Dear Mr Graham,

RE: Connecting embedded energy rule change (ERC0147) submission—technical assessment of automatic right of connection

The Property Council’s Embedded Energy Technical Working Group undertook an assessment of the performance requirements in Chapter 5 of the National Electricity Rules (NER). The group specifically assessed the applicability of these requirements to medium sized embedded generators.

The assessment is attached and the group’s observations are those marked up and shown as comments.

Principally, this assessment found that the existing provisions in Chapter 5’s Technical Schedules 5.1, 5.2, 5.3 and 5.36 could be made less onerous to enable medium sized generators grid connection without compromising the electricity grid’s safety and reliability. This will involve a significant amount of technical input to upgrade these technical terms.

Other ways to permit an automatic right of connection for medium sized embedded generators include:

- Developing a national standard(s), as per the precedent of AS4777, which is for micro embedded generators; and
- Using existing equipment manufacturers’ specifications.

The South Australian distributor, ETSA Utilities, used a manufacturer’s specifications in order to verify the performance capabilities of a recent medium sized embedded generator. As a result, that embedded generator was successfully connected to the electricity grid to ETSA’s satisfaction.

The Embedded Energy Technical Working Group’s assessment is designed to shed light on the ability of embedded generators to receive an ‘automatic right of connection’ to the electricity grid. This would only be provided if embedded generators satisfy performance criteria.
An automatic right of connection is a key solution in Rule Change ERC0147 that is before the AEMC. It was proposed by ClimateWorks Australia, Seed Advisory and the Property Council of Australia.

Chapter 5 of the NER has existing provisions to allow for the connection of very large generators, mainly those generators with ratings of 30 MVA and above.

This assessment provides commentary of the appropriateness of these provisions for medium sized generators with ratings up to and equal to 5 MVA.

To discuss this work further please contact the Energy Reform Project Manager, Mendo Kundevski, on 0419 750 417.

Yours sincerely,

Jennifer Cunich
Executive Director
Victoria Division
Schedule 5.1a  System standards

S5.1a  Purpose

The purpose of this schedule is to establish system standards that:

(a) are necessary or desirable for the safe and reliable operation of the facilities of Registered Participants;
(b) are necessary or desirable for the safe and reliable operation of equipment;
(c) could be reasonably considered good electricity industry practice; and
(d) seek to avoid the imposition of undue costs on the industry or Registered Participants.

A Registered Participant should not, by virtue of this schedule, rely on system standards being fully complied with at a connection point under all circumstances. However, a Registered Participant should expect to be reasonably informed of circumstances where the standard of supply at its connection points will not conform to the system standards.

Except for standards of frequency and system stability, a Registered Participant should have the opportunity to negotiate or renegotiate relevant terms of a connection agreement (including relevant charges), to improve the standard of supply to the level of the system standard.

The system standards are set out below.

S5.1a.2  Frequency

The frequency operating standards are system standards and are as determined by the Reliability Panel and published by the AEMC.

S5.1a.3  System stability

The power system should remain in synchronism and be stable:

(a) Transient stability: following any credible contingency event; and
(b) Oscillatory stability: in the absence of any contingency event, for any level of inter-regional or intra-regional power transfer up to the applicable operational limit; and
(c) Voltage stability: stable voltage control must be maintained following the most severe credible contingency event.

For the purposes of clause S5.1a.3 a credible contingency event includes the application of a fault (other than a three-phase fault) to any part of the power system and de-energisation of the faulted element within the allowable clearance time applicable to that element according to clause S5.1a.8.

The halving time of any inter-regional or intra-regional oscillation, being the time for the amplitude of an oscillation to reduce by half, should be less than 10 seconds. To allow for planning and operational uncertainties, the power system should be planned and operated to achieve a halving time of 5 seconds.

Comment [ABT1]: This clause applies to a regional network and not necessarily a local network. System stability is important and requirements for transient stability, oscillatory stability, voltage stability needs to be defined in for local generation context. This clause needs re-writing.
S5.1a.4  Power frequency voltage

Except as a consequence of a contingency event, the voltage of supply at a connection point should not vary by more than 10 percent above or below its normal voltage, provided that the reactive power flow and the power factor at the connection point is within the corresponding limits set out in the connection agreement.

As a consequence of a credible contingency event, the voltage of supply at a connection point should not rise above its normal voltage by more than a given percentage of normal voltage for longer than the corresponding period shown in Figure S5.1a.1 for that percentage.

As a consequence of a contingency event, the voltage of supply at a connection point could fall to zero for any period.

Figure S5.1a.1

S5.1a.5  Voltage fluctuations

The voltage fluctuation level of supply should be less than the “compatibility levels” set out in 1 of Australian Standard AS/NZS 61000.3.7:2001. To facilitate the application of this standard, Network Service Providers must establish “planning levels” for their networks as provided for in the Australian Standard.

The following principles apply to the use of the shared network:

(a) the sharing between Network Users of the capability of connection assets to withstand voltage fluctuations is to be managed by Network Service Providers in accordance with the provisions of clause S5.1.5 of schedule 5.1; and
(b) to the extent practicable, the costs of managing or abating the impact of voltage fluctuations in excess of the costs which would result from the application of an automatic access standard are to be borne by those Network Users whose facilities cause the voltage fluctuations.

S5.1a.6 Voltage waveform 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 Network Service Providers must establish “planning levels” for their networks as provided for in the Australian Standard.

The following principles apply to the use of the shared network:

(a) the sharing between Network Users of the capability of connection assets to absorb or mitigate harmonic voltage distortion is to be managed by Network Service Providers in accordance with the provisions of clause S5.1.6 of schedule 5.1; and

(b) to the extent practicable, the costs of managing or abating the impact of harmonic distortion in excess of the costs which would result from the application of an automatic access standard are to be borne by those Network Users whose facilities cause the harmonic voltage distortion.

S5.1a.7 Voltage unbalance

Except as a 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 a consequence of a credible contingency 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.

For the purpose of this clause, voltage unbalance is measured as negative sequence voltage.
Table S5.1a.1

<table>
<thead>
<tr>
<th>Nominal supply voltage (kV)</th>
<th>Maximum negative sequence voltage (% of nominal voltage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column 1</td>
<td>Column 2</td>
</tr>
<tr>
<td></td>
<td>no contingency event</td>
</tr>
<tr>
<td></td>
<td>30 minute average</td>
</tr>
<tr>
<td>more than 100</td>
<td>0.5</td>
</tr>
<tr>
<td>more than 10 but not more than 100</td>
<td>1.3</td>
</tr>
<tr>
<td>10 or less</td>
<td>2.0</td>
</tr>
</tbody>
</table>

S5.1a.8 Fault clearance times

(a) Faults anywhere within the power system should be cleared sufficiently rapidly that:

1. the power system does not become unstable as a result of faults that are credible contingency events;
2. inter-regional or intra-regional power transfers are not unduly constrained; and
3. consequential equipment damage is minimised.

(b) The fault clearance time of a primary protection system for a short circuit fault of any fault type anywhere:

1. within a substation;
2. within connected plant; or
3. on at least the half of a power line nearer to the protection system, should not exceed the relevant time in column 2 of Table S5.1a.2 for the nominal voltage that applies at the fault location.

(c) The fault clearance time of a primary protection system for a short circuit fault of any fault type anywhere on the remote portion of a power line for which the near portion is protected by a primary protection system under clause S5.1a8(b) should not exceed the relevant time in column 3 of Table S5.1a.2 for the nominal voltage that applies at the fault location.

(d) The fault clearance time of a breaker fail protection system or similar back-up protection system for a short circuit fault of any fault type should not exceed the relevant time in column 4 of Table S5.1a.2 for the nominal voltage that applies at the fault location.
(e) The owner of the faulted element may require shorter fault clearance times to minimise plant damage.

(f) The allowable fault clearance times specified in Table S5.1a.2 apply in accordance with the provisions of clause S5.1.9 to facilities constructed or modified on or after the performance standards commencement date.

(g) For facilities other than those referred to in clause S5.1a.8(f), the applicable allowable fault clearance times must be derived by the relevant Network Service Provider from the existing capability of each facility on the performance standards commencement date.

Table S5.1a.2

<table>
<thead>
<tr>
<th>Nominal voltage at fault location (kV)</th>
<th>Time (milliseconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column 1</td>
<td>Column 2</td>
</tr>
<tr>
<td>400kV and above</td>
<td>80</td>
</tr>
<tr>
<td>at least 250kV but less than 400kV</td>
<td>100</td>
</tr>
<tr>
<td>more than 100kV but less than 250kV</td>
<td>120</td>
</tr>
<tr>
<td>less than or equal 100 kV</td>
<td>As necessary to prevent plant damage and meet stability requirements</td>
</tr>
</tbody>
</table>

Schedule 5.1 Network Performance Requirements to be Provided or Co-ordinated by Network Service Providers

S5.1.1 Introduction

This schedule describes the planning, design and operating criteria that must be applied by Network Service Providers to the transmission networks and distribution networks which they own, operate or control. It also describes the requirements on Network Service Providers to institute consistent processes to determine the appropriate technical requirements to apply for each connection enquiry or application to connect processed by the Network Service Provider with the objective that all connections satisfy the requirements of this schedule.

The criteria and the obligations of Registered Participants to implement them, fall into two categories, namely:

(a) those required to achieve adequate levels of network power transfer capability or quality of supply for the common good of all, or a significant number of, Registered Participants; and
those required to achieve a specific level of network service at an individual connection point.

A Network Service Provider must:

(1) fully describe the quantity and quality of network services which it agrees to provide to a person under a connection agreement in terms that apply to the connection point as well as to the transmission or distribution system as a whole;

(2) ensure that the quantity and quality of those network services are not less than could be provided to the relevant person if the national grid were planned, designed and operated in accordance with the criteria set out in this clause S5.1.1 and recognising that levels of service will vary depending on location of the connection point in the network; and

(3) observe and apply the relevant provisions of the system standards in accordance with this schedule 5.1.

To the extent that this schedule 5.1 does not contain criteria which are relevant to the description of a particular network service, the Network Service Provider must describe the network service in terms which are fair and reasonable.

This schedule includes provisions for Network Service Providers and Registered Participants to negotiate the criteria to apply to a connection within defined ranges between a lower bound (minimum access standard) and an upper bound (automatic access standard). All criteria which are intended to apply to a connection must be recorded in a connection agreement. Where it is intended to apply a negotiated access standard in accordance with clause 5.3.4A of the Rules, the Network Service Provider must first be satisfied that the application of the negotiated access standard will not adversely affect other Registered Participants.

S5.1.2 Network reliability

S5.1.2.1 Credible contingency events

Network Service Providers must plan, design, maintain and operate their transmission networks and distribution networks to allow the transfer of power from generating units to Customers with all facilities or equipment associated with the power system in service and may be required by a Registered Participant under a connection agreement to continue to allow the transfer of power with certain facilities or plant associated with the power system out of service, whether or not accompanied by the occurrence of certain faults (called credible contingency events).

The following credible contingency events and practices must be used by Network Service Providers for planning and operation of transmission networks and distribution networks unless otherwise agreed by each Registered Participant who would be affected by the selection of credible contingency events:

(a) The credible contingency events must include the disconnection of any single generating unit or transmission line, with or without the application of a single circuit two-phase-to-ground solid fault on lines operating at or
above 220 kV. and a single circuit three-phase solid fault on lines operating below 220 kV. The Network Service Provider must assume that the fault will be cleared in primary protection time by the faster of the duplicate protections with installed intertrips available. For existing transmission lines operating below 220 kV but above 66 kV, a two-phase to earth fault criterion may be used if the modes of operation are such as to minimise the probability of three-phase faults occurring and operational experience shows this to be adequate, and provided that the Network Service Provider upgrades performance when the opportunity arises.

(b) For lines at any voltage above 66 kV which are not protected by an overhead earth wire and/or lines with tower footing resistances in excess of 10 ohms, the Network Service Provider may extend the criterion to include a single circuit three-phase solid fault to cover the increased risk of such a fault occurring. Such lines must be examined individually on their merits by the relevant Network Service Provider.

e) For lines at any voltage above 66 kV, a Network Service Provider must adopt operational practices to minimise the risk of slow fault clearance in case of inadvertent closing on to earths applied to equipment for maintenance purposes. These practices must include but not be limited to:

(1) Not leaving lines equipped with intertrips alive from one end during maintenance; and

(2) Off-loading a three terminal (tee connected) line prior to restoration, to ensure switch on to fault facilities are operative.

d) The Network Service Provider must ensure that all protection systems for lines at a voltage above 66 kV, including associated intertripping, are well maintained so as to be available at all times other than for short periods (not greater than eight hours) while the maintenance of a protection system is being carried out.

S5.1.2.2 Network service within a region

The following paragraphs of this section set out minimum standards for certain network services to be provided to Registered Participants by Network Service Providers within a region. The amount of network redundancy provided must be determined by the process set out in clause 5.6.2 of the Rules and is expected to reflect the grouping of generating units, their expected capacity factors and availability and the size and importance of Customer groups.

The standard of service to be provided at each connection point must be included in the relevant connection agreement, and must include a power transfer capability such as that which follows:

(a) In the satisfactory operating state, the power system must be capable of providing the highest reasonably expected requirement for power transfer (with appropriate recognition of diversity between individual peak requirements and the necessity to withstand credible contingency events) at any time.

(b) During the most critical single element outage the power transfer available through the power system may be:
(1) zero (single element supply);
(2) the defined capacity of a backup supply, which, in some cases, may be provided by another Network Service Provider;
(3) a nominated proportion of the normal power transfer capability (eg 70 percent); or
(4) the normal power transfer capability of the power system (when required by a Registered Participant).

In the case of clauses S5.1.2.2(b)(2) and (3) the available capacity would be exceeded sufficiently infrequently to allow maintenance to be carried out on each network element by the Network Service Provider. A connection agreement may state the expected proportion of time that the normal capability will not be available, and the capability at those times, taking account of specific design, locational and seasonal influences which may affect performance, and the random nature of element outages.

A connection agreement may also state a conditional power transfer capability that allows for both circuits of a double circuit line or two closely parallel circuits to be out of service.

S5.1.2.3 Network service between regions

The power transfer capability between regions must be determined by the process set out in rules 5.6 and 5.6A.

The following paragraphs of this section set out a framework within which Network Service Providers must describe to AEMO the levels of network service that apply for power transfer between regions. In cases where power transfer capability is determined by stability considerations on the power system (refer to clause S5.1.8 of this schedule) it is expected that line outages within transmission networks within a region will weaken the network so as to result in reduced power transfer capability even in the absence of outages of the lines between regions.

(a) In the satisfactory operating state the power transfer capability between regions is defined by a multi-term equation for each connection between regions which takes account of all power system operating conditions which can significantly impact on performance. The majority of these operating conditions are the result of market operation and are outside the control of the Network Service Provider. In the satisfactory operating state the network must be planned by the Network Service Provider and operated by AEMO to withstand the impact of any single contingency with severity less than the credible contingency events stated in clause S5.1.2.1.

(b) During critical single element outages reduced power transfer capabilities will apply. In those cases where outage of the remaining element will result in breaking of the connection between the regions AEMO must provide for the effect on power system frequency in the separate transmission systems following this event when determining the maximum power transfer.

Comment [ABT7]: A localised system is not deemed to be a regional system.

Comment [ABT8]: Not Applicable
S5.1.3 Frequency variations

A Network Service Provider must ensure that within the extreme frequency excursion tolerance limits all of its power system equipment will remain in service unless that equipment is required to be switched to give effect to load shedding in accordance with clause S5.1.10, or is required by AEMO to be switched for operational purposes.

Sustained operation outside the extreme frequency excursion tolerance limits need not be taken into account by Network Service Providers in the design of plant which may be disconnected if this is necessary for the protection of that plant.

S5.1.4 Magnitude of power frequency voltage

A Transmission Network Service Provider must plan and design its transmission system and equipment for control of voltage such that the minimum steady state voltage magnitude, the maximum steady state voltage magnitude and variations in voltage magnitude are consistent with the levels stipulated in clause S5.1a.4 of the system standards.

(a) The Network Service Provider must determine the automatic access standard for the voltage of supply at the connection point such that the voltage may vary in accordance with clause S5.1a.1 of the system standards.

(b) The Network Service Provider must determine the minimum access standard for the voltage of supply at the connection point such that the voltage may vary:

1. as a consequence of a credible contingency event in accordance with clause S5.1a.4; and
2. otherwise, between 95 percent and 105 percent of the target voltage.

(c) For the purposes of clause S5.1.4(b) the target voltage must be determined as follows:

1. if the connection point is connected to a transmission line (but not through a transformer), the Network Service Provider must determine the target voltage in consultation with AEMO taking into account the capability of existing facilities that are subject to that supply voltage; and
2. otherwise, Network Users that share the same supply voltage must jointly determine the target voltage which may be specified to vary with aggregate loading level, provided that at all times the supply voltage remains between 90 percent and 110 percent of the normal voltage determined in accordance with clause S5.1a.4 except as a consequence of a contingency event.

(d) For the purposes of this clause, the voltage of supply is measured as the RMS phase voltage.

Where the independent control of voltage at the connection point is possible without adverse impact on voltage control at another connection point, the Network Service Provider must make reasonable endeavors to meet the request. The target voltage and any agreement to a target range of voltage magnitude must
be specified in the relevant connection agreement. The agreement may include a different target range in the satisfactory operating state and after a credible contingency event (and how these target ranges may be required to vary with loading).

A Network Service Provider must ensure that each facility that is part of its transmission network or distribution network is capable of continuous uninterrupted operation in the event that variations in voltage magnitude occur due to faults external to the facility. The design of a facility should anticipate the likely time duration and magnitude of variations in the power frequency phase voltages which may arise dependent on the nature and location of the fault.

S5.1.5 Voltage fluctuations

A Network Service Provider must use reasonable endeavours to design and operate its transmission system or distribution system and include conditions in connection agreements in relation to the permissible variation with time of the power generated or load taken by a Network User to ensure that other Network Users are supplied with a power frequency voltage which fluctuates to an extent that is less than the levels stipulated in accordance with the provisions of clause S5.1a.5 of the system standards and this clause S5.1.5.

