous generating unit, details of the voltage and reactive control system would be in the form of an excitation system design report that includes a block diagram and the derivation of key control system parameters. The coordination of excitation limiters with protection can be covered in the excitation system design report, or in the protection design report required for clause S5.2.5.8. Where a PSS is being installed, detail on how the design parameters were determined is also required. For a wind farm, PV solar power station or other asynchronous generating systems, details of the voltage and reactive power control system would include a block diagram and the derivation of key control system parameters for individual component voltage and reactive power control, and, where installed, the overall park voltage control scheme.

The time domain dynamic studies should demonstrate the adequacy of the voltage and reactive control system(s) and be consistent with typical commissioning tests. In the case of a synchronous generating unit[8], this would include, though not be limited to, step response studies with the following:

- the generating unit unsynchronised, demonstrating adequate damping;
- the generating unit synchronised, demonstrating adequate damping with steps proving the performance of both over-excitation and under-excitation limiters;
- the generating unit synchronised, demonstrating the performance of over-excitation and under-excitation limiters against the Rules requirements; and
- excitation/voltage control sensitivity, rise time and ceiling voltage.

In the case of a wind farm or PV solar power station this would include, though not be limited to, steps into the overall generating system voltage control scheme.

The frequency domain (small-signal) studies should show:

- that local modes of oscillation are adequately damped;
- the damping performance of the PSS (if installed); and
- in the case of a wind farm or PV solar power station, the impact of displacing synchronous generating units with an asynchronous generating system.

Confirmation is required of a coordinated design between the generating system and any existing NSP voltage control schemes in the surrounding network by the provision of a letter from the connecting NSP.

The proposed performance standard can be accepted by AEMO following confirmation of a coordinated design between the generating system voltage and reactive power control system, and any existing NSP voltage control systems.

Where a proposed performance standard is below the automatic access standard, it can be accepted if the generator has demonstrated to the NSP why the automatic access standard cannot be reasonably achieved and the negotiated access standard is the highest level that the generating

[8] Refer to the Excitation Control System Design Guidelines for further details on the range of studies to cover.

system can reasonably achieve, including by installation of additional dynamic reactive power equipment and through optimising its control systems.

10.14 Active power control (S5.2.5.14)

These technical requirements consider the ability of a generating system to increase or decrease its active power transfer in response to a dispatch instruction from AEMO, as opposed to a frequency event described in clause S5.2.5.11.

Assessment requires details of the active power control system to be supplied, which may include schematic diagrams of the overall control scheme and a qualitative description of the active power control system with sufficient detail to allow AEMO to understand how the generating system will respond to dispatch targets and whether any time constants are sufficiently small to require a model suitable for dynamic studies to be supplied.

Where a proposed performance standard is below the automatic access standard, the assessment must consider:

- whether there may be a future need to upgrade facilities to receive electronic instructions and fully implement them within five minutes if the number or frequency of verbal instructions becomes difficult to manage; and
- if there is a need to document any operational arrangements to manage network flows, including any requirements for the generating system to be operated in a manner that prevents its output changing within five minutes by more than an amount specified by a control centre.

The proposed performance standard can be accepted by AEMO when it has been demonstrated that the active power control system is adequately damped.

Where a proposed performance standard is below the automatic access standard, it can be accepted if the operational arrangements necessary to manage network flows, such as a requirement for a generating system to prevent its output changing within five minutes by more than an amount specified by a control centre, has been documented to AEMO's satisfaction.

10.15 Remote monitoring (S5.2.6.1)

These technical requirements consider the level of remote monitoring required for AEMO control centres to monitor the performance of the generating system.

Assessment requires:

- a list of operational data to be supplied to AEMO by the generator9; and
- confirmation that the generator's communications facilities meet AEMO's Standard for Power System Data Communications (available at AEMO's website).

10.16 Communications equipment (S5.2.6.2)

These technical requirements consider the communications between the generator and AEMO's control centre(s), and the electrical supply to the installed remote monitoring and control equipment.

Assessment requires design details of the communication facilities to be installed. This may include schematic diagrams and a qualitative description of the communication facilities with sufficient detail to allow AEMO to understand fully the communication facilities being installed.

[9] Remote monitoring requirements of new generating systems are described in Appendix 2 of Connecting New Generation – A Process Overview (available on AEMO's website).

Where a proposed performance standard is below the automatic access standard, the assessment must consider if:

- a back-up telephone facility independent of commercial telephone service providers is required;
- a communications path (with appropriate redundancy) from the remote monitoring or control equipment installed to a communications interface agreed with the NSP (with the NSP responsible for the communication path back to AEMO) has been provided; and
- appropriate accommodation and secure power supplies for any NSP facilities have been provided.

Where a proposed performance standard is below the automatic access standard, it can be accepted where:

- a communications path (with appropriate redundancy) from the remote monitoring or control equipment installed to a communications interface agreed with the NSP has been provided; and
- appropriate accommodation and secure power supplies for any NSP facilities has been provided.

10.17 Power station auxiliary supplies (S5.2.7)

These technical requirements consider how a generating system gains auxiliary power.

Assessment requires advice from the generator on how power is supplied to the auxiliary load of its generating system. Where active power is supplied from an alternative connection point to that through which a generating system's active power is transferred, performance standards must be established under clause S5.3.5. An SLD showing the connection arrangements, auxiliary loads and how the auxiliary power is supplied is required.

Clause S5.2.7 is not an AEMO advisory matter, except where active power is supplied from an alternative connection point. Clause S5.3.5 is an AEMO advisory matter.

10.18 Fault current (S5.2.8)

These technical requirements consider the fault current contribution of a generating system to the connecting network, and the fault current withstand of the both generating system and those circuit breakers used to isolate it from the network.

Acceptance requires that assessment be completed by the connecting NSP to define:

- maximum and minimum fault levels at the point of connection;
- maximum and minimum fault levels in the wider network; and
- equipment specifications for the generating system that specify the fault withstand capability required.

The NSP also needs to ensure that:

- protection setting details provided for clauses S5.2.5.8 and S5.2.5.9 are appropriate for the equipment; and
- the agreed fault contribution from the generating system will not result in the fault withstand capability of the surrounding network to be exceeded.

AEMO can accept the proposed performance standard when confirmation has been received that the connecting NSP has also accepted the proposed performance standard.