



CLARIFICATION OF
GENERATOR TECHNICAL
PERFORMANCE
REQUIREMENTS (S5.2.5)



1. PURPOSE

AEMO has prepared this document to clarify AEMO's interpretation of particular clauses in Schedule 5.2 of the National Electricity Rules (NER). It is intended to assist generation proponents seeking connection to the National Electricity Market (NEM) power system in assessing performance requirements, as well improving consistency and understanding between Network Service Providers (NSPs).

It is envisaged that this document will be expanded in future to address other clauses of Schedule 5.2.5 (Technical requirements) as required.

The discussion in this document is based on version 106 of the NER.

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2. GENERAL BACKGROUND

Where a Connection Applicant proposes negotiated access standards, AEMO (as the system operator) is required to respond any AEMO-related advisory matters. Following a review of the proposal and the conclusion of any resulting negotiations, AEMO issues a letter to the connecting NSP detailing AEMO's acceptance of specified negotiated standards.

Importantly, AEMO does not certify whether plant will comply with these specific negotiated standards, which must be recorded in the connection agreement and become the performance standards that will apply to the connected generating system.

Compliance with the performance standards must be demonstrated by the Connection Applicant when it applies for registration as a Generator under Chapter 2 of the National Electricity Rules (**NER**). Applicants will note that one of the eligibility requirements for registration (see clause 2.2.1(e)(3)) is that the applicant must satisfy AEMO that its generating system will be capable of meeting or exceeding its performance standards.

This document clarifies the requirements of particular clauses of Schedule 5.2.5 to assist generation proponents seeking connection to the National Electricity Market (NEM) power system in assessing performance requirements, as well improving consistency and understanding between Network Service Providers (NSPs).

3. REAL AND REACTIVE POWER CAPABILITY OF SOLAR FARMS DURING NORMAL OPERATION

3.1 Statement of issue

A number of Connection Applicants have expressed concerns to AEMO over the capability requirements of inverter connected generators, in particular the real and reactive power capability requirements of solar generating systems proposed to be connected to the grid. A number of factors are believed to have led to this:

- A rapid increase in the number of connection enquiries and applications, many for concurrent projects.
- Trends in the specification of solar farms.
- Differing understandings of the requirements specified in the relevant technical requirements in Schedule S5.2 of the NER.
- A perception that acceptance of performance standards is a guarantee by the connecting NSP (Network Service Provider) and AEMO that those performance standards can be met.
- A perception that AEMO is applying its proposed changes to clause S5.2.5.4 of the NER before they are made by the Australian Energy Market Commission.

3.2 NER requirements

The minimum access standard for the technical requirement in clause S5.2.5.4 of the NER is:

... a generating system ... 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 ...

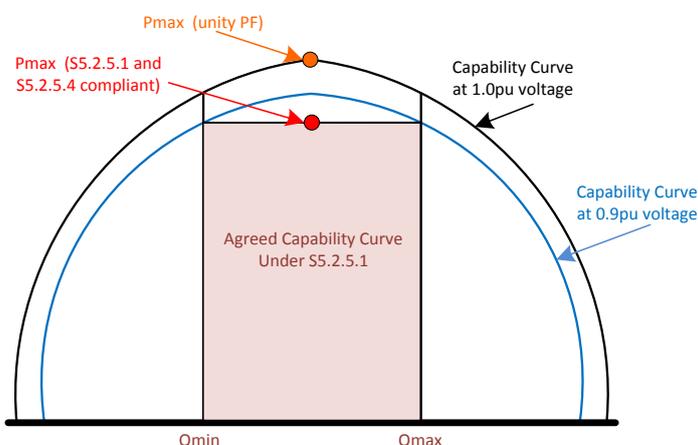
Where 'continuous uninterrupted operation' (CUO) is defined as:

In respect of a generating system or operating generating unit operating immediately prior to a power system disturbance, not disconnecting from the power system except under its performance standards established under clauses S5.2.5.8 and S5.2.5.9 and, after clearance of any electrical fault that caused the disturbance, only substantially varying its active power and reactive power required by its performance standards established under clauses S5.2.5.11, S5.2.5.13 and S5.2.5.14, with all essential auxiliary and reactive plant remaining in service, and responding so as to not exacerbate or prolong the disturbance or cause a subsequent disturbance for other connected plant.