In accordance with AS/NZS 61000.3.7:2001 and guidelines published by Standards Australia and applying the assumption that Customers will comply with their obligations under schedule 5.3, a Network Service Provider must determine “Planning Levels” for connection points on their network in order to maintain voltage fluctuation levels for all supply points to customers supplied from their network below the “Compatibility Levels” defined in Table 1 of AS/NZS 61000.3.7:2001.

The Network Service Provider must allocate emission limits in response to a connection enquiry or an application to connect and evaluate the acceptability for connection of fluctuating sources as follows:

(a) Automatic access standard: the Network Service Provider must allocate emission limits no more onerous than the lesser of the acceptance levels determined in accordance with either of the stage 1 or the stage 2 evaluation procedures defined in AS/NZS 61000.3.7:2001.

(b) Minimum access standard: subject to clause S5.1.5(c), the determination by the Network Service Provider of acceptable emission limits must be undertaken in consultation with the party seeking connection using the stage 3 evaluation procedure defined in AS/NZS 61000.3.7:2001.

(c) In respect of each new connection at a level of performance below the automatic access standard the Network Service Provider must include provisions in the relevant connection agreement requiring the Network User if necessary to meet the system standards or allow connection of other Network Users to either upgrade to the automatic access standard or fund the reasonable cost of the works necessary to mitigate their effect of connecting at a standard below the automatic access standard.
(d) If for existing customer connections the level of voltage fluctuation is, or may be, exceeded as a result of a proposed new connection, the Network Service Provider must, if the cause of that excessive level cannot be remedied by enforcing the provisions of existing connection agreements, undertake all reasonable works necessary to meet the technical standards in this schedule or to permit the proposed new connection within the requirements stated in this clause.

For other than a new connection in accordance with the preceding paragraph, the responsibility of a Network Service Provider for excursions in voltage fluctuations above the levels defined above is limited to voltage fluctuations caused by network plant and the pursuit of all reasonable measures available under the Rules and its connection agreements.

S5.1.6 Voltage harmonic or voltage notching distortion

A Network Service Provider must use reasonable endeavours to design and operate its network and include conditions in connection agreements to ensure that the effective harmonic voltage distortion at any point in the network will be limited to less than the levels stipulated in accordance with the provisions of clause S5.1a.6 of the system standards and this clause S5.1.6.

In accordance with AS/NZS 61000.3.6:2001 and guidelines published by Standards Australia and applying the assumption that Customers will comply with their obligations under schedule 5.3 Network Service Providers must determine “Planning Levels” for connection points on their network in order to maintain harmonic voltage distortion for all supply points to customers supplied from their network below the “Compatibility Levels,” defined in Table 1 of AS/NZS 61000.3.6:2001.

The Network Service Provider must allocate emission limits to a connection enquiry or an application to connect and must evaluate the acceptability for connection of distorting sources as follows:

(a) Automatic access standard: the Network Service Provider must allocate emission limits no more onerous than the lesser of the acceptance levels determined in accordance with either of the stage 1 or the stage 2 evaluation procedures defined in AS/NZS 61000.3.6:2001.

(b) Minimum access standard: subject to clause S5.1.6(c), the determination by the Network Service Provider of acceptable emission limits must be undertaken in consultation with the party seeking connection using the Stage 3 evaluation procedure defined in AS/NZS61000.3.6:2001.

(c) In respect of each new connection at a level of performance below the automatic access standard the Network Service Provider must include provisions in the relevant connection agreement requiring the Network User if necessary to meet the system standards or allow connection of other Network Users to either upgrade to the automatic access standard or fund the reasonable cost of the works necessary to mitigate their effect of connecting at a standard below the automatic access standard.

(d) If for existing customer connections the level of harmonic voltage distortion is, or may be, exceeded as a result of a proposed new connection, the
Network Service Provider must, if the cause of that excessive level cannot be remedied by enforcing the provisions of existing connection agreements, undertake all works necessary to meet the technical standards in this schedule or to permit a proposed new connection within the automatic access standard defined in clause S5.3.8 and the requirements stated in this clause.

For other than a new connection in accordance with the preceding paragraph, the responsibility of a Network Service Provider for harmonic voltage distortion outside the range defined above is limited to harmonic voltage distortion caused by network plant and the pursuit of all measures available under the Rules and its connection agreements.

S5.1.7 Voltage unbalance

(a) A Transmission Network Service Provider must balance the effective impedance of the phases of its network, and a Distribution Network Service Provider must balance the current drawn in each phase at each of its connection points, so as to achieve average levels of negative sequence voltage at all connection points that are equal to or less than the values set out in Table S5.1a.1 as determined in accordance with the accompanying provisions of clause S5.1a.7 of the system standards.

(b) A Network Service Provider must include conditions in connection agreements to ensure that a Connection Applicant will balance the current drawn in each phase at each of its connection points so as to achieve:

(1) for those Network Users listed in clause S5.3(a): the levels permitted in accordance with clause S5.3.6 of schedule 5.3;

(2) for Market Network Service Providers: the levels permitted in accordance with clause S5.3a.9 of schedule 5.3a;

(3) otherwise: the average levels of negative sequence voltage at each of its connection points that are equal to or less than the values set out in Table S5.1a.1 and the accompanying provisions of clause S5.1a.7 of the system standards.

The responsibility of the Network Service Provider for voltage unbalance outside the ranges defined above is limited to voltage unbalance caused by the network and the pursuit of all measures available under the Rules and its connection agreements.

(c) A Network Service Provider must include conditions in connection agreements to ensure that each Generator will balance:

(1) the voltage generated in each phase of its generating system; and

(2) when not generating, the current drawn in each phase,

in order to achieve average levels of negative sequence voltage at each of the generating system connection points due to phase imbalances within the generating plant that are not more than the values determined by the Network Service Provider to achieve average levels of negative sequence voltage at the connection points of other Network Users in accordance with clause S5.1a.7.
(d) When including conditions under paragraph (c), the Network Service Provider must have regard to the capabilities of the relevant generating plant technology.

S5.1.8 Stability

In conforming with the requirements of the system standards, the following criteria must be used by Network Service Providers for both planning and operation:

For stable operation of the national grid, both in a satisfactory operating state and following any credible contingency events described in clause S5.1.2.1:

(a) the power system will remain in synchronism;
(b) damping of power system oscillations will be adequate; and
(c) voltage stability criteria will be satisfied.

Damping of power system oscillations must be assessed for planning purposes according to the design criteria which states that power system damping is considered adequate if after the most critical credible contingency event, simulations calibrated against past performance indicate that the halving time of the least damped electromechanical mode of oscillation is not more than five seconds.

To assess the damping of power system oscillations during operation, or when analysing results of tests such as those carried out under clause 5.7.7 of the Rules, the Network Service Provider must take into account statistical effects. Therefore, the power system damping operational performance criterion is that at a given operating point, real-time monitoring or available test results show that there is less than a 10 percent probability that the halving time of the least damped mode of oscillation will exceed ten seconds, and that the average halving time of the least damped mode of oscillation is not more than five seconds.

The voltage control criterion is that stable voltage control must be maintained following the most severe credible contingency event. This requires that an adequate reactive power margin must be maintained at every connection point in a network with respect to the voltage stability limit as determined from the voltage/reactive load characteristic at that connection point. Selection of the appropriate margin at each connection point is at the discretion of the relevant Network Service Provider, subject only to the requirement that the margin (expressed as a capacitive reactive power (in MVAr)) must not be less than one percent of the maximum fault level (in MVA) at the connection point.

In planning a network a Network Service Provider must consider non-credible contingency events such as busbar faults which result in tripping of several circuits, uncleared faults, double circuit faults and multiple contingencies which could potentially endanger the stability of the power system. In those cases where the consequences to any network or to any Registered Participant of such events are likely to be severe disruption a Network Service Provider and/or a Registered Participant must install emergency controls within the Network Service Provider's or Registered Participant's system or in both, as necessary, to minimise disruption to any transmission or distribution network and to significantly reduce the probability of cascading failure.
A Registered Participant must co-operate with a Network Service Provider to achieve stable operation of the national grid and must use all reasonable endeavours to negotiate with the Network Service Provider regarding the installation of emergency controls as described in the previous paragraph. The cost of installation, maintenance and operation of the emergency controls must be borne by the Network Service Provider who is entitled to include this cost when calculating the Transmission Customer use of system price.

S5.1.9 Protection systems and fault clearance times

Network Users

(a) A Network Service Provider must determine the automatic access standard and minimum access standard that applies to the protection zone of each protection system in relation to the connection point and the plant to be connected, as follows:

(1) The automatic access standard for fault clearance time for any fault type is the lesser of the system standard set out in clause S5.1a.8 that applies to the highest nominal voltage within the protection system's protection zone and the corresponding minimum access standard determined under clause S5.1.9(a)(2) or clause S5.1.9(a)(3) as applicable.

(2) The minimum access standard for fault clearance time of a primary protection system is:

(i) for a fault type that constitutes a credible contingency event in the relevant protection zone, the longest time such that a short circuit fault of that fault type that is cleared in that time would not cause the power system to become unstable when operating at any level of inter-regional or intra-regional power transfer that would be permissible (taking into account all other limiting criteria) if the fault clearance time for such a fault at the connection point were the system standard set out in clause S5.1a.8 that applies to the nominal voltage at the connection point; and

(ii) for a fault type that does not constitute a credible contingency event in the relevant protection zone:

(A) if a two phase to ground fault in that protection zone constitutes a credible contingency event, the corresponding fault clearance time for a two phase to ground short circuit fault in that protection zone as determined under clause S5.1.9(a)(2)(i); and

(B) otherwise, the shortest of the fault clearance times for a two phase to ground short circuit fault in each adjoining protection zone (excluding transformer protection zones and dead zones) as determined under clause S5.1.9(a)(2)(i) or clause S5.1.9(e).

(3) The minimum access standard for fault clearance time of a breaker fail protection system or similar back-up protection system is the longest time such that a short circuit fault of any fault type that is cleared in that time would not damage any part of the power system (other than the faulted element) while the fault current is flowing or being interrupted.

(b) The negotiation of access standards in relation to paragraph (a) must involve AEMO under clause 5.3.1A(e) of the Rules.
Transmission systems and distribution systems

(c) Subject to clauses S5.1.9(k) and S5.1.9(l), a Network Service Provider must provide sufficient primary protection systems and back-up protection systems (including breaker fail protection systems) to ensure that a fault of any fault type anywhere on its transmission system or distribution system is automatically disconnected in accordance with clause S5.1.9(e) or clause S5.1.9(f).

(d) If the fault clearance time determined under clause S5.1.9(e) of a primary protection system for a two phase to ground short circuit fault is less than 10 seconds, the primary protection system must have sufficient redundancy to ensure that it can clear short circuit faults of any fault type within the relevant fault clearance time with any single protection element (including any communications facility upon which the protection system depends) out of service.

(e) The fault clearance time of a primary protection system of a Network Service Provider must not exceed:

(1) for any fault type that constitutes a credible contingency event in the relevant protection zone, the longest time such that a short circuit fault of that fault type that is cleared in that time would not cause the power system to become unstable when operating at any level of inter-regional or intra-regional power transfer that would be permissible (taking into account all other limiting criteria) if the fault clearance time for such a fault in that protection zone were the relevant system standard set out in clause S5.1a.8; and

(2) for any fault type that does not constitute a credible contingency event in the relevant protection zone:

(i) if a two phase to ground fault in that protection zone is a credible contingency event, the corresponding fault clearance time for a two phase to ground fault in that protection zone as determined under clause S5.1.9(e)(1); and

(ii) otherwise, the shortest of the fault clearance times for a two phase to ground fault in each adjoining protection zone (excluding transformer protection zones and dead zones) as determined under clauses S5.1.9(a)(2)(i), S5.1.9(e)(1) or S5.1.9(e)(2)(i).

(f) The fault clearance time of each breaker fail protection system or similar back-up protection system of a Network Service Provider must be such that a short circuit fault of any fault type that is cleared in that time would not damage any part of the power system (other than the faulted element) while the fault current is flowing or being interrupted.

(g) A Network Service Provider must demonstrate to AEMO that each fault clearance time for a primary protection system that is longer than the relevant system standard set out in clause S5.1a.8 and is less than 10 seconds would not cause or require an inter-regional or intra-regional power transfer capability to be reduced.

(h) A Network Service Provider must include in each connection agreement entered into after the performance standards commencement date.
(1) the fault clearance times for each fault type of each of its protection systems that could reasonably be expected to interrupt supply to or from the relevant connection point; and

(2) an agreement to not increase those fault clearance times without the prior written agreement of the other party.

(i) Network Service Providers must coordinate and cooperate with Network Users to implement breaker fail protection for circuit breakers provided to isolate the Network User’s facility from the Network Service Provider’s facilities.

(j) Where practicable and economic to achieve, new network investment should meet the system standard for fault clearance times as specified in clause S5.1a.8 for two-phase to ground short circuit faults.

(k) A primary protection system may clear faults other than short circuit faults slower than the relevant fault clearance time, provided that each fault would be cleared sufficiently promptly to not adversely impact on power system security compared with its operation for the corresponding short circuit fault. In the case of a fault within equipment at a station, the corresponding short circuit fault is to be taken as a two-phase to ground short circuit fault at the external connections of the equipment.

(l) Protection systems may rely on breaker fail protection systems or other back-up protection systems to completely clear faults of any fault type that:

(1) occur within a substation between a protection zone and a circuit breaker adjacent to that protection zone that is required to open to clear the fault (a dead zone); and

(2) remain connected through a power line or transformer after operation of a primary protection system,

provided that the relevant Network Service Provider assesses that the likelihood of a fault occurring within the dead zone is not greater than the likelihood of a fault occurring on busbars.

(m) For the purposes of this clause S5.1.9, a credible contingency event includes any event that clause S5.1.2.1 requires a Network Service Provider to consider as a credible contingency event.

(n) The provisions of clause S5.1.9(d) apply to facilities constructed or modified on or after the performance standards commencement date.

(o) For facilities other than those referred to in clause S5.1.9(n), the requirement for primary protection system redundancy must be derived by the Network Service Provider from the existing capability of each facility on the performance standards commencement date.

S5.1.10 Load and network control facilities

S5.1.10.1 General

Each Network Service Provider in consultation with AEMO must ensure that:

(a) sufficient load is under the control of underfrequency relays where required to ensure that in the event of the sudden, unplanned simultaneous
occurrence of multiple contingency events, the power system frequency does not move outside the extreme frequency excursion tolerance limits;

(b) where determined to be necessary, sufficient load is under the control of undervoltage relays to minimize or reduce the risk of voltage collapse on the occurrence of multiple contingency events; and

(c) there is sufficient load under manual or automatic control either locally or from remotely located control centres to allow the load shedding procedures to be implemented on instruction from AEMO to enable AEMO to maintain power system security.

A Network Service Provider may require load shedding arrangements to be installed to cater for abnormal operating conditions.

Arrangements for load shedding must be agreed between Transmission Network Service Providers and connected Distribution Network Service Providers and may include the opening of circuits in either a transmission or distribution network.

The Transmission Network Service Provider must specify, in the connection agreement, control and monitoring requirements to be provided by a Distribution Network Service Provider for load shedding facilities.

S5.1.10.2 Distribution Network Service Providers

A Distribution Network Service Provider must:

(a) provide, install, operate and maintain facilities for load shedding in respect of any connection point at which the maximum load exceeds 10MW in accordance with clause 4.3.5 of the Rules;

(b) in accordance with the provisions of the relevant connection agreement, cooperate with the Transmission Network Service Providers in conducting periodic functional testing of the facilities, which must not require load to be disconnected;

(c) apply underfrequency settings to relays as determined by AEMO in consultation with the Network Service Provider; and

(d) apply undervoltage settings to relays as notified by the Transmission Network Service Provider in accordance with clause S5.1.10.3(b).

S5.1.10.3 Transmission Network Service Providers

Transmission Network Service Providers must:

(a) conduct periodic functional tests of the load shedding facilities; and

(b) notify Distribution Network Service Providers regarding the settings of undervoltage load shed relays as determined by AEMO in consultation with the Transmission Network Service Provider.

S5.11—Automatic reclosure of transmission or distribution lines

Where automatic reclose equipment is provided on transmission lines or distribution lines, check or blocking facilities must be applied to the automatic reclose equipment in those circumstances where there is any possibility of the two ends of the transmission line or distribution line being energised from sources that are not in synchronism.
S5.1.12 Rating of transmission lines and equipment

For operational purposes each Network Service Provider must, on reasonable request, advise AEMO of the maximum current that may be permitted to flow (under conditions nominated by AEMO) through each transmission line, distribution line or other item of equipment that forms part of its transmission system or distribution system.

This maximum current is called a current rating of the transmission line, distribution line or item of equipment notwithstanding that it may be determined by equipment associated with its connection to the power system (including switchgear, droppers, current transformers and protection systems).

AEMO may request for a transmission line, distribution line or other item of equipment:

(a) a continuous current rating, being the level of current that is permitted to flow in that item of equipment for an indefinite period; and

(b) one or more short term current ratings for a period of time nominated by AEMO after consultation with the Network Service Provider, being the level of current that is permitted to flow in that item of equipment for that period of time if the current had been less than the corresponding continuous current rating for a reasonable prior period taking into account the thermal properties of the item of equipment.

The Network Service Provider may be required by AEMO to advise different current ratings to be applied under nominated conditions including, without limitation:

(a) ambient weather conditions;

(b) seasons and/or times of day;

(c) ratios of the current during an emergency to the current prior to the emergency (taking into account pre-contingent loading history where applicable); and

(d) period of loading at the nominated level.

A Transmission Network Service Provider is entitled to advise AEMO of short term current ratings which may apply for nominated periods of time to the relevant transmission line or item of equipment provided that these ratings do not materially affect the safety of the transmission line or item of equipment, or the safety of persons. Short term ratings for transmission lines or items of equipment may be implemented by a methodology or algorithm in a format agreed with AEMO.

S5.1.13 Information to be provided

A Network Service Provider must, in response to a connection enquiry or an application to connect made in accordance with clause 5.3.2 of the Rules, provide the connection applicant electrical design information relevant to the nominal point of connection in accordance with a relevant requirement of schedules 5.2, 5.3 or 5.3a.

Comment [ABT14]: Needs rewriting
As part of standard connection process, a standard list of technical information about the embedded generator relating to load and network control protection elements must be provided. This is likely to include:

- Reverse power relays
- Under/over voltage relays
- Under/over frequency relays
- Short circuit/over current protection
Schedule 5.2  Conditions for Connection of Generators

S5.2.1 Outline of requirements

(a) This schedule sets out details of additional requirements and conditions that Generators must satisfy as a condition of connection of a generating system to the power system.

(b) This schedule does not apply to any generating system that is:

(1) subject to an exemption from registration under clause 2.2.1(c); or

(2) eligible for exemption under any guidelines issued under clause 2.2.1(c),

and which is connected or intended for use in a manner the Network Service Provider considers is unlikely to cause a material degradation in the quality of supply to other Network Users.

(c) This schedule also sets out the requirements and conditions which subject to clause 5.2.5 of the Rules, are obligations on Generators:

(1) to co-operate with the relevant Network Service Provider on technical matters when making a new connection; and

(2) to provide information to the Network Service Provider or AEMO.

(d) The equipment associated with each generating system must be designed to withstand without damage the range of operating conditions which may arise consistent with the system standards.

(e) Generators must comply with the performance standards and any attached terms or conditions of agreement agreed with the Network Service Provider or AEMO in accordance with a relevant provision of schedules 5.1a or 5.1.

(f) This schedule does not set out arrangements by which a Generator may enter into an agreement or contract with AEMO to:

(1) provide additional services that are necessary to maintain power system security; or

(2) provide additional services to facilitate management of the market.

(g) This schedule provides for automatic access standards and the determination of negotiated access standards derived from minimum access standards which once determined, must be recorded together with the automatic access standards in a connection agreement and registered with AEMO as performance standards.

S5.2.2 Application of Settings

A Generator must only apply settings to a control system or a protection system that are necessary to comply with performance requirements of this schedule 5.2 if the settings have been approved in writing by the relevant Network Service Provider and, if the requirement is one that would involve AEMO under clause 5.3.1A(c) of the Rules, also by AEMO. A Generator must not allow its generating unit to supply electricity to the power system without such prior approval.
If a Generator seeks approval from the Network Service Provider to apply or change a setting, approval must not be withheld unless the Network Service Provider or, if the requirement is one that would involve AEMO under clause 5.3.4A(c) of the Rules, AEMO, reasonably determines that the changed setting would cause the generating unit to not comply with the relevant performance standard or cause an inter-regional or intra-regional power transfer capability to be reduced.

If the Network Service Provider or, if the requirement is one that would involve AEMO under clause 5.3.4A(c) of the Rules, AEMO, reasonably determines that a setting of a generating unit’s control system or protection system needs to change to comply with the relevant performance standard or to maintain or restore an inter-regional or intra-regional power transfer capability, the Network Service Provider or AEMO (as applicable) must consult with the relevant Generator, and the Network Service Provider may request in writing that a setting be applied in accordance with the determination.

The Network Service Provider may also request a test to verify the performance of the relevant plant with the new setting. The Network Service Provider must provide AEMO with a copy of its request to a Generator to apply a setting or to conduct a test.

A Generator who receives such a request must arrange for the notified setting to be applied as requested and for a test to be conducted as requested. After the test, the Generator must, on request, provide both AEMO and the Network Service Provider with a report of a requested test, including evidence of its success or failure. Such a report of a test is confidential information.

A Generator must not change a setting requested by the Network Service Provider without its prior written agreement. If the Network Service Provider requires a Generator to change a setting within 18 months of a previous request, the Network Service Provider must pay the Generator its reasonable costs of changing the setting and conducting the tests as requested.

S5.2.3 Technical matters to be coordinated

(a) A Generator and the relevant Network Service Provider must use all reasonable endeavours to agree upon relevant technical matters in respect of each new or altered connection of a generating system to a network including:

1. design at the connection point;
2. physical layout adjacent to the connection point;
3. primary protection and backup protection (clause S5.2.5);
4. control characteristics (clause S5.2.5);
5. communications facilities (clause S5.2.6);
6. insulation co-ordination and lightning protection (paragraph (b));
7. fault levels and fault clearance (clause S5.2.8);
8. switching and isolation facilities (clause S5.2.8);
9. interlocking and synchronising arrangements; and
(10) metering installations.

(b) A Generator must ensure that in designing a generating system’s electrical plant, including any substation for the connection of the generating system to the network, to operate at the same nominal voltage as at the connection point:

(1) the plant complies with the relevant Australian Standards unless a provision of these Rules allows or requires otherwise;

(2) the earthing of the plant complies with the ENA EG1-2006: Substation Earthing Guide to reduce step and touch potentials to safe levels;

(3) the plant is capable of withstanding, without damage the voltage impulse levels specified in the connection agreement;

(4) the insulation levels of the plant are co-ordinated with the insulation levels of the network to which the generating system is connected as specified in the connection agreement; and

(5) safety provisions in respect of the plant comply with requirements applicable to the participating jurisdiction in which the generating system is located, as notified by the Network Service Provider.

(c) If no relevant Australian Standard exists for the purposes of paragraph (b)(1), the Generator must agree with the Network Service Provider for the Generator to comply with another relevant standard.

S5.2.4 Provision of information

(a) A Generator or person who is negotiating a connection agreement with a Network Service Provider must promptly on request by AEMO or the Network Service Provider provide all data in relation to that generating system specified in schedule 5.5.

(b) A Generator, or person required under the Rules to register as the Generator in respect of a generating system comprised of generating units with a combined nameplate rating of 30 MW or more, by the earlier of

(1) the day on which an application to connect is made under clause 5.3.4(a);

(2) the day on which amendments to performance standards are submitted under rule 4.14(p) or clause 5.3.9(b);

(3) three months before commissioning of a generating system or planned alteration to a generating system; or

(4) 5 business days before commissioning of a generating system alteration that is repairing plant after a plant failure, if plant performance after the alteration will differ from performance prior to the plant failure, must provide:

(5) to AEMO and the relevant Network Service Providers (including the relevant Transmission Network Service Provider in respect of an embedded
generating unit) the following information about the control systems of the generating system:

(i) a set of functional block diagrams, including all functions between feedback signals and generating system output;

(ii) the parameters of each functional block, including all settings, gains, time constants, delays, deadbands and limits; and

(iii) the characteristics of non-linear elements, with sufficient detail for AEMO and Network Service Providers to perform load flow and dynamic simulation studies;

(6) to AEMO, model source code associated with the model in subparagraph (5) in an unencrypted form suitable for at least one of the software simulation products nominated by AEMO and in a form that would allow conversion for use with other software simulation products by AEMO;

(7) [Deleted]

(8) to AEMO and the relevant Network Service Providers (including the relevant Transmission Network Service Provider in respect of an embedded generating unit) a releasable user guide.

(c) The information provided under paragraph (b) must:

(1) encompass all control systems that respond to voltage or frequency disturbances on the power system, and which are either integral to the generating units or otherwise part of the generating system, including those applying to reactive power equipment that forms part of the generating system; and

(2) conform with the applicable models developed in accordance with the Generating System Model Guidelines, or an alternative model agreed with AEMO to be necessary to adequately represent the generating plant to carry out load flow and dynamic simulations.

(d) The Generator must provide to AEMO information that updates the information provided under clause S5.2.4(b) and must provide to the relevant Network Service Providers information that updates the information provided under clause S5.2.4(b)(5):

(1) within 3 months after commissioning tests or other tests undertaken in accordance with clause S5.7.3 are completed;

(2) when the Generator becomes aware that the information is incomplete, inaccurate or out of date; or

(3) on request by AEMO or the relevant Network Service Provider, where AEMO or the relevant Network Service Provider considers that the information is incomplete, inaccurate or out of date.

(d1) A Generator is only required to provide new information under clause S5.2.4(d) to the extent that it is different to the information previously provided under clause S5.2.4(b);

(e) For the purposes of clause S5.2.4(e1), a Connection Applicant must be registered as an Intending Participant in accordance with rule 2.7.
(e1) For the purposes of clause 5.3.2(f), the technical information that a Network Service Provider must, if requested, provide to a Connection Applicant in respect of a proposed connection for a generating system includes:

1. the highest expected single phase and three phase fault levels at the connection point with the generating system not connected;
2. the clearing times of the existing protection systems that would clear a fault at the location at which the new connection would be connected into the existing transmission system or distribution system;
3. the expected limits of voltage fluctuation, harmonic voltage distortion and voltage unbalance at the connection point with the generating system not connected;
4. technical information relevant to the connection point with the generating system not synchronised including equivalent source impedance information, sufficient to estimate fault levels, voltage fluctuations, harmonic voltage distortion (for harmonics relevant to the generating system) and voltage unbalance; and
5. information relating to the performance of the national grid that is reasonably necessary for the Connection Applicant to prepare an application to connect, including:
   (i) a model of the power system, including relevant considered projects and the range of expected operating conditions, sufficient to carry out load flow and dynamic simulations; and
   (ii) information on inter-regional and intra-regional power transfer capabilities and relevant plant ratings.

(f) All information provided under this clause S5.2.4 must be treated as confidential information.

S5.2.5 Technical requirements

S5.2.5.1 Reactive power capability

Automatic access standard

(a) The automatic access standard is a generating system operating at:

   1. any level of active power output; and
   2. any voltage at the connection point within the limits established under clause S5.1a.1 without a contingency event,

must be capable of supplying and absorbing continuously at its connection point an amount of reactive power of at least the amount equal to the product of the rated active power of the generating system and 0.395.

Minimum access standard

(b) The minimum access standard is no capability is required to supply or absorb reactive power at the connection point.
Negotiated access standard

(c) When negotiating a negotiated access standard, the Generator and the Network Service Provider:

(1) must subject to any agreement under paragraph (d)(4), ensure that the reactive power capability of the generating system is sufficient to ensure that all relevant system standards are met before and after credible contingency events under normal and planned outage operating conditions of the power system, taking into account at least existing projects and considered projects;

(2) may negotiate either a range of reactive power absorption and supply, or a range of power factor, at the connection point, within which the plant must be operated; and

(3) may negotiate a limit that describes how the reactive power capability varies as a function of active power output due to a design characteristic of the plant.

(d) If the generating system is not capable of the level of performance established under paragraph (c)(1) the Generator, depending on what is reasonable in the circumstances, must:

(1) pay compensation to the Network Service Provider for the provision of the deficit of reactive power (supply and absorption) from within the network;

(2) install additional equipment connecting at the generating system’s connection point or another location, to provide the deficit of reactive power (supply and absorption), and such equipment is deemed to be part of the generating system;

(3) reach a commercial arrangement with a Registered Participant to provide the deficit of reactive power (supply and absorption); or

(4) if the inability to meet the performance level only occurs for particular operating conditions, agree to and document as part of the proposed negotiated access standard, operational arrangements by which the plant can achieve an agreed level of performance for those operating conditions.

(e) The Generator may select one or more options referred to in paragraph (d).

General requirements

(f) An access standard must record the agreed value for rated active power and where relevant the method of determining the value.

(g) An access standard for consumption of energy by a generating system when not supplying or absorbing reactive power under an ancillary services agreement is to be established under clause S5.3.5 as if the Generator were a Market Customer.

S5.2.5.2 Quality of electricity generated

(a) For the purpose of this clause S5.2.5.2 in respect of a synchronous generating unit, AS 1359.101 and IEC 60034-1 are plant standards for harmonic voltage distortion.
Automatic access standard

(b) The automatic access standard is a generating system when generating and when not generating must not produce at any of its connection points for generation:

(1) voltage fluctuation greater than the limits allocated by the Network Service Provider under clause S5.1.5(a);

(2) harmonic voltage distortion greater than the emission limits specified by a plant standard under paragraph (a) or allocated by the Network Service Provider under clause S5.1.6(a); and

(3) voltage unbalance greater than the limits allocated by the Network Service Provider in accordance with clause S5.1.7(c).

Minimum access standard

(c) The minimum access standard is a generating system when generating and when not generating must not produce at any of its connection points for generation:

(1) voltage fluctuations greater than limits determined under clause S5.1.5(b);

(2) harmonic voltage distortion more than the lesser of the emission limits determined by the relevant Network Service Provider under clause S5.1.6(b) and specified by a plant standard under paragraph (a); and

(3) voltage unbalance more than limits determined under clause S5.1.7(c).

Negotiated access standard

(d) A negotiated access standard negotiated under this clause S5.2.5.2 must not prevent the Network Service Provider meeting the system standards or contractual obligations to existing Network Users.

S5.2.5.3 Generating unit response to frequency disturbances

(a) For the purposes of this clause S5.2.5.3:

normal operating frequency band, operational frequency tolerance band, or extreme frequency excursion tolerance limits are references to the widest range specified for those terms for any condition (including an “island” condition) in the frequency operating standards that apply to the region in which the generating unit is located.

stabilisation time and recovery time mean the longest times allowable for system frequency to remain outside the operational frequency tolerance band and the normal operating frequency band, respectively, for any condition (including an “island” condition) in the frequency operating standards that apply to the region in which the generating unit is located.

transient frequency limit and transient frequency time mean the values of 47.5 Hz and 9 seconds respectively, or such other values determined by the Reliability Panel.
Automatic access standard

(b) The automatic access standard is a generating system and each of its generating units must be capable of continuous uninterrupted operation for frequencies in the following ranges:

1. the lower bound of the extreme frequency excursion tolerance limits to the lower bound of the operational frequency tolerance band for at least the stabilisation time;
2. the lower bound of the operational frequency tolerance band to the lower bound of the normal operating frequency band, for at least the recovery time including any time spent in the range under subparagraph (1);
3. the normal operating frequency band for an indefinite period;
4. the upper bound of the normal operating frequency band to the upper bound of the operational frequency tolerance band, for at least the recovery time including any time spent in the range under subparagraph (5); and
5. the upper bound of the operational frequency tolerance band to the upper bound of the extreme frequency excursion tolerance limits for at least the stabilisation time,

unless the rate of change of frequency is outside the range of –4 Hz to 4 Hz per second for more than 0.25 seconds or such other range as determined by the Reliability Panel from time to time.

Note:
The automatic access standard is illustrated in the following diagram. To the extent of any inconsistency between the diagram and paragraph (b), paragraph (b) prevails.
Minimum access standard

(c) The minimum access standard is a generating system and each of its generating units must be capable of continuous uninterrupted operation for frequencies in the following ranges:

1. the lower bound of the extreme frequency excursion tolerance limits to the transient frequency limit for at least the transient frequency time;
2. the transient frequency limit to the lower bound of the operational frequency tolerance band for at least the stabilisation time;
3. the lower bound of the operational frequency tolerance band to the lower bound of the normal operating frequency band for at least the recovery time including any time spent in the ranges under subparagraphs (1) and (2);
4. the normal operating frequency band for an indefinite period;
5. the upper bound of the normal operating frequency band to the upper bound of the operational frequency tolerance band for at least the recovery time including any time spent in the ranges under subparagraph (6) unless the generating system has a protection system to trip a generating unit if the frequency exceeds a level agreed with AEMO; and
6. in respect of a generating system:
   (i) of 30 MW or more; and
(ii) that does not have a protection system to trip the generating unit if the frequency exceeds a level agreed with AEMO,

the upper bound of the operational frequency tolerance band to the upper bound of the extreme frequency excursion tolerance limits (including an “island” condition) for at least the transient frequency time,

unless the rate of change of frequency is outside the range of -1 Hz to 1 Hz per second for more than one second or such other range as determined by the Reliability Panel from time to time.

Note:
The minimum access standard is illustrated in the following diagram. To the extent of any inconsistency between the diagram and paragraph (c), paragraph (c) prevails.

Negotiated access standard

(d) A negotiated access standard can be accepted by the Network Service Provider provided that AEMO and the Network Service Provider agree that:

1. the negotiated access standard is as close as practicable to the automatic access standard while respecting the need to protect the plant from damage;
2. 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 generating units; and
(3) there would be no material adverse impact on quality of supply to other Network Users or power system security.

(e) AEMO must advise on matters relating to negotiated access standards under this clause S5.2.5.3.

\section*{S5.2.5.4 Generating system response to voltage disturbances}

\subsection*{Automatic access standard}

(a) The automatic access standard is a generating system and each of its generating units must be capable of continuous uninterrupted operation where a power system disturbance causes the voltage at the connection point to vary within the following ranges:

\begin{itemize}
  \item[(1)] voltages over 110\% for the durations permitted under clause S5.1a.4;
  \item[(2)] 90\% to 110\% of normal voltage continuously;
  \item[(3)] 80\% to 90\% of normal voltage for a period of at least 10 seconds; and
  \item[(4)] 70\% to 80\% of normal voltage for a period of at least 2 seconds.
\end{itemize}

\subsection*{Minimum access standard}

(b) The minimum access standard is a generating system including all operating generating units must be capable of continuous uninterrupted operation where a power system disturbance causes the voltage at the connection point to vary in the range of 90\% to 110\% of normal voltage, provided that the ratio of voltage to frequency (as measured at the connection point and expressed as percentage of normal voltage and a percentage of 50 Hz) does not exceed:

\begin{itemize}
  \item[(1)] a value of 1.15 for more than two minutes; or
  \item[(2)] a value of 1.10 for more than 10 minutes.
\end{itemize}

\subsection*{Negotiated access standard}

(c) In negotiating a negotiated access standard, a generating system and each of its operating generating units must be capable of continuous uninterrupted operation for the range of voltages specified in the automatic access standard except where AEMO and the Network Service Provider agree that:

\begin{itemize}
  \item[(1)] the negotiated access standard is as close as practicable to the automatic access standard while respecting the need to protect the plant from damage;
  \item[(2)] the generating plant that would be tripped as a result of any voltage excursion within levels specified by the automatic access standard, is not more than 100 MW or a greater limit based on what AEMO and the Network Service Provider both consider to be reasonable in the circumstances; and
  \item[(3)] there would be no material adverse impact on the quality of supply to other Network Users or power system security.
(d) In carrying out assessments of proposed negotiated access standards under this clause S5.2.5.4, AEMO and the Network Service Provider must at a minimum, take into account:

1. the expected performance of existing networks and considered projects;
2. the expected performance of existing generating plant and other relevant projects; and
3. any corresponding performance standard (or where no performance standard has been registered, the access standard) that allows generating plant to trip for voltage excursions in ranges specified under the automatic access standards.

(e) AEMO must advise on matters relating to negotiated access standards under this clause S5.2.5.4.

General requirement

(f) The access standard must include any operational arrangements necessary to ensure the generating system and each of its generating units will meet its agreed performance levels under abnormal network or generating system conditions.

S5.2.5.5 Generating system response to disturbances following contingency events

(a) In this clause S5.2.5.5 a fault includes:

1. a fault of the relevant type having a metallic conducting path; and
2. a fault of the relevant type resulting from reclosure onto a fault by the operation of automatic reclose equipment.

Automatic access standard

(b) The automatic access standard is:

1. a generating system and each of its generating units must remain in continuous uninterrupted operation for a disturbance caused by an event that is:
   (i) a credible contingency event other than a fault referred to in subparagraph (iv);
   (ii) a three phase fault in a transmission system cleared by all relevant primary protection systems;
   (iii) a two phase to ground, phase to phase or phase to ground fault in a transmission system cleared in:
      (A) the longest time expected to be taken for a relevant breaker fail protection system to clear the fault; or
      (B) if a protection system referred to in subparagraph (A) is not installed, the greater of the time specified in column 4 of Table S5.1a.2 (or if none is specified, 430 milliseconds)
and the longest time expected to be taken for all relevant primary protection systems to clear the fault; and

(iv) a three-phase, two-phase to ground, phase to phase or phase to ground fault in a distribution network cleared in:

(A) the longest time expected to be taken for the breaker fail protection system to clear the fault; or

(B) if a protection system referred to in subparagraph (A) is not installed, the greater of 430 milliseconds and the longest time expected to be taken for all relevant primary protection systems to clear the fault,

provided that the event is not one that would disconnect the generating unit from the power system by removing network elements from service; and

(2) subject to any changed power system conditions or energy source availability beyond the Generator's reasonable control, a generating system and each of its generating units, in respect of the types of fault described in subparagraphs (1)(ii) to (iv), must supply to or absorb from the network:

(i) to assist the maintenance of power system voltages during the application of the fault, capacitive reactive current of at least the greater of its pre-disturbance reactive current and 4% of the maximum continuous current of the generating system including all operating generating units (in the absence of a disturbance) for each 1% reduction (from its pre-fault level) of connection point voltage during the fault;

(ii) after disconnection of the faulted element, reactive power sufficient to ensure that the connection point voltage is within the range for continuous uninterrupted operation under clause S5.2.5.4; and

(iii) from 100 milliseconds after disconnection of the faulted element, active power of at least 95% of the level existing just prior to the fault.

Minimum access standard

(c) The minimum access standard is:

(1) a generating system and each of its generating units must remain in continuous uninterrupted operation for the disturbance caused by an event that is:

(i) a credible contingency event other than a fault referred to in subparagraph (iii);

(ii) a single phase to ground, phase to phase or two phase to ground fault in a transmission system cleared in the longest time expected to be taken for all relevant primary protection systems to clear the fault unless AEMO and the Network Service Provider agree that:
(A) the total reduction of generation in the power system due to that fault would not exceed 100 MW;
(B) there is unlikely to be an adverse impact on quality of supply to other Network Users; and
(C) there is unlikely to be a material adverse impact on power system security; and

(iii) a single phase to ground, phase to phase or two phase to ground fault in a distribution network, cleared in the longest time expected to be taken for all relevant primary protection systems to clear the fault, unless AEMO and the Network Service Provider agree that:

(A) the total reduction of generation in the power system due to that fault would not exceed 100 MW;
(B) there is unlikely to be a material adverse impact on quality of supply to other Network Users; and
(C) there is unlikely to be a material adverse impact on power system security,

provided that the event is not one that would disconnect the generating unit from the power system by removing network elements from service; and

(2) subject to any changed power system conditions or energy source availability beyond the Generator’s reasonable control after disconnection of the faulted element, each generating system must, in respect of the types of fault described in subparagraphs (1)(ii) and (iii), deliver to the network active power and supply or absorb leading or lagging reactive power, sufficient to ensure that the connection point voltage is within the range for continuous uninterrupted operation agreed under clause S5.2.5.4.

Negotiated access standard

(d) In carrying out assessments of proposed negotiated access standards under this clause S5.2.5.5, the Network Service Provider and AEMO must take into account, without limitation:

(1) the expected performance of:
   (i) existing networks and considered projects;
   (ii) existing generating plant and other relevant projects; and
   (iii) control systems and protection systems, including auxiliary systems and automatic reclose equipment; and

(2) the expected range of power system operating conditions.

(e) A proposed negotiated access standard may be accepted if the connection of the plant at the proposed access level would not cause other generating plant or loads to trip as a result of an event, when they would otherwise not have tripped for the same event.
(f) AEMO must advise on matters relating to negotiated access standards under this clause S5.2.5.5.

General requirement

(g) The access standard must include any operational arrangements to ensure the generating system including all operating generating units will meet its agreed performance levels under abnormal network or generating system conditions.

S5.2.5.6 Quality of electricity generated and continuous uninterrupted operation

Minimum access standard

The minimum access standard is a generating system including each of its operating generating units and reactive plant, must not disconnect from the power system as a result of voltage fluctuation, harmonic voltage distortion and voltage unbalance conditions at the connection point within the levels specified in clauses S5.1a.5, S5.1a.6, S5.1a.7.

S5.2.5.7 Partial load rejection

(a) For the purposes of this clause S5.2.5.7 minimum load means minimum sent out generation for continuous stable operation.

(b) This clause S5.2.5.7 does not apply to an asynchronous generating unit.

Automatic access standard

(e) The automatic access standard is a generating unit must be capable of continuous uninterrupted operation during and following a power system load reduction of 30% from its predisturbance level or equivalent impact from separation of part of the power system in less than 10 seconds, provided that the loading level remains above minimum load.

Minimum access standard

(d) The minimum access standard is a generating unit must be capable of continuous uninterrupted operation during and following a power system load reduction of 5% or equivalent impact from separation of part of the power system in less than 10 seconds, provided that the loading level remains above minimum load.

Negotiated access standard

(e) If in accordance with clause 5.3.4A the Generator and the Network Service Provider determine a negotiated access standard is to apply, the Network Service Provider must consult AEMO to ensure that the negotiated access standard does not materially adversely affect power system security.

(f) AEMO must advise on matters relating to negotiated access standards under this clause S5.2.5.7.

General requirements

(g) The actual partial load rejection performance must be recorded in the access standards.
S5.2.5.8 Protection of generating systems from power system disturbances

Minimum access standard

(a) The minimum access standard is:

(1) subject to subparagraph (2) and paragraph (e), for a generating system or any of its generating units that is required by a Generator or Network Service Provider to be automatically disconnected from the power system in response to abnormal conditions arising from the power system, the relevant protection system or control system must not disconnect the generating system for:

(i) conditions for which it must remain in continuous uninterrupted operation; or

(ii) conditions it must withstand under the Rules; and

(2) a generating system with a nameplate rating of 30MW or more, or generating system comprised of generating units with a combined nameplate rating of 30 MW or more, connected to a transmission system must have facilities to automatically and rapidly reduce its generation:

(i) by at least half, if the frequency at the connection point exceeds a level nominated by AEMO (not less than the upper limit of the operational frequency tolerance band) and the duration above this frequency exceeds a value nominated by AEMO where the reduction may be achieved:

(A) by reducing the output of the generating system within 3 seconds, and holding the output at the reduced level until the frequency returns to within the normal operating frequency band; or

(B) by disconnecting the generating system from the power system within 1 second; or

(ii) in proportion to the difference between the frequency at the connection point and a level nominated by AEMO (not less than the upper limit of the operational frequency tolerance band), such that the generation is reduced by at least half, within 3 seconds of the frequency reaching the upper limit of the extreme frequency excursion tolerance limits.

Negotiated access standard

(b) AEMO must advise on matters relating to negotiated access standards under this clause S5.2.5.8.

General requirements

(c) AEMO or the Network Service Provider may require that an access standard include a requirement for the generating system to be automatically disconnected by a local or remote control scheme whenever the part of the network to which it is connected has been disconnected from the national grid, forming an island that supplies a Customer.
(d) The access standard must include specification of conditions for which the generating unit or generating system must trip and must not trip.

(e) Notwithstanding clauses S5.2.5.3, S5.2.5.4, S5.2.5.5, S5.2.5.6 and S5.2.5.7, a generating system may be automatically disconnected from the power system under any of the following conditions:

1. in accordance with an ancillary services agreement between the Generator and AEMO;

2. where a load that is not part of the generating system has the same connection point as the generating system and AEMO and the Network Service Provider agree that the disconnection would in effect be under-frequency load shedding;

3. where the generating system is automatically disconnected under paragraph (a) or clause S5.2.5.9;

4. where the generating system is automatically disconnected under clause S5.2.5.10 due to a failure of the generating plant; or

5. in accordance with an agreement between the Generator and a Network Service Provider (including an agreement in relation to an emergency control scheme under clause S5.1.8) to provide a service that AEMO agrees is necessary to maintain or restore power system security in the event of a specified contingency event.

(f) The Network Service Provider is not liable for any loss or damage incurred by the Generator or any other person as a consequence of a fault on either the power system, or within the Generator’s facility.

S5.2.5.9 Protection systems that impact on power system security

Automatic access standard

(a) The automatic access standard is:

1. subject to clauses S5.1.9(k) and S5.1.9(l), primary protection systems must be provided to disconnect from the power system any faulted element in a generating system and in protection zones that include the connection point within the applicable fault clearance time determined under clause S5.1.9(a)(1);

2. each primary protection system must have sufficient redundancy to ensure that a faulted element within its protection zone is disconnected from the power system within the applicable fault clearance time with any single protection element (including any communications facility upon which that protection system depends) out of service; and

3. breaker fail protection systems must be provided to clear faults that are not cleared by the circuit breakers controlled by the primary protection system within the applicable fault clearance time determined under clause S5.1.9(a)(1).

(b) In relation to an automatic access standard under this clause S5.2.5.9, the Generator must provide redundancy in the primary protection systems under paragraph (a)(2) and provide breaker fail protection systems under
paragraph (a)(3) if AEMO or the Network Service Provider consider that a lack of these facilities could result in:

(1) a material adverse impact on power system security or quality of supply to other Network Users; or

(2) a reduction in inter-regional or intra-regional power transfer capability through any mechanism including:

(3) consequential tripping of, or damage to, other network equipment or facilities of other Network Users, that would have a power system security impact; or

(4) instability that would not be detected by other protection systems in the network.

Minimum access standard

(c) The minimum access standard is:

(1) subject to clauses S5.1.9(k) and S5.1.9(l), protection systems must be provided to disconnect from the power system any faulted element within a generating system and in protection zones that include the connection point within the applicable fault clearance time determined under clause S5.1.9(a)(2); and

(2) if a fault clearance time determined under clause S5.1.9(a)(2) for a protection zone is less than 10 seconds, a breaker fail protection system must be provided to clear from the power system any fault within that protection zone that is not cleared by the circuit breakers controlled by the primary protection system within the applicable fault clearance time determined under clause S5.1.9(a)(3).

Negotiated access standard

(d) AEMO must advise on matters relating to negotiated access standards under this clause S5.2.5.9.

General requirements

(e) The Network Service Provider and the Generator must cooperate in the design and implementation of protection systems to comply with this clause S5.2.5.9, including cooperation on:

(1) the use of current transformer and voltage transformer secondary circuits (or equivalent) of one party by the protection system of the other;

(2) tripping of one party’s circuit breakers by a protection system of the other party; and

(3) co-ordination of protection system settings to ensure inter-operation.

(f) The protection system design referred to in paragraphs (a) and (c) must:

(1) be coordinated with other protection systems;
(2) avoid consequential disconnection of other Network Users’ facilities; and
(3) take into account existing obligations of the Network Service Provider under connection agreements with other Network Users.

**S5.2.5.10 Protection to trip plant for unstable operation**

**Automatic access standard**

(a) The automatic access standard is:

(1) a synchronous generating unit must have a protection system to disconnect it promptly when a condition that would lead to pole slipping is detected in order to prevent pole slipping or other conditions where a generating unit causes active power, reactive power or voltage at the connection point to become unstable as assessed in accordance with the power system stability guidelines established under clause 4.3.4(h); and

(2) an asynchronous generating unit must have a protection system to disconnect it promptly for conditions where the active power, reactive power or voltage at the connection point becomes unstable as assessed in accordance with the guidelines for power system stability established under clause 4.3.4(h).

**Minimum access standard**

(b) The minimum access standard is a generating unit must not cause a voltage disturbance at the connection point due to sustained unstable behaviour of more than the maximum level specified in Table 7 of Australian Standard AS/NZS 61000.3.7:2001.

**Negotiated access standard**

(c) If the Network Service Provider and the Generator agree, a protection system may also trip any other part of the generating system in order to cease the instability.

(d) Notwithstanding paragraph (c), a protection system must be provided in the access standard to trip the affected generating unit where:

(1) the Network Service Provider considers it necessary to prevent consequential tripping of, or damage to, other generating units, network equipment or other Network Users’ facilities; or

(2) AEMO considers it necessary to prevent unstable operation having an adverse impact on power system security.

(e) AEMO must advise on matters relating to negotiated access standards under this clause S5.2.5.10

**S5.2.5.11 Frequency control**

(a) For the purpose of this clause S5.2.5.11:

maximum operating level means in relation to:
(1) a non-scheduled generating unit, the maximum sent out generation consistent with its nameplate rating;

(2) a scheduled generating unit or semi-scheduled generating unit, the maximum sent out generation;

(3) a non-scheduled generating system, the combined maximum sent out generation consistent with the nameplate ratings of its in-service generating units; and

(4) a scheduled generating system or semi-scheduled generating system, the combined maximum sent out generation of its in-service generating units.

**minimum operating level** means in relation to:

(1) a non-scheduled generating unit, its minimum sent out generation for continuous stable operation;

(2) a scheduled generating unit or semi-scheduled generating unit, its minimum sent out generation for continuous stable operation consistent with its registered bid and offer data;

(3) a non-scheduled generating system, the combined minimum operating level of its in-service generating units; and

(4) a scheduled generating system or semi-scheduled generating system, the combined minimum sent out generation of its in-service generating units, consistent with its registered bid and offer data.

**pre-disturbance level** means in relation to a generating unit and a frequency disturbance, the generating unit's level of output just before the system frequency first exceeds the upper or lower limit of the normal operating frequency band during the frequency disturbance.

**system frequency** means the frequency of the transmission system or distribution system to which the generating unit or generating system is connected.

**Automatic access standard**

(b) The automatic access standard is:

(1) a generating system’s active power transfer to the power system must not:

   (i) increase in response to a rise in system frequency; or

   (ii) decrease in response to a fall in system frequency;

(2) a generating system must be capable of automatically reducing its active power transfer to the power system:

   (i) whenever the system frequency exceeds the upper limit of the normal operating frequency band;

   (ii) by an amount that equals or exceeds the least of:

      (A) 20% of its maximum operating level times the frequency difference between system frequency and the upper limit of the normal operating frequency band;
(B) 10% of its maximum operating level; and

(C) the difference between the generating unit’s pre-disturbance level and minimum operating level, but zero if the difference is negative; and

(iii) sufficiently rapidly for the Generator to be in a position to offer measurable amounts of lower services to the spot market for market ancillary services; and

(3) a generating system must be capable of automatically increasing its active power transfer to the power system:

(i) whenever the system frequency falls below the lower limit of the normal operating frequency band;

(ii) by the amount that equals or exceeds the least of:

   (A) 20% of its maximum operating level times the percentage frequency difference between the lower limit of the normal operating frequency band and system frequency;

   (B) 5% of its maximum operating level; and

   (C) one third of the difference between the generating unit’s maximum operating level and pre-disturbance level, but zero if the difference is negative; and

(iii) sufficiently rapidly for the Generator to be in a position to offer measurable amounts of raise services to the spot market for market ancillary services.

Minimum access standard

(c) The minimum access standard is a generating system under relatively stable input energy, active power transfer to the power system must not:

(1) increase in response to a rise in system frequency; and

(2) decrease more than 2% per Hz in response to a fall in system frequency.

Negotiated access standard

(d) A Generator proposing a negotiated access standard in respect of paragraph (c)(2) must demonstrate to AEMO that the proposed increase and decrease in active power transfer to the power system are as close as practicable to the automatic access standard for that plant.

(e) The negotiated access standard must record the agreed values for maximum operating level and minimum operating level, and where relevant the method of determining the values and the values for a generating system must take into account its in-service generating units.

(f) AEMO must advise on matters relating to negotiated access standards under this clause S5.2.5.11.
General requirements

(g) Each control system used to satisfy this clause S5.2.5.11 must be adequately damped.

(h) The amount of a relevant market ancillary service for which the plant may be registered must not exceed the amount that would be consistent with the performance standard registered in respect of this requirement.

S5.2.5.12 Impact on network capability

Automatic access standard

(a) The automatic access standard is a generating system must have plant capabilities and control systems that are sufficient so that when connected it does not reduce any inter-regional or intra-regional power transfer capability below the level that would apply if the generating system were not connected.

Minimum access standard

(b) The minimum access standard is a generating system must have plant capabilities, control systems and operational arrangements sufficient to ensure there is no reduction in:

1. the ability to supply Customer load as a result of a reduction in power transfer capability; and

2. power transfer capabilities into a region by more than the combined sent out generation of its generating units.

Negotiated access standard

(c) In carrying out assessments of proposed negotiated access standards under this clause S5.2.5.12, the Network Service Provider and AEMO must take into account:

1. the expected performance of:
   (i) existing networks and considered projects;
   (ii) existing generating plant and other relevant projects; and
   (iii) control systems and protection systems, including automatic reclose equipment; and

2. the expected range of power system operating conditions.

(d) The negotiated access standard must include:

1. control systems to minimise any reduction in power transfer capabilities; and

2. operational arrangements, including curtailment of the generating system’s output if necessary to ensure that the generating plant is operated in a way that meets at least the minimum access standard under abnormal network and generating system conditions, so that power system security can be maintained.
(e) A negotiated access standard under this clause S5.2.5.12 must detail the plant capabilities, control systems and operational arrangements that will be maintained by the Generator, notwithstanding that change to the power system, but not changes to the generating system, may reduce the efficacy of the plant capabilities, control systems and operational arrangements over time.

(f) AEMO must advise on matters relating to negotiated access standards under this clause S5.2.5.12.

General requirement

(g) If a Network Service Provider considers that power transfer capabilities of its network would be increased through provision of additional control system facilities to a generating system (such as a power system stabiliser), the Network Service Provider and the Generator may negotiate for the provision of such additional control system facilities as a commercial arrangement.

S5.2.5.13 Voltage and reactive power control

(a) For the purpose of this clause S5.2.5.13:

rise time means in relation to a step response test or simulation of a control system, the time taken for an output quantity to rise from 10% to 90% of the maximum change induced in that quantity by a step change of an input quantity.

settling time means in relation to a step response test or simulation of a control system, the time measured from initiation of a step change in an input quantity to the time when the magnitude of error between the output quantity and its final settling value remains less than 10% of:

1. if the sustained change in the quantity is less than half of the maximum change in that output quantity, the maximum change induced in that output quantity; or
2. the sustained change induced in that output quantity.

static excitation system means in relation to a synchronous generating unit, an excitation control system that does not use rotating machinery to produce the field current.

Automatic access standard

(b) The automatic access standard is:

1. a generating system must have plant capabilities and control systems sufficient to ensure that:

   i. power system oscillations, for the frequencies of oscillation of the generating unit against any other generating unit, are adequately damped;

   ii. operation of the generating system does not degrade the damping of any critical mode of oscillation of the power system; and
(iii) operation of the generating system does not cause instability (including hunting of tap-changing transformer control systems) that would adversely impact other Registered Participants;

(2) a control system must have:

(i) for the purposes of disturbance monitoring and testing, permanently installed and operational, monitoring and recording facilities for key variables including each input and output; and

(ii) facilities for testing the control system sufficient to establish its dynamic operational characteristics;

(3) a synchronous generating system must have an excitation control system that:

(i) regulates voltage at the connection point or another agreed location in the power system (including within the generating system) to within 0.5% of the setpoint;

(ii) is able to operate the stator continuously at 105% of nominal voltage with rated active power output;

(iii) regulates voltage in a manner that helps to support network voltages during faults and does not prevent the Network Service Provider from achieving the requirements of clause S5.1a.3 and S5.1a.4;

(iv) allows the voltage setpoint to be continuously controllable in the range of at least 95% to 105% of normal voltage at the connection point or the agreed location, without reliance on a tap-changing transformer;

(v) has limiting devices to ensure that a voltage disturbance does not cause the generating unit to trip at the limits of its operating capability;

(vi) has an excitation ceiling voltage of at least:

(A) for a static excitation system, 2.3 times; or
(B) for other excitation control systems, 1.5 times,
the excitation required to achieve generation at the nameplate rating for rated power factor, rated speed and nominal voltage;

(vii) has settling times for a step change of voltage setpoint or voltage at the location agreed under subparagraph (i) of:

(A) generated voltage less than 2.5 seconds for a 5% voltage disturbance with the generating unit not synchronised;

(B) active power, reactive power and voltage less than 5.0 seconds for a 5% voltage disturbance with the generating unit synchronised, from an operating point where the voltage disturbance would not cause any limiting device to operate; and

(C) in respect of each limiting device, active power, reactive power and voltage less than 7.5 seconds for a 5% voltage
disturbance with the generating unit synchronised, when operating into a limiting device from an operating point where a voltage disturbance of 2.5% would just cause the limiting device to operate;

(viii) is able to increase field voltage from rated field voltage to the excitation ceiling voltage in less than:

(A) 0.05 second for a static excitation system; or
(B) 0.5 second for other excitation control systems;

(ix) has a power system stabiliser with sufficient flexibility to enable damping performance to be maximised, with characteristics as described in paragraph (c); and

(x) has reactive current compensation settable for boost or droop;

and

(4) a generating system, other than one comprised of synchronous generating units, must have a voltage control system that:

(i) regulates voltage at the connection point or an agreed location in the power system (including within the generating system) to within 0.5% of its setpoint;

(ii) regulates voltage in a manner that helps to support network voltages during faults and does not prevent the Network Service Provider from achieving the requirements of clauses S5.1a.3 and S5.1a.4;

(iii) allows the voltage setpoint to be continuously controllable in the range of at least 95% to 105% of normal voltage at the connection point or agreed location in the power system, without reliance on a tap changing transformer;

(iv) has limiting devices to ensure that a voltage disturbance does not cause the generating unit to trip at the limits of its operating capability;

(v) with the generating system connected to the power system, has settling times for active power, reactive power and voltage due to a step change of voltage setpoint or voltage at the location agreed under clause subparagraph (i), of less than:

(A) 5.0 seconds for a 5% voltage disturbance with the generating system connected to the power system, from an operating point where the voltage disturbance would not cause any limiting device to operate; and

(B) 7.5 seconds for a 5% voltage disturbance with the generating system connected to the power system, when operating into any limiting device from an operating point where a voltage disturbance of 2.5% would just cause the limiting device to operate;

(vi) has reactive power rise time, for a 5% step change in the voltage setpoint, of less than 2 seconds;
(vii) has a power system stabiliser with sufficient flexibility to enable damping performance to be maximised, with characteristics as described in paragraph (c); and

(viii) has reactive current compensation.

(c) A power system stabiliser provided under paragraph (b) must have:

(1) for a synchronous generating unit, measurements of rotor speed and active power output of the generating unit as inputs, and otherwise, measurements of power system frequency and active power output of the generating unit as inputs;

(2) two washout filters for each input, with ability to bypass one of them if necessary;

(3) sufficient (and not less than two) lead-lag transfer function blocks (or equivalent number of complex poles and zeros) with adjustable gain and time-constants, to compensate fully for the phase lags due to the generating plant;

(4) an output limiter, which for a synchronous generating unit is continually adjustable over the range of –10% to +10% of stator voltage;

(5) monitoring and recording facilities for key variables including inputs, output and the inputs to the lead-lag transfer function blocks; and

(6) facilities to permit testing of the power system stabiliser in isolation from the power system by injection of test signals, sufficient to establish the transfer function of the power system stabiliser.

Minimum access standard

(d) The minimum access standard is:

(1) a generating system must have plant capabilities and control systems, including, if appropriate, a power system stabiliser, sufficient to ensure that:

   (i) power system oscillations, for the frequencies of oscillation of the generating unit against any other generating unit, are adequately damped;

   (ii) operation of the generating unit does not degrade:

       (A) any mode of oscillation that is within 0.3 nepers per second of being unstable, by more than 0.01 nepers per second; and

       (B) any other mode of oscillation to within 0.29 nepers per second of being unstable; and

   (iii) operation of the generating unit does not cause instability (including hunting of tap-changing transformer control systems) that would adversely impact other Registered Participants;

(2) a generating system comprised of generating units with a combined nameplate rating of 30 MW or more must have facilities for testing its
control systems sufficient to establish their dynamic operational characteristics;

(3) a generating unit or generating system must have facilities:
   (i) where the connection point nominal voltage is 100 kV or more, to regulate voltage in a manner that does not prevent the Network Service Provider from achieving the requirements of clauses S5.1a.3 and S5.1a.4; or
   (ii) where the connection point nominal voltage is less than 100 kV, to regulate voltage or reactive power or power factor in a manner that does not prevent the Network Service Provider from achieving the requirements of clauses S5.1a.3 and S5.1a.4, and sufficient to achieve the performance agreed in respect of clauses S5.2.5.1, S5.2.5.2, S5.2.5.3, S5.2.5.4, S5.2.5.5, S5.2.5.6 and S5.2.5.12;

(4) a synchronous generating unit, that is part of a generating system comprised of generating units with a combined nameplate rating of 30 MW or more, must have an excitation control system that:
   (i) regulates voltage, power factor or reactive power as agreed with the Network Service Provider and AEMO;
   (ii) has excitation ceiling voltage of at least 1.5 times the excitation required to achieve generation at the nameplate rating for rated power factor, rated speed and nominal voltage;
   (iii) subject to co-ordination under paragraph (i), has a settling time of less than 5.0 seconds for a 5% voltage disturbance with the generating unit synchronised, from an operating point where such a voltage disturbance would not cause any limiting device to operate; and
   (iv) has over and under excitation limiting devices sufficient to ensure that a voltage disturbance does not cause the generating unit to trip at the limits of its operating capability; and

(5) a generating system comprised of generating units with a combined nameplate rating of 30 MW or more and which are asynchronous generating units, must have a control system that:
   (i) regulates voltage, power factor or reactive power as agreed with the Network Service Provider and AEMO;
   (ii) subject to co-ordination under subparagraph (i), has a settling time less than 7.5 seconds for a 5% voltage disturbance with the generating unit electrically connected to the power system from an operating point where such a voltage disturbance would not cause any limiting device to operate; and
   (iii) has limiting devices to ensure that a voltage disturbance would not cause the generating unit to trip at the limits of its operating capability.
Negotiated access standard

(e) If a generating system cannot meet the automatic access standard, the Generator must demonstrate to the Network Service Provider why that standard could not be reasonably achieved and propose a negotiated access standard.

(f) The negotiated access standard proposed by the Generator under paragraph (e) must be the highest level that the generating system can reasonably achieve, including by installation of additional dynamic reactive power equipment, and through optimising its control systems.

(g) AEMO must advise on matters relating to negotiated access standards under this clause S5.2.5.13.

General requirements

(h) A limiting device provided under paragraphs (b) and (c) must:
   (1) not detract from the performance of any power system stabiliser; and
   (2) be co-ordinated with all protection systems.

(i) The Network Service Provider may require that the design and operation of the control systems of a generating unit or generating system be coordinated with the existing voltage control systems of the Network Service Provider and of other Network Users, in order to avoid or manage interactions that would adversely impact on the Network Service Provider and other Network Users.

(j) Any requirements imposed by the Network Service Provider under paragraph (i) must be recorded in the access standard.

(k) The assessment of impact of the generating units on power system stability and damping of power system oscillations shall be in accordance with the guidelines for power system stability established under clause 4.3.4(h).

S5.2.5.14 Active power control

(a) The automatic access standard is a generating system comprised of generating units with a combined nameplate rating of 30 MW or more must have an active power control system capable of:
   (1) for a scheduled generating unit or a scheduled generating system:
      (i) maintaining and changing its active power output in accordance with its dispatch instructions; and
      (ii) ramping its active power output linearly from one level of dispatch to another;
   (2) subject to energy source availability, for a non-scheduled generating unit or non-scheduled generating system:
      (i) automatically reducing or increasing its active power output within 5 minutes, at a constant rate, to or below the level specified in an instruction electronically issued by a control centre, subject to subparagraph (iii);
(ii) automatically limiting its active power output, to below the level specified in subparagraph (i); and

(iii) not changing its active power output within 5 minutes by more than the raise and lower amounts specified in an instruction electronically issued by a control centre; and

(2) subject to energy source availability, for a semi-scheduled generating unit or a semi-scheduled generating system:

(i) automatically reducing or increasing its active power output within 5 minutes at a constant rate, to or below the level specified in an instruction electronically issued by a control centre;

(ii) automatically limiting its active power output, to or below the level specified in subparagraph (i);

(iii) not changing its active power output within 5 minutes by more than the raise and lower amounts specified in an instruction electronically issued by a control centre; and

(iv) ramping its active power output linearly from one level of dispatch to another.

**Minimum access standard**

(b) The minimum access standard is a generating system comprised of generating units with a combined nameplate rating of 30 MW or more must have an active power control system capable of:

(1) for a scheduled generating unit or a scheduled generating system, maintaining and changing its active power output in accordance with its dispatch instructions;

(2) for a non-scheduled generating system:

(i) reducing its active power output, within 5 minutes, to or below the level required to manage network flows that is specified in a verbal instruction issued by the control centre;

(ii) limiting its active power output, to or below the level specified in subparagraph (i);

(iii) subject to energy source availability, ensuring that the change of active power output in a 5 minute period does not exceed a value specified in a verbal instruction issued by the control centre; and

(iv) being upgraded to receive electronic instructions from the control centre and fully implement them within 5 minutes; and

(3) for a semi-scheduled generating unit or a semi-scheduled generating system, maintaining and changing its active power output in accordance with its dispatch instructions.

Comment [ABT28]: Applies Partially

Needs to be more specific to SMVA range
Negotiated access standard

(c) A negotiated access standard may provide that if the number or frequency of verbal instructions becomes difficult for a control centre to manage, AEMO may require the Generator to upgrade its facilities to receive electronic instructions and fully implement them within 5 minutes.

(d) The negotiated access standard must document to AEMO’s satisfaction any operational arrangements necessary to manage network flows that may include a requirement for the generating system to be operated in a manner that prevents its output changing within 5 minutes by more than an amount specified by a control centre.

(e) AEMO must advise on matters relating to negotiated access standards under this clause S5.2.5.14.

General requirements

(f) Each control system used to satisfy the requirements of paragraphs (a) and (b) must be adequately damped.

S5.2.6 Monitoring and control requirements

S5.2.6.1 Remote Monitoring

Automatic access standard

(a) The automatic access standard is a:

(1) scheduled generating unit;

(2) scheduled generating system;

(3) non-scheduled generating unit with a nameplate rating of 30 MW or more;

(4) non-scheduled generating system with a combined nameplate rating of 30 MW or more;

(5) semi-scheduled generating unit; or

(6) semi-scheduled generating system.

must have remote monitoring equipment to transmit to AEMO’s control centres in real time in accordance with rule 4.11 the quantities that AEMO reasonably requires to discharge its market and power system security functions set out in Chapters 3 and 4.

(b) The quantities referred to under paragraph (a) that AEMO may request include:

(1) in respect of a generating unit with a nameplate rating of 30 MW or more:

(i) current, voltage, active power and reactive power in respect of generating unit stators or power conversion systems (as applicable);

(ii) the status of all switching devices that carry the generation; and

(iii) tap-changing transformer tap position;
(2) in respect of a generating system that includes a generating unit with a nameplate rating of less than 30 MW:
   (i) its connected status, tap-changing transformer tap position and voltages;
   (ii) active power and reactive power aggregated for groups of identical generating units;
   (iii) either the number of identical generating units operating or the operating status of each non-identical generating unit; and
   (iv) active power and reactive power for the generating system;
(3) in respect of an auxiliary supply system with a capacity of 30 MW or more associated with a generating unit or generating system, active power and reactive power;
(4) in respect of reactive power equipment that is part of a generating system but not part of a particular generating unit, its reactive power;
(5) in respect of a wind farm type of generating system:
   (i) wind speed;
   (ii) wind direction;
   (iii) ambient temperature; and
(6) any other quantity that AEMO reasonably requires to discharge its market and power system security functions as set out in Chapters 3 and 4.

Minimum access standard

(c) The minimum access standard is a:
   (1) scheduled generating unit;
   (2) scheduled generating system;
   (3) non-scheduled generating system with a combined nameplate rating of 30 MW or more;
   (4) semi-scheduled generating unit; or
   (5) semi-scheduled generating system,
   must have remote monitoring equipment to transmit to AEMO’s control centres in real time:
   (6) the active power output of the generating unit or generating system (as applicable);
   (7) if connected to a transmission system, the reactive power output of the generating unit or generating system (as applicable); and
   (8) if a wind farm type of generating system:
       (i) number of units operating;
       (ii) wind speed; and
       (iii) wind direction.
in accordance with rule 4.11.

Negotiated access standard

d) AEMO may advise on matters relating to negotiated access standards under this clause S5.2.6.1.

S5.2.6.2 Communications equipment

Automatic access standard

(a) The automatic access standard is a Generator must:

(1) provide and maintain two separate telephone facilities using independent telecommunications service providers, for the purposes of operational communications between the Generator’s responsible operator under clause 4.11.3(a) and AEMO’s control centre; and

(2) provide electricity supplies for remote monitoring equipment and remote control equipment installed in relation to its generating system capable of keeping such equipment available for at least 3 hours following total loss of supply at the connection point for the relevant generating unit.

Minimum access standard

(b) The minimum access standard is a Generator must:

(1) provide and maintain a telephone facility for the purposes of operational communications between the Generator’s responsible operator under clause 4.11.3(a) and AEMO’s control centre; and

(2) provide electricity supplies for remote monitoring equipment and remote control equipment installed in relation to its generating system capable of keeping such equipment available for at least 1 hour following total loss of supply at the connection point for the relevant generating unit.

Negotiated access standard

(e) A negotiated access standard must include, where the Network Service Provider or AEMO reasonably require, a back-up telephone facility be independent of commercial telephone service providers, and the Network Service Provider must provide and maintain the separate facility on a cost-recovery basis only through the charge for connection.

(d) A negotiated access standard must include that a Generator must provide communications paths (with appropriate redundancy) from the remote monitoring equipment or remote control equipment installed for each of its generating systems as appropriate, to a interface for communication purposes in a location reasonably acceptable to the Network Service Provider at the relevant generation facility.

(e) Communications systems between the interface for communication purposes under paragraph (d) and the control centre must be the responsibility of the Network Service Provider unless otherwise agreed by the Generator and the Network Service Provider.
A negotiated access standard must include that the Generator provide accommodation and secure power supplies for communications facilities provided by the Network Service Provider under this clause S5.2.6.2.

AEMO may advise on matters relating to negotiated access standards under this clause S5.2.6.2.

S5.2.7 Power station auxiliary supplies

In cases where a generating system takes its auxiliary supplies via a connection point through which its generation is not transferred to the network, the access standards must be established under clause S5.3.5 as if the Generator were a Market Customer.

S5.2.8 Fault current

Automatic access standard

(a) The automatic access standard is:

(1) the contribution of the generating system to the fault current on the connecting network through its connection point must not exceed the contribution level that will ensure that the total fault current can be safely interrupted by the circuit breakers of the connecting network and safely carried by the connecting network for the duration of the applicable breaker fail protection system fault clearance times, as specified for the relevant connection point by the Network Service Provider;

(2) a generating system’s connected plant must be capable of withstanding fault current through the connection point up to the higher of:

(i) the level specified in clause S5.2.4(e1)(1) ; and

(ii) the highest level of current at the connection point that can be safely interrupted by the circuit breakers of the connecting network and safely carried by the connecting network for the duration of the applicable breaker fail protection system fault clearance times, as specified by the Network Service Provider; and

(3) a circuit breaker provided to isolate a generating unit or generating system from the network must be capable of breaking, without damage or restrike, the maximum fault currents that could reasonably be expected to flow through the circuit breaker for any fault in the network or in the generating unit or generating system, as specified in the connection agreement.

Minimum access standard

(b) The minimum access standard is:

(1) the generating system does not need to limit fault current contribution;
(2) a generating system’s connected plant must be capable of withstanding fault current through the connection point up to the level specified in clause S5.2.4(e1)(1); and

(3) a circuit breaker provided to isolate a generating unit or generating system from the network must be capable of breaking, without damage or restrike, the maximum fault currents that could reasonably be expected to flow through the circuit breaker for any fault in the network or in the generating unit or generating system, as specified in the connection agreement.

**Negotiated access standard**

(c) In negotiating a negotiated access standard, the Network Service Provider must consider alternative network configurations in the determination of the applicable fault current level and must prefer those options that maintain an equivalent level of service to other Network Users and which, in the opinion of the Generator, impose the least obligation on the Generator.

(d) In carrying out assessments of proposed negotiated access standards under this clause S5.2.8, the Network Service Provider must take into account, without limitation:

1. the expected performance of existing networks and considered projects;
2. the expected performance of existing generating plant and other relevant projects; and
3. the expected range of power system operating conditions.

**Schedule 5.3 Conditions for Connection of Customers**

**S5.3.1a Introduction to the schedule**

(a) This schedule applies to the following classes of Network User:

1. a First-Tier Customer in respect of its first-tier load;
2. a Second-Tier Customer in respect of its second-tier load;
3. a Market Customer in respect of its market load;
4. a Non-Registered Customer in respect of supply it takes from a network; and
5. a Distribution Network Service Provider in respect of its distribution network.

(b) For the purposes of this schedule 5.3 the term Network Service Provider must be interpreted to mean the Network Service Provider with whom the Connection Applicant has sought, or is seeking, a connection in accordance with clause 5.3.2 of the Rules.

(c) All Network Users must comply with the requirements for the establishment of performance standards in accordance with provisions contained in schedule 5.1a for system standards or schedule 5.1 for Network Service Providers and this schedule 5.3 for Customers.
(d) If the Connection Applicant is a Registered Participant in relation to the proposed connection, the Network Service Provider may include as terms and conditions of the connection agreement any provision of this schedule that is expressed as an obligation on a Network User. If the Connection Applicant is not a Registered Participant in relation to the proposed connection, the Network Service Provider must include as terms and conditions of the connection agreement:

(1) each provision of this schedule that is expressed as an obligation on a Network User; and

(2) each agreed performance standard and an obligation to comply with it.

(e) The purpose of this schedule is to:

(1) describe the information that must be exchanged for the connection enquiry and application to connect processes described in rule 5.3 of the Rules;

(2) establish the automatic access standards and minimum access standards that will apply to the process of negotiating access standards under clause 5.3.4A of the Rules; and

(3) establish obligations to apply prudent design standards for the plant to be connected.

S5.3.1 Information

(a) Before a Network User connects any new or additional equipment to a network, the Network User must submit the following kinds of information to the Network Service Provider:

(1) a single line diagram with the protection details;

(2) metering system design details for any metering equipment being provided by the Network User;

(3) a general arrangement locating all the equipment on the site;

(4) a general arrangement for each new or altered substation showing all exits and the position of all electrical equipment;

(5) type test certificates for all new switchgear and transformers, including measurement transformers to be used for metering purposes in accordance with Chapter 7 of the Rules;

(6) earthing details;

(7) the proposed methods of earthing cables and other equipment to comply with the regulations of the relevant participating jurisdiction;

(8) plant and earth grid test certificates from approved test authorities;

(9) a secondary injection and trip test certificate on all circuit breakers;

(10) certification that all new equipment has been inspected before being connected to the supply; and

(11) operational arrangements.
For the purposes of clause 5.3.2(f) of the Rules, the technical information that a Network Service Provider must, if requested, provide to a Connection Applicant in respect of the proposed connection includes:

(1) the highest expected single phase and three phase fault levels at the connection point without the proposed connection;

(2) the clearing times of the existing protection systems that would clear a fault at the location at which the new connection would be connected into the existing transmission system or distribution system;

(3) the expected limits of voltage fluctuation, harmonic voltage distortion and voltage unbalance at the connection point without the proposed connection;

(4) technical information relevant to the connection point without the proposed connection including equivalent source impedance information, sufficient to estimate fault levels, voltage fluctuations, harmonic voltage distortion and voltage unbalance; and

(5) any other information or data not being confidential information relating to the performance of the Network Service Provider's facilities that is reasonably necessary for the Connection Applicant to prepare an application to connect;

except where the Connection Applicant agrees the Network Service Provider may provide alternative or less detailed technical information in satisfaction of this clause S5.3.1.(b).

**S5.3.2 Design standards**

A Network User must ensure that:

(a) the electrical plant in its facility complies with the relevant Australian Standards as applicable at the time of first installation of that electrical plant in the facility;

(b) circuit breakers provided to isolate the Network User's facilities from the Network Service Provider's facilities are capable of breaking, without damage or restrike, fault currents nominated by the Network Service Provider in the relevant connection agreement; and

(c) new equipment including circuit breakers provided to isolate the Network User's facilities from the Network Service Provider's facilities is capable of withstanding, without damage, power frequency voltages and impulse levels nominated by the Network Service Provider to apply at the connection point in accordance with the relevant provisions of the system standards and recorded in the relevant connection agreement.

**S5.3.3 Protection systems and settings**

A Network User must ensure that all connections to the network are protected by protection devices which effectively and safely disconnect any faulty circuit automatically within a time period specified by the Network Service Provider in accordance with the following provisions:

(a) The automatic access standard is:
(1) Primary protection systems must be provided to disconnect any faulted element from the power system within the applicable fault clearance time determined under clause S5.1.9(a)(1), but subject to clauses S5.1.9(k) and S5.1.9(l).

(2) Each primary protection system must have sufficient redundancy to ensure that a faulted element within its protection zone is disconnected from the power system within the applicable fault clearance time with any single protection element (including any communications facility upon which that protection system depends) out of service.

(3) Breaker fail protection systems must be provided to clear faults that are not cleared by the circuit breakers controlled by the primary protection system, within the applicable fault clearance time determined under clause S5.1.9(a)(1).

(b) The minimum access standard is:

(1) Primary protection systems must be provided to disconnect from the power system any faulted element within their respective protection zones within the applicable fault clearance time determined under clause S5.1.9(a)(2), but subject to clauses S5.1.9(k) and S5.1.9(l).

(2) If a fault clearance time determined under clause S5.1.9(a)(2) for a protection zone is less than 10 seconds, a breaker fail protection system must be provided to clear from the power system any fault within that protection zone that is not cleared by the circuit breakers controlled by the primary protection system, within the applicable fault clearance time determined under clause S5.1.9(a)(3).

(c) The Network Service Provider and the Network User must cooperate in the design and implementation of protection systems to comply with this clause, including cooperation with regard to:

(1) the use of current transformer and voltage transformer secondary circuits (or equivalent) of one party by the protection system of the other;

(2) tripping of one party's circuit breakers by a protection system of the other party; and

(3) co-ordination of protection system settings to ensure inter-operation.

Before the Network User’s installation is connected to the Network Service Provider's transmission or distribution system the Network User’s protection system must be tested and the Network User must submit the appropriate test certificate to the Network Service Provider.

The application of settings of the protection scheme must be undertaken in accordance with clause S5.3.4.

S5.3.4 Settings of protection and control systems

A Network User must only apply settings to a control system or a protection system that are necessary to comply with performance requirements of this schedule 5.3 if the settings have been approved in writing by the Network Service Provider and, if the requirement is one that would involve AEMO under
clause 5.3.4A(c) of the Rules, also by AEMO. A Network User must not allow its plant to take supply of electricity from the power system without such prior approval.

If a Network User seeks approval from the Network Service Provider to apply or change a setting, approval must not be withheld unless the Network Service Provider or, if the requirement is one that would involve AEMO under clause 5.3.4A(c) of the Rules, AEMO, reasonably determines that the changed setting would cause the plant to not comply with the relevant performance standard or cause an inter-regional or intra-regional power transfer capability to be reduced.

If the Network Service Provider or, if the requirement is one that would involve AEMO under clause 5.3.4A(c) of the Rules, AEMO, reasonably determines that a setting of a control system or protection system of the plant needs to change to comply with the relevant performance standard or to maintain or restore an inter-regional or intra-regional power transfer capability, the Network Service Provider or AEMO (as applicable) must consult with the Network User, and the Network Service Provider may request in writing that a setting be applied in accordance with the determination.

The Network Service Provider may also request a test to verify the performance of the relevant plant with the new setting.

A Network User who receives such a request must arrange for the notified setting to be applied as requested and for a test to be conducted as requested. After the test, the Network User must, on request, provide both AEMO and the Network Service Provider with a report of a requested test, including evidence of its success or failure. Such a report of a test is confidential information.

A Network User must not change a setting requested by the Network Service Provider without its prior written agreement. If the Network Service Provider requires a Network User to change a setting within 18 months of a previous request, the Network Service Provider must pay the Network User its reasonable costs of changing the setting and conducting the tests as requested.

S5.3.5 Power factor requirements

Automatic access standard: For loads equal to or greater than 30 percent of the maximum demand at the connection point the power factors for Network Users and for distribution networks connected to another transmission network or distribution network are shown in Table S5.3.1:

Table S5.3.1

<table>
<thead>
<tr>
<th>Supply Voltage (nominal)</th>
<th>Power Factor Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 400 kV</td>
<td>0.98 lagging to unity</td>
</tr>
<tr>
<td>250 kV - 400 kV</td>
<td>0.96 lagging to unity</td>
</tr>
<tr>
<td>50 kV - 250 kV</td>
<td>0.95 lagging to unity</td>
</tr>
</tbody>
</table>
Permissible Range

<table>
<thead>
<tr>
<th>Supply Voltage (nominal)</th>
<th>Power Factor Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 kV &lt; 50 kV</td>
<td>0.90 lagging to 0.90 leading</td>
</tr>
</tbody>
</table>

For load less than 30 percent of the maximum demand at the connection point a Network Service Provider may accept a power factor outside the range stipulated in Table S5.3.1 provided this does not cause the system standards to be violated.

Minimum access standard: A Network Service Provider may permit a lower lagging or leading power factor where the Network Service Provider is advised by AEMO that this will not detrimentally affect power system security or reduce intra-regional or inter-regional power transfer capability.

General:

If the power factor falls outside the relevant performance standard over any critical loading period nominated by the Network Service Provider, the Network User must, where required by the Network Service Provider in order to maintain satisfactory voltage levels at the connection point or to restore intra-regional or inter-regional power transfer capability, take action to ensure that the power factor falls within range as soon as reasonably practicable. This may be achieved by installing additional reactive plant or reaching a commercial agreement with the Network Service Provider to install, operate and maintain equivalent reactive plant as part of the connection assets or by alternative commercial arrangements with another party.

A Registered Participant who installs shunt capacitors to comply with power factor requirements must comply with the Network Service Provider’s reasonable requirements to ensure that the design does not severely attenuate audio frequency signals used for load control or operations, or adversely impact on harmonic voltage levels at the connection point.

S5.3.6 Balancing of load currents

A Network Service Provider may require a connected Registered Participant’s load to be balanced across all phases in order to maintain the negative sequence voltage at each connection point at less than or equal to the limits set out in Table S5.1a.1 of the system standards for the applicable nominal supply voltage level.

Automatic access standard: A Network User must ensure that:

(a) for connections at 30 kV or higher voltage, the current in any phase is not greater than 102 percent or less than 98 percent of the average of the currents in the three phases; and

(b) for connections at voltages less than 30 kV, that the current in any phase is not greater than 105 percent or less than 95 percent of the average of the currents in the three phases.

Minimum access standard: Where agreed with the relevant Network Service Provider and subject to any specific conditions imposed, a Network User may cause current unbalance greater than that specified in the automatic access
standard provided the Network User does not cause the limits specified in clause S5.1a.7 to be exceeded at any point in the network.

General:

The limit to load current unbalance must be included in the connection agreement and is subject to verification of compliance by the Network Service Provider.

Where these requirements cannot be met the Registered Participant may enter into a commercial arrangement with the Network Service Provider for the installation of equipment to correct the phase unbalance. Such equipment must be considered as part of the connection assets for the Registered Participant.

The limit to load current unbalance must be included in the connection agreement and is subject to verification of compliance by the Network Service Provider.

S5.3.7 Voltage fluctuations

(a) Automatic access standard: The voltage fluctuations caused by variations in loading level at the connection point, including those arising from energisation, de-energisation or other operation of plant, must not exceed the limits determined under clause S5.1.5(a).

(b) Minimum access standard: The voltage fluctuations caused by variations in loading level at the connection point, including those arising from energisation, de-energisation or other operation of plant, must not exceed the limits determined under clause S5.1.5(b).

The voltage fluctuation emission limits and any specified conditions must be included in the connection agreement, and are subject to verification of compliance by the Network Service Provider.

S5.3.8 Harmonics and voltage notching

(a) Automatic access standard: The harmonic voltage distortion caused by non-linearity, commutation of power electronic equipment, harmonic resonance and other effects within the plant, must not exceed the limits determined under clause S5.1.6(a).

(b) Minimum access standard: The harmonic voltage distortion caused by non-linearity, commutation of power electronic equipment, harmonic resonance and other effects within the plant, must not exceed the limits determined under clause S5.1.6(b).

The harmonic voltage distortion emission limits and any special conditions must be included in the connection agreement, and is subject to verification of compliance by the Network Service Provider.

S5.3.9 Design requirements for Network Users’ substations

A Network User must comply with the following requirements applicable to the design, station layout and choice of equipment for a substation:

(a) safety provisions must comply with requirements applicable to the participating jurisdiction notified by the Network Service Provider;

(b) where required by the Network Service Provider, appropriate interfaces and accommodation must be incorporated for communication facilities, remote
monitoring and control and protection of plant which is to be installed in the substation;

(c) a substation must be capable of continuous uninterrupted operation with the levels of voltage, harmonics, unbalance and voltage fluctuation specified in the system standards as modified in accordance with the relevant provisions of schedule 5.1;

(d) earthing of primary plant in the substation must be in accordance with the Electricity Supply Association of Australia Safe Earthing Guide and must reduce step and touch potentials to safe levels;

(e) synchronisation facilities or reclose blocking must be provided if a generating unit is connected through the substation;

(f) secure electricity supplies of adequate capacity must be provided for plant performing communication, monitoring, control and protection functions;

(g) plant must be tested to ensure that the substation complies with the approved design and specifications as included in a connection agreement;

(h) the protection equipment required would normally include protection schemes for individual items of plant, back-up arrangements, auxiliary DC supplies and instrumentation transformers; and

(i) insulation levels of plant in the substation must co-ordinate with the insulation levels of the network to which the substation is connected as nominated in the connection agreement.

S5.3.10 Load shedding facilities

Network Users who are Market Customers and who have expected peak demands in excess of 10MW must provide automatic interruptible load in accordance with clause 4.3.5 of the Rules.

Load shedding procedures may be applied by AEMO in accordance with the provisions of clause 4.3.2 of the Rules for the shedding of all loads including sensitive loads.

Schedule 5.3a Conditions for connection of Market Network Services

S5.3a.1a Introduction to the schedule

This schedule sets out obligations of Market Network Service Providers who connect to either a transmission network or a distribution network. It represents the requirements to be met for access to a network. Particular provisions may be varied by the Network Service Provider under the provisions of the Rules for the application of minimum access standards and automatic access standards.

This schedule includes specific provisions for the determination of automatic access standards and negotiated access standards derived from minimum access standards which, once determined, must be recorded together with the automatic access standards in a connection agreement and registered with AEMO as performance standards.
In this schedule, the term *Network Service Provider* applies only to the *Network Service Provider* with whom the *Market Network Service Provider* has lodged, or is considering lodging, an *application to connect*.

(a) The schedule includes, in respect of each *market network service*, provisions regarding the capability to:

1. automatically control the transfer of real power at the *connection point* for any given set of system conditions within the limits permitted under the *Rules*;
2. respond to control requirements under expected normal and abnormal conditions;
3. comply with general requirements to meet quality of supply obligations in accordance with clauses S5.3a.9, S5.3a.10 and S5.3a.11 and to maintain security of supply to other *Registered Participants*; and
4. automatically *disconnect* itself when necessary to prevent any damage to the *market network service facilities* or threat to power system security.

(b) This schedule also sets out the requirements and conditions, which (subject to clause 5.2.3 of the *Rules*) are obligations of *Market Network Service Providers* to:

1. co-operate with the relevant *Network Service Provider* on technical matters when making a new connection;
2. provide information to the *Network Service Provider* or *AEMO*; and
3. observe and apply the relevant provisions of the *system standards* contained in schedule 5.1a in relation to the planning, design and operation of its *market network service facilities*.

(c) This schedule does not set out arrangements by which a *Market Network Service Provider* may enter into an agreement or contract with *AEMO* to:

1. provide additional services that are necessary to maintain power system security; or
2. provide additional service to facilitate management of the *market*.

### S5.3a.1 Provision of Information

(a) Before a *Market Network Service Provider* connects any new or additional equipment to a *network*, the *Market Network Service Provider* must submit the following kinds of information to the *Network Service Provider*:

1. a single line diagram with the protection details;
2. *metering system* design details for any metering equipment being provided by the *Market Network Service Provider*;
3. a general arrangement locating all relevant equipment on the site;
4. a general arrangement for each new or altered *substation* showing all exits and the position of all electrical equipment;
(5) type test certificates for all new switchgear and transformers, including measurement transformers to be used for metering purposes in accordance with Chapter 7 of the Rules;

(6) earthing details;

(7) the proposed methods of earthing cables and other equipment to comply with the regulations of the relevant participating jurisdiction;

(8) plant and earth grid test certificates from approved test authorities;

(9) a secondary injection and trip test certificate on all circuit breakers;

(10) certification that all new equipment has been inspected before being connected to the supply; and

(11) operational arrangements.

(b) For the purposes of clause 5.3.2(f) of the Rules, the technical information that a Network Service Provider must, if requested, provide to a Connection Applicant in respect of the proposed connection of a market network service facility includes:

(1) the highest expected single phase and three phase fault levels at the connection point without the proposed connection;

(2) the clearing times of the existing protection systems that would clear a fault at the location at which the new connection would be connected into the existing transmission system or distribution system;

(3) the expected limits of voltage fluctuation, harmonic voltage distortion and voltage unbalance at the connection point without the proposed connection;

(4) technical information relevant to the connection point without the proposed connection including equivalent source impedance information, sufficient to estimate fault levels, voltage fluctuations, harmonic voltage distortion and voltage unbalance; and

(5) any other information or data not being confidential information relating to the performance of the Network Service Provider's facilities that is reasonably necessary for the Connection Applicant to prepare an application to connect;

except where the Connection Applicant agrees the Network Service Provider may provide alternative or less detailed technical information in satisfaction of this clause S5.3a.1(b).

S5.3a.2 Application of settings

A Market Network Service Provider must only apply settings to a control system or a protection system that are necessary to comply with performance requirements of this schedule 5.3a if the settings have been approved in writing by the Network Service Provider and, if the requirement is one that would involve AEMO under clause 5.3.4A(c) of the Rules, also by AEMO. A Market Network Service Provider must not allow its market network service facilities to take electricity from the power system without such prior approval.
If a Market Network Service Provider seeks approval from the Network Service Provider to apply or change a setting, approval must not be withheld unless the Network Service Provider or, if the requirement is one that would involve AEMO under clause 5.3.4A(c) of the Rules, AEMO, reasonably determines that the changed setting would cause the market network service facilities to not comply with the relevant performance standard or cause an inter-regional or intra-regional power transfer capability to be reduced.

If the Network Service Provider or, if the requirement is one that would involve AEMO under clause 5.3.4A(c) of the Rules, AEMO, reasonably determines that a setting of a market network service facility’s control system or protection system needs to change to comply with the relevant performance standard or to maintain or restore an inter-regional or intra-regional power transfer capability, the Network Service Provider or AEMO (as applicable) must consult with the Market Network Service Provider, and may request in writing that a setting be applied in accordance with the determination.

The Network Service Provider may also request a test to verify the performance of the relevant plant with the new setting. The Network Service Provider must provide AEMO with a copy of its request to a Market Network Service Provider to apply a setting or to conduct a test.

A Market Network Service Provider who receives such a request must arrange for the notified setting to be applied as requested and for a test to be conducted as requested. After the test, the Market Network Service Provider must, on request, provide both AEMO and the Network Service Provider with a report of a requested test, including evidence of its success or failure. Such a report of a test is confidential information.

A Market Network Service Provider must not change a setting requested by the Network Service Provider without its prior written agreement. If the Network Service Provider requires a Market Network Service Provider to change a setting within 18 months of a previous request, the Network Service Provider must pay the Market Network Service Provider its reasonable costs of changing the setting and conducting the tests as requested.

S5.3a.3 Technical matters to be co-ordinated

A Market Network Service Provider and the relevant Network Service Provider must use all reasonable endeavours to agree upon the following matters in respect of each new or altered connection of a market network service facility to a network:

(a) design at the connection point;
(b) physical layout adjacent to the connection point;
(c) primary protection and backup protection (clause S5.3a.6);
(d) control characteristics (clause S5.3a.4);
(e) communications and alarms (clause S5.3a.4);
(f) insulation co-ordination and lightning protection;
(g) fault levels and fault clearance times;
(h) switching and isolation facilities;
(i) interlocking arrangements; and
(j) metering installations as described in Chapter 7 of the Rules.

S5.3a.4 Monitoring and control requirements

S5.3a.4.1 Remote Monitoring

(a) Automatic access standard:

(1) Each market network service facility must have remote monitoring equipment to transmit to AEMO’s control centres in real time, the quantities that AEMO reasonably requires to discharge its market and power system security functions as set out in Chapters 3 and 4 of the Rules respectively.

(2) The quantities may include such data as current, voltage, active power, reactive power, operational limits and critical temperatures in respect of connection points and power conversion systems.

(b) Minimum access standard:

(1) Each market network service facility must have remote monitoring equipment to transmit to AEMO’s control centres in real time:

(A) connection point active power flow, reactive power flow and voltage;

(B) active power, reactive power and voltage for AC power lines, transformers and busbars, and power and voltage (or alternatively current) for DC power lines; and

(C) the status of circuit breakers.

(e) The negotiation of access standards in relation to this clause S5.3a.4.1 must involve AEMO under clause 5.3.4A(c) of the Rules.

S5.3a.4.2 [Deleted]

S5.3a.4.3 Communications equipment

A Market Network Service Provider must provide electricity supplies for remote monitoring equipment and remote control equipment installed in relation to its market network service facilities capable of keeping such equipment available for at least three hours following total loss of supply at the connection point for the relevant market network service facility.

A Market Network Service Provider must provide communications paths (with appropriate redundancy) from the remote monitoring equipment or remote control equipment installed at any of its market network service facilities to a interface for communication purposes in a location reasonably acceptable to the Network Service Provider at the relevant connection point. Communications systems between this interface for communication purposes and the control centre are the responsibility of the Network Service Provider unless otherwise agreed by the Market Network Service Provider and the Network Service Provider.
Telecommunications between Network Service Providers and Market Network Service Providers for operational communications must be established in accordance with the requirements set down below.

(a) **Primary Speech Facility**

The relevant Network Service Provider must provide and maintain equipment by means of which routine and emergency control telephone calls may be established between the Market Network Service Provider’s responsible Engineer/Operator and AEMO.

The facilities to be provided, including the interface requirement between the Network Service Provider’s equipment and the Market Network Service Provider’s equipment, must be specified by the Network Service Provider.

The costs of the equipment must be recovered by the Network Service Provider only through the charge for connection.

(b) **Back-up Speech Facility**

Where the Network Service Provider or AEMO reasonably determines that a back-up speech facility to the primary facility is required, the Network Service Provider must provide and maintain a separate telephone link or radio installation on a cost-recovery basis only through the charge for connection.

The Network Service Provider is responsible for radio system planning and for obtaining all necessary radio licences.

**S5.3a.5 Design standards**

A Market Network Service Provider must ensure that:

(a) the electrical plant in its facility complies with the relevant Australian Standards as applicable at the time of first installation of that electrical plant in the facility;

(b) circuit breakers provided to isolate the Market Network Service Provider’s facilities from the Network Service Provider’s facilities are capable of breaking, without damage or restrike, fault currents nominated by the Network Service Provider in the relevant connection agreement; and

(c) all new equipment including circuit breakers provided to isolate the Market Network Service Provider’s facilities from the Network Service Provider’s facilities is capable of withstanding, without damage, power frequency voltages and impulse levels nominated by the Network Service Provider in accordance with the relevant provisions of the system standards and recorded in the relevant connection agreement.

**S5.3a.6 Protection systems and settings**

A Market Network Service Provider must ensure that all connections to the network are protected by protection devices which effectively and safely disconnect any faulty circuit automatically within a time period specified by the Network Service Provider in accordance with the following provisions:

(a) The automatic access standard is:
(1) Primary protection systems must be provided to disconnect any faulted element from the power system within the applicable fault clearance time determined under clause S5.1.9(a)(1), but subject to clauses S5.1.9(k) and S5.1.9(l).

(2) Each primary protection system must have sufficient redundancy to ensure that a faulted element within its protection zone is disconnected from the power system within the applicable fault clearance time with any single protection element (including any communications facility upon which that protection system depends) out of service.

(3) Breaker fail protection systems must be provided to clear faults that are not cleared by the circuit breakers controlled by the primary protection system, within the applicable fault clearance time determined under clause S5.1.9(a)(1).

(b) The minimum access standard is:

(1) Primary protection systems must be provided to disconnect from the power system any faulted element within their respective protection zones within the applicable fault clearance time determined under clause S5.1.9(a)(2), but subject to clauses S5.1.9(k) and S5.1.9(l).

(2) If a fault clearance time determined under clause S5.1.9(a)(2) for a protection zone is less than 10 seconds, a breaker fail protection system must be provided to clear from the power system any fault within that protection zone that is not cleared by the circuit breakers controlled by the primary protection system, within the applicable fault clearance time determined under clause S5.1.9(a)(3).

(c) The Network Service Provider and the Market Network Service Provider must cooperate in the design and implementation of protection systems to comply with this clause, including cooperation with regard to:

(1) the use of current transformer and voltage transformer secondary circuits (or equivalent) of one party by the protection system of the other;

(2) tripping of one party’s circuit breakers by a protection system of the other party; and

(3) co-ordination of protection system settings to ensure inter-operation.

The Market Network Service Provider must ensure that the protection settings of its protective equipment grade with the Network Service Provider’s transmission system or distribution system protection settings. Similarly the grading requirements of fuses must be co-ordinated with the Network Service Provider. The Market Network Service Provider must provide details of the protection scheme implemented by the Market Network Service Provider to the Network Service Provider and must liaise with the Network Service Provider when determining gradings and settings.

The application of settings of the protection scheme must be undertaken in accordance with clause S5.3a.2.

Before the Market Network Service Provider’s installation is connected to the Network Service Provider’s transmission or distribution system the Market
Network Service Provider’s protection system must be tested and the Market Network Service Provider must submit the appropriate test certificate to the Network Service Provider.

S5.3a.7 [Deleted]

S5.3a.8 Reactive power capability

Subject to the access standards stated in this clause S5.3a.8, if additional reactive support is required as a result of the connection or operation of the network elements which provide a market network service then the requisite reactive support must be supplied or paid for by the Market Network Service Provider.

Additional reactive support is required if, at rated power output as measured at the connection point of the market network service the market network service has a lagging power factor of less than 0.9 or a leading power factor of less than 0.95.

**Automatic access standard:** For power export, at rated power output and target network voltage as determined in accordance with clause S5.1a.4 of the system standards when measured at the connection point of the market network service, the market network service must be capable of operation in the range from a lagging power factor of 0.9 to a leading power factor of 0.95. For power import, the power factor must satisfy the requirements of clause S5.3.5 of schedule 5.3.

**Minimum access standard:** With the agreement of AEMO and the Network Service Provider, a power factor capability less than that defined by the automatic access standard may be provided if the requirements of the system standards are satisfied under all operating conditions of the market network service.

S5.3a.9 Balancing of load currents

A Network Service Provider may require a Market Network Service Provider’s power transfer to be balanced at a connection point in order to maintain the negative sequence voltage at each connection point at less than or equal to the limits set out in Table S5.1a.1 of the system standards for the applicable nominal supply voltage level.

**Automatic access standard:** A Market Network Service Provider must ensure that for connections at 11kV or higher voltage, the current in any phase drawn by its equipment from the Network Service Provider’s network is not greater than 102 percent or less than 98 percent of the average of the currents in the three phases.

**Minimum access standard:** Where agreed with the relevant Network Service Provider and subject to any specific conditions imposed, a Market Network Service Provider may cause current unbalance greater than that specified in the automatic access standard provided the Market Network Service Provider does not cause the limits specified in clause S5.1a.7 of the system standards to be exceeded at any point in the network.

Where these requirements cannot be met the Market Network Service Provider may enter into a commercial arrangement with the Network Service Provider for the installation of equipment to correct the phase unbalance. Such equipment must be considered as part of the connection assets for the Market Network Service Provider.
The limit to power transfer current unbalance must be included in the connection agreement and is subject to verification of compliance by the Network Service Provider.

S5.3a.10 Voltage fluctuations

(a) **Automatic access standard:** The voltage fluctuations caused by variations in loading level at the connection point, including those arising from energisation, de-energisation or other operation of plant, must not exceed the limits determined under clause S5.1.5(a).

(b) **Minimum access standard:** The voltage fluctuations caused by variations in loading level at the connection point, including those arising from energisation, de-energisation or other operation of plant, must not exceed the limits determined under clause S5.1.5(b).

The voltage fluctuation emission limits and any specified conditions must be included in the connection agreement, and are subject to verification of compliance by the Network Service Provider.

S5.3a.11 Harmonics and voltage notching

(a) **Automatic access standard:** The harmonic voltage distortion caused by non-linearity, commutation of power electronic equipment, harmonic resonance and other effects within the plant, must not exceed the limits determined under clause S5.1.6(a).

(b) **Minimum access standard:** The harmonic voltage distortion caused by non-linearity, commutation of power electronic equipment, harmonic resonance and other effects within the plant, must not exceed the limits determined under clause S5.1.6(b).

A Market Network Service Provider must ensure that all of its plant connected to a transmission network or distribution network is capable of withstanding the effects of harmonic levels produced by that plant plus those imposed from the network.

The harmonic voltage distortion emission limits and any special conditions must be included in the connection agreement, and are subject to verification of compliance by the Network Service Provider.

S5.3a.12 Design requirements for Market Network Service Providers’ substations

A Market Network Service Provider must comply with the following requirements applicable to the design, station layout and choice of equipment for a substation:

(a) safety provisions must comply with requirements applicable to the participating jurisdiction notified by the Network Service Provider;

(b) where required by the Network Service Provider, appropriate interfaces and accommodation must be incorporated for communication facilities, remote monitoring and control and protection of plant which is to be installed in the substation;

(c) a substation must be capable of continuous uninterrupted operation with the levels of voltage, harmonics, unbalance and voltage fluctuation specified in
(d) earthing of primary plant in the substation must be in accordance with the Electricity Supply Association of Australia Safe Earthing Guide and must reduce step and touch potentials to safe levels;

(e) synchronisation facilities or reclose blocking must be provided if necessary;

(f) secure electricity supplies of adequate capacity must be provided for plant performing communication, monitoring, control and protection functions;

(g) plant must be tested to ensure that the substation complies with the approved design and specifications as included in a connection agreement;

(h) the protection equipment required would normally include protection schemes for individual items of plant, back-up arrangements, auxiliary DC supplies and instrumentation transformers; and

(i) insulation levels of plant in the substation must co-ordinate with the insulation levels of the network to which the substation is connected as nominated in the connection agreement.

S5.3a.13 Market network service response to disturbances in the power system

(a) Each market network service must be capable of continuous uninterrupted operation during the occurrence of:

(1) power system frequency within the frequency operating standards; or

(2) the range of voltage variation conditions permitted by the system standards.

(b) The equipment associated with each market network service must be designed to withstand without damage or reduction in life expectancy the harmonic distortion and voltage unbalance conditions determined to apply in accordance with the provisions of schedule 5.1, clauses S5.1.6 and S5.1.7, respectively, at the connection point.

S5.3a.14 Protection of market network services from power system disturbances

(a) Minimum access standard: If a Connection Applicant requires that its market network service facility be automatically disconnected from the power system in response to abnormal conditions arising from the power system, the relevant protection system or control system must not disconnect the facility for conditions under which it must continuously operate or must withstand under a provision of the Rules.

(b) There is no automatic access standard for this technical requirement.

(c) For the purposes of this clause S5.3a.14, the abnormal conditions include:

(1) frequency outside the extreme frequency excursion tolerance limits;

(2) sustained and uncontrollable DC current beyond a short term current rating for the period assigned to that rating;

(3) DC voltage above the voltage maximum rating or sustained below any lower limit for stable operation.
(4) voltage to frequency ratio beyond a transformer magnetic flux based voltage to frequency rating;

(5) sustained voltage fluctuations at the connection point beyond the level determined under clause S5.1.5(a);

(6) sustained harmonic voltage distortion at the connection point beyond the level determined under clause S5.1.6(a);

(7) sustained negative phase sequence voltage at the connection point beyond the level determined under clause S5.1.7(a); and

(8) any similar condition agreed between the Market Network Service Provider and AEMO after consultation with each relevant Network Service Provider.

(d) The negotiation of access standards in relation to this clause S5.3a.14 must involve AEMO under clause 5.3.4A(c) of the Rules.

(e) The Network Service Provider is not liable for any loss or damage incurred by the Market Network Service Provider or any other person as a consequence of a fault on either the power system, or within the Market Network Service Provider’s facility.

Schedule 5.4 Information to be Provided with Preliminary Enquiry

The following items of information are required to be submitted with a preliminary enquiry for connection or modification of an existing connection:

(a) Type of plant – (eg. gas turbine generating unit; rolling mill, etc.).

(b) Preferred site location – (listing any alternatives in order of preference as well).

(c) Maximum power generation or demand of whole plant – (maximum MW and/or MVA, or average over 15 minutes or similar).

(d) Expected energy production or consumption (MWh per month).

(e) Plant type and configuration – (eg. number and type of generating units or number of separate production lines).

(f) Nature of any disturbing load (size of disturbing component MW/MVAr, duty cycle, nature of power electronic plant which may produce harmonic distortion).

(g) Technology of proposed generating unit (e.g. synchronous generating unit, induction generator, photovoltaic array, etc).

(h) When plant is to be in service – (eg. estimated date for each generating unit).

(i) Name and address of enquirer, and, if relevant, of the party for whom the enquirer is acting.

(j) Other information may be requested by the Network Service Provider, such as amount and timing of power required during construction or any auxiliary power requirements.
Schedule 5.5  Technical Details to Support Application for Connection and Connection Agreement

S5.5.1 Introduction to the schedule

Various sections of the Rules require that Registered Participants submit technical data to the Network Service Provider. This schedule lists the range of data which may be required. The actual data required will be advised by the Network Service Provider, and will form part of the technical specification in the connection agreement. These data will also be made available to AEMO and to other Network Service Providers by the Network Service Provider at the appropriate time.

S5.5.2 Categories of data

Data is coded in categories, according to the stage at which it is available in the build-up of data during the process of forming a connection or obtaining access to a network, with data acquired at each stage being carried forward, or enhanced in subsequent stages, eg. by testing.

Preliminary system planning data

Preliminary system planning data is required for submission with the application to connect, to allow the Network Service Provider to prepare an offer of terms and conditions for a connection agreement and to assess the requirement for, and effect of, network augmentation or extension options. Such data is normally limited to the items denoted as Standard Planning Data (S) in the Generating System Model Guidelines, Generating System Design Data Sheet, Generating System Setting Data Sheet and in schedules 5.5.3 to 5.5.5.

The Network Service Provider may, in cases where there is reasonable doubt as to the viability of a proposal, require the submission of other data before making an offer to connect or to amend a connection agreement.

Registered system planning data

Registered system planning data is the class of data which will be included in the connection agreement signed by both parties. It consists of the preliminary system planning data plus those items denoted in the attached schedules as Detailed Planning Data (D). The latter must be submitted by the Registered Participant in time for inclusion in the connection agreement.

Registered data

Registered Data consists of data validated and agreed between the Network Service Provider and the Registered Participant, such data being:

(a) prior to actual connection and provision of access, data derived from manufacturers' data, detailed design calculations, works or site tests etc. (R1); and

(b) after connection, data derived from on-system testing (R2).

All of the data will, from this stage, be categorised and referred to as Registered Data; but for convenience the schedules omit placing a higher ranked code next to items which are expected to already be valid at an earlier stage.
S5.5.3 Review, change and supply of data

Data will be subject to review at reasonable intervals to ensure its continued accuracy and relevance. The Network Service Provider must initiate this review. A Registered Participant may change any data item at a time other than when that item would normally be reviewed or updated by submission to the Network Service Provider of the revised data, together with authentication documents, eg. test reports.

The Network Service Provider must supply data relating to its system to other Network Service Providers for planning purposes and to other Registered Participants and AEMO as specified in the various sections of the Rules, including through the statement of opportunities.

S5.5.4 Data Requirements

Schedules 5.5.3 to 5.5.5 cover the following data areas:

(a) schedule 5.5.3 - Network Plant Technical Data. This comprises fixed electrical parameters.

(b) schedule 5.5.4 - Plant and Apparatus Setting Data. This comprises settings which can be varied by agreement or by direction of the Network Service Provider or AEMO.

(c) schedule 5.5.5 - Load Characteristics. This comprises the estimated design parameters of loads.

The documents and schedules applicable to each class of Registered Participant are as follows:

(a) Generators: the Generating System Model Guidelines, Generating System Design Data Sheet and Generating System Setting Data Sheet;

(b) Customers and Network Service Providers: schedules 5.5.3 and 5.5.4; and

(c) Customers: schedule 5.5.5.

S5.5.5 Asynchronous generating unit data

A Generator that connects a generating system, that is an asynchronous generating unit, must be given exemption from complying with those parts of the Generating System Model Guidelines, Generating System Design Data Sheet and Generating System Setting Data Sheet that are determined by the Network Service Provider to be not relevant to such generating systems, but must comply with those parts of schedules 5.5.3, 5.5.4, and 5.5.5 that are relevant to such generating systems, as determined by the Network Service Provider.

S5.5.6 Generating units equal to or smaller than 30MW data

A Generator that connects a generating unit equal to or smaller than 30 MW or a number of generating units totalling less than 30 MW to a connection point to a distribution network will usually be required to submit less registered system planning data and less registered data than is indicated in the Generating System Model Guidelines, Generating System Design Data Sheet and Generating System Setting Data Sheet. In general these data will be limited to confirmation of the
preliminary system planning data, marked (S), but other data must be supplied if reasonably required by the Network Service Provider or AEMO.

Codes:

S = Standard Planning Data
D = Detailed Planning Data
R = Registered Data (R1 pre-connection, R2 post-connection)

S5.5.7 Generating System Design Data Sheet, Generating System Setting Data Sheet and Generating System Model Guidelines

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

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

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

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

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

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

(1) allow generating units and generating systems to be mathematically modelled by NEMMCO in load flow and dynamic stability assessments with sufficient accuracy to permit:

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

   (ii) proposed access standards and performance standards of generating units and generating systems to be assessed; and

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

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

(c) Any person may submit a request (with written reasons) to AEMO to amend the Generating System Design Data Sheet, Generating System Setting Data Sheet or the Generating System Model Guidelines and AEMO must conduct the Rules consultation procedures in relation to the request.

(d) AEMO can make amendments requested under paragraph (c) or otherwise to the Generating System Design Data Sheet, Generating System Setting Data Sheet or the Generating System Model Guidelines without conducting the Rules consultation procedures if the amendment is minor or administrative in nature.

(e) AEMO may at the conclusion of the Rules consultation procedures under paragraph (c) or otherwise under paragraph (d), amend the relevant data sheet or guidelines (if necessary).

Schedule 5.5.1 [Deleted]
Schedule 5.5.2 [Deleted]
Schedule 5.5.3 Network and plant technical data of equipment at or near connection point

<table>
<thead>
<tr>
<th>Data Description</th>
<th>Units</th>
<th>Data Category</th>
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<tbody>
<tr>
<td>Voltage Rating</td>
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<tr>
<td>Nominal voltage</td>
<td>kV</td>
<td>S, D</td>
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<tr>
<td>Highest voltage</td>
<td>kV</td>
<td>D</td>
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Insulation Co-ordination

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<thead>
<tr>
<th>Data Description</th>
<th>Units</th>
<th>Data Category</th>
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<tbody>
<tr>
<td>Rated lightning impulse withstand voltage</td>
<td>kVp</td>
<td>D</td>
</tr>
<tr>
<td>Rated short duration power frequency withstand voltage</td>
<td>kV</td>
<td>D</td>
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Rated Currents

<table>
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<tr>
<th>Data Description</th>
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<tr>
<td>Circuit maximum current</td>
<td>kA</td>
<td>S, D</td>
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<tr>
<td>Rated Short Time Withstand Current</td>
<td>kA for seconds</td>
<td>D</td>
</tr>
<tr>
<td>Ambient conditions under which above current</td>
<td>Text</td>
<td>S,D</td>
</tr>
<tr>
<td>Data Description</td>
<td>Units</td>
<td>Data Category</td>
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<tr>
<td>----------------------------------------</td>
<td>---------------</td>
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</tr>
<tr>
<td>applies</td>
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**Earthing**

System Earthing Method  
Text  
S, D

Earth grid rated current  
kA for seconds  
D

**Insulation Pollution Performance**

Minimum total creepage  
mm  
D

Pollution level  
Level of IEC 815  
D

**Controls**

Remote control and data transmission arrangements  
Text  
D

**Metering Provided by Customer**

Measurement transformer ratios:  
D

Current transformers  
A/A  
D

Voltage transformers  
V/kV  
D

Measurement Transformer Test Certification details  
Text  
R1

**Network Configuration**

Operation Diagrams showing the electrical circuits of the existing and proposed main facilities within the Registered Participant's ownership including busbar arrangements, phasing arrangements, earthing arrangements, switching facilities and operating voltages.

Single line Diagrams  
S, D, R1

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<table>
<thead>
<tr>
<th>Data Description</th>
<th>Units</th>
<th>Data Category</th>
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</thead>
<tbody>
<tr>
<td><strong>Network Impedance</strong></td>
<td></td>
<td>S, D, R1</td>
</tr>
<tr>
<td>For each item of <em>plant</em>:</td>
<td>% on 100 MVA base</td>
<td></td>
</tr>
<tr>
<td>details of the positive, negative and zero sequence series and shunt impedance, including mutual coupling between physically adjacent elements.</td>
<td></td>
<td></td>
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<tr>
<td><strong>Short Circuit Infeed to the Network</strong></td>
<td></td>
<td>S, D, R1</td>
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<tr>
<td>Maximum generator 3-phase short circuit infeed including infeeds from generating units connected to the Registered Participant's system, calculated by method of AS 3851 (1991).</td>
<td>kA symmetrical</td>
<td></td>
</tr>
<tr>
<td>The total infeed at the instant of fault (including contribution of induction motors).</td>
<td>kA</td>
<td>D, R1</td>
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<tr>
<td>Minimum zero sequence impedance of Registered Participant's network at connection point.</td>
<td>% on 100 MVA base</td>
<td>D, R1</td>
</tr>
<tr>
<td>Minimum negative sequence impedance of Registered Participant's network at connection point.</td>
<td>% on 100 MVA base</td>
<td>D, R1</td>
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<td><strong>Load Transfer Capability:</strong></td>
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<td>Text D</td>
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<td>Where a load, or group of loads, may be fed from alternative connection points:</td>
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<td>D, R1</td>
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<td>Load normally taken from connection point X</td>
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<td>Load normally taken from connection point Y</td>
<td>MW</td>
<td>D, R1</td>
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<tr>
<td>Arrangements for transfer under planned or fault outage conditions</td>
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<tr>
<td><strong>Circuits Connecting Embedded Generating Units to the Network:</strong></td>
<td></td>
<td>D, R</td>
</tr>
<tr>
<td>For all generating units, all connecting lines/cables, transformers etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Series Resistance</td>
<td>% on 100</td>
<td></td>
</tr>
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</table>
Data Description | Units | Data Category
--- | --- | ---
Series Reactance | % on 100 MVA base | D, R
Shunt Susceptance | % on 100 MVA base | D, R
Normal and short-time emergency ratings | MVA | D,R

Technical Details of generating units and generating systems as per the Generating System Design Data Sheet, Generating System Setting Data Sheet and the Generating System Model Guidelines where such details are not confidential information.

Transformers at connection points:
- Saturation curve Diagram R
- Equipment associated with DC Links
- Number of poles MVA D,R
- Converters per station Quantity D,R
- Reactive Power consumption of converters MCAr D,R
- Location and Rating of A.C. Filters MVAr D,R
- Location and Rating of Shunt Capacitors MVAr D,R
- Location and Rating of Smoothing Reactor MVAr D,R
- Location and Rating of DC Filter MVAr D,R

Schedule 5.5.4 Network Plant and Apparatus Setting Data

Data Description | Units | Data Category
--- | --- | ---
Protection Data for Protection relevant to Connection Point:
- Reach of all protections on transmission lines, or cables ohms or % on 100 MVA base S, D

Comment [ABT36]: Applies Partially Needs to be more specific to 5MVA range.
### Data Description

<table>
<thead>
<tr>
<th>Data Description</th>
<th>Units</th>
<th>Data Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of protections on each item</td>
<td>Text</td>
<td>S, D</td>
</tr>
<tr>
<td>Total fault clearing times for near and remote faults</td>
<td>ms</td>
<td>S, D, R1</td>
</tr>
<tr>
<td>Line reclosure sequence details</td>
<td>Text</td>
<td>S, D, R1</td>
</tr>
</tbody>
</table>

### Tap Change Control Data:

- Time delay settings of all *transformer* tap changers. | Seconds | D, R1 |

### Reactive Compensation:

- Location and Rating of individual *shunt reactors* | MVAr  | D, R1 |
- Location and Rating of individual *shunt capacitor* banks | MVAr  | D, R1 |
- Capacitor bank capacitance | microfarads | D |
- Inductance of switching *reactor* (if fitted) | millihenries | D |
- Resistance of capacitor plus *reactor* | Ohms  | D |
- Details of special controls (e.g. Point-on-wave switching) | Text  | D |

### For each shunt reactor or capacitor bank:

- Method of switching | Text  | S |
- Details of automatic control logic such that operating characteristics can be determined | Text  | D, R1 |

### FACTS Installation:

- Data sufficient to enable static and dynamic performance of the installation to be modelled | Text, diagrams control settings | S, D, R1 |
- Transmission line flow control device | Text, | D |
### Data Description

#### Units

<table>
<thead>
<tr>
<th>Data Description</th>
<th>Units</th>
<th>Data Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Details of the operation of the control device under normal operation conditions (including startup and shutdown of the line) and during a fault (close up and remote)</td>
<td>diagrams</td>
<td>D</td>
</tr>
<tr>
<td>Models for the control device and transmission line appropriate for load flow, small signal stability and transient stability analysis</td>
<td>Text, diagrams</td>
<td>D</td>
</tr>
<tr>
<td>Capability of the line flow control device</td>
<td>KA, MVA, MW</td>
<td>D</td>
</tr>
<tr>
<td>Details of the rate of change of flow capability of the control device</td>
<td>Text</td>
<td>D</td>
</tr>
<tr>
<td>Details of the capability of the control device to provide frequency and voltage control</td>
<td>Text</td>
<td>D</td>
</tr>
<tr>
<td>Description of possible failure modes of control device</td>
<td>Text</td>
<td>D</td>
</tr>
<tr>
<td>Details of performance of the control device under disturbance conditions including changes in AC frequency, variations in AC system voltages and AC system waveform distortion.</td>
<td>Text</td>
<td>D</td>
</tr>
<tr>
<td>For DC control devices, contribution to the AC system short circuit level</td>
<td>KA, MVA</td>
<td>D</td>
</tr>
</tbody>
</table>

#### Schedule 5.5.5 Load Characteristics at Connection Point

<table>
<thead>
<tr>
<th>Data Description</th>
<th>Units</th>
<th>Data Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>For all Types of Load</td>
<td>Text</td>
<td>S</td>
</tr>
<tr>
<td>Type of Load</td>
<td>Text</td>
<td>S</td>
</tr>
<tr>
<td>eg controlled rectifiers or large motor drives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>For Fluctuating Loads</td>
<td>Graph</td>
<td>S</td>
</tr>
<tr>
<td>Cyclic variation of active power over period</td>
<td>MW/time</td>
<td>S</td>
</tr>
</tbody>
</table>

Comment [ABT37]: Applies Partially Needs to be more specific to 5MVA range
Largest Step Change:

In active power  
MW  S

In reactive power  
MVAr  S

**Schedule 5.6 Terms and Conditions of Connection agreements**

The connection agreements must contain the specific conditions that have been agreed to for connection and access to the transmission or distribution network, including but not limited to:

(a) details of the connection point including the distribution network coupling points where appropriate;

(b) metering arrangements and adjustments for losses where the point of metering is significantly different to the connection point;

(c) authorised demand which may be taken or supplied at the connection point (under specified conditions);

(c1) details of each access standard agreed between the Network Service Provider and the Registered Participant and all related conditions of agreement resulting from the application of any access provisions contained in schedule 5.1 for Network Service Providers, or schedule 5.2 for Generators, or schedule 5.3 for Customers, or schedule 5.3a for Market Network Service Providers;

(d) connection service charges;

(e) payment conditions;

(f) duration and termination conditions of the connection agreement;

(g) terms, conditions and constraints that have been agreed to for connection to the network to protect the legitimate interest of the Network Service Providers including rights to disconnect the Registered Participant for breach of commercial undertakings;

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Comment [ABT38]: Applies Partially Needs to be more specific to SMVA range
(h) details of any agreed standards of reliability of transmission service or distribution service at the connection points or within the network;
(i) testing intervals for protection systems associated with the connection point;
(j) agreed protocols for maintenance co-ordination;
(k) where an expected load, to be connected to a network, has a peak load requirement in excess 10 MW, the provision, installation, operation and maintenance of automatic load shedding facilities for 60 percent of the load at anytime; and
(l) terms and conditions of access to the metering installation for the Metering Provider and access to metering installations type 5 and 6 for the Metering Data Provider.

The connection agreements may include other technical, commercial and legal conditions governing works required for the connection or extension to the network which the parties have negotiated and agreed to. The circumstances under which the terms of the connection agreement would require renegotiation may also be included.

Schedule 5.7 Annual Forecast Information for Planning Purposes

This schedule sets out the information in respect of each connection point that must be provided to the relevant Network Service Provider by each Registered Participant that has a connection point to a transmission network of that Network Service Provider.

<table>
<thead>
<tr>
<th>Data Description</th>
<th>Units</th>
<th>Time Scale</th>
<th>Data Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Maximum Active power- Winter</td>
<td>MW</td>
<td>years 1-10</td>
<td>Annual</td>
</tr>
<tr>
<td>Coincident Reactive Power - Winter</td>
<td>MVAr</td>
<td>years 1-10</td>
<td>Annual</td>
</tr>
<tr>
<td>Annual Maximum Active power- Summer</td>
<td>MW</td>
<td>years 1-10</td>
<td>Annual</td>
</tr>
<tr>
<td>Coincident Reactive Power- Summer</td>
<td>MVAr</td>
<td>years 1-10</td>
<td>Annual</td>
</tr>
</tbody>
</table>

Comment [ABT39]: Applies Partially Needs to be more specific to SMVA range
<table>
<thead>
<tr>
<th>Data Description</th>
<th>Units</th>
<th>Time Scale</th>
<th>Data Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecast load diversity between each connection point to the network (winter and summer)</td>
<td>%</td>
<td>years 1-5</td>
<td>Annual</td>
</tr>
</tbody>
</table>

*Load Profiles:*

The following forecast daily profiles of connection point half-hourly average active and reactive loads are required, net of all generating plant:

- **Day of the peak summer and winter MW peak load at connection point**
  - MW and MVAr
  - years 1-5
  - Annual

- **Day of network peak summer and winter MW load (as specified)**
  - MW and MVAr
  - years 1-5
  - Annual

<table>
<thead>
<tr>
<th>Data Description</th>
<th>Units</th>
<th>Time Scale</th>
<th>Data Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each July, October, January, April under average conditions representing:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) weekdays</td>
<td>MW and MVAr</td>
<td>years 1-5</td>
<td>Annual</td>
</tr>
<tr>
<td>(b) Saturdays</td>
<td>MW and MVAr</td>
<td>years 1-5</td>
<td>Annual</td>
</tr>
<tr>
<td>(c) Sundays/holidays</td>
<td>MW and MVAr</td>
<td>years 1-5</td>
<td>Annual</td>
</tr>
</tbody>
</table>

*Day of the network minimum demand (as*
<table>
<thead>
<tr>
<th>Data Description</th>
<th>Units</th>
<th>Time Scale</th>
<th>Data Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>specified)</td>
<td>MVAr</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Undispatched generation:

For each connection point to the network the following information is required:

- **No. of generating units**
  - Units: No.
  - Time Scale: years 1-5
  - Data Category: Annual

- **Capacity of each generating unit**
  - Units: MW (sent out)
  - Time Scale: years 1-5
  - Data Category: Annual

- **Daily/Seasonal Operating characteristics**
  - Units: Text
  - Time Scale: years 1-5
  - Data Category: Annual

- **Expected output at time of peak network Winter load (as specified)**
  - Units: MW
  - Time Scale: years 1-5
  - Data Category: Annual

- **Expected output at time of peak network Summer load (as specified)**
  - Units: MW
  - Time Scale: years 1-5
  - Data Category: Annual