From early 2017, AEMO started to receive an increasing number of proposals under clause 5.3.4(e) from solar farm developers that did not propose sufficient capability to maintain active power and reactive power following voltage disturbances within the range of 90% to 110% of normal voltage.

The figure below illustrates a compliant operating point (red dot) versus non-compliant performance (orange dot). For operation at the intersection of the vertical axis and the circular curve (orange dot) following a reduction in voltage to 90%, the inverter will either:

- Reduce reactive power, active power, or both, when operated in P-priority mode¹
- Reduce active power when operated in Q-priority mode



3.3 Discussion

3.3.1 General

As a minimum, generating systems must be capable of continuous uninterrupted operation (i.e. remain connected, and not vary active power or reactive power such that it would exacerbate a disturbance) for voltages within the normal operating range of 90% to 110%.

The need to maintain active power and reactive power (such that they do not exacerbate a disturbance) was not an issue for other types of generation, such as synchronous generators and wind farms. For a small number of early applicant solar farm developers, where a small deviation in active power or reactive power was observed in their proposed solar farms, in some cases, AEMO accepted that outcome subject to an assessment of their impact on the power system, and following consultation with the connecting NSP.

Each generation project is considered on its merits and in collaboration with the connecting NSP. When assessing the suitability of a proposed negotiated access standard, both AEMO and the connecting NSP will consider the broader power system implications at the time of the proposal. From early 2017, AEMO and NSPs identified an emerging trend whereby plant was being specified in a manner that resulted in issues with reactive control and active power regulation, resulting in non-compliance with the minimum technical requirements in clauses S5.2.5.1, S5.2.5.4, or both.

There is a significant volume of solar farm connection proposals (totalling 7 GW with active connection applications across the NEM), and the performance of these plants will have an increasing impact on power system performance. AEMO is of the view that acceptance of proposals allowing variations in active or reactive power would result in:

- Compromised voltage stability.
- Voltage changes impacting frequency control.

¹ Note that operation in P-priority mode should be carefully considered in consultation with the manufacturer of the generating unit. AEMO is aware of some potential adverse operational impacts of operation in P-priority mode.

- Errors in operational forecasts impacting causer pays costs.
- Potential (future) requirement for operational constraints.
- Increased regulation and contingency Frequency Control Ancillary Services (FCAS) requirements (by adding to the size of the largest credible contingency).

AEMO sought to resolve questions relating to the materiality of active power variations through a change in the NER.²

3.3.2 Assessment methodology

Clause S5.2.5.1 (Reactive Power Capability) is negotiated between the connecting NSP and the Connection Applicant, whereas a proposed negotiated access standard under clause S5.2.5.4 is an AEMO advisory matter, which means AEMO must be consulted before any agreement is reached between the connecting NSP and the Connection Applicant. For AEMO to be satisfied that the proposed negotiated access standard under clause S5.2.5.4 is acceptable, the proposed plant should be able to maintain its active power and reactive power at the connection point within the capability envelope agreed under clause S5.2.5.1 for connection point voltages between 90% and 110%.

Detailed analysis involves computer simulations of a generating system at maximum output and application of a step change in voltage magnitude from a typical connection point voltage to 90%. This assessment is undertaken at a transformer tap position aligned with the plant's operating point and the typical connection point voltage. The assessment requires consideration of a range of factors including:

- Initial generating system operating point within the plant capability (clause S5.2.5.1).
- Typical operating voltage at the connection point based on network characteristics and the plant's operating point.
- Transformer tap positions consistent with the plant's operating point and connection point voltage and desired connection asset voltages.

In general, if the maximum capacity (MW) of a solar farm is less than 85% of the nameplate rating in MVA, it could be expected to meet the technical requirements specified in clause S5.2.5.4.

3.4 Frequently asked questions

1. Can AEMO consider a materiality threshold for my solar farm – for example, consider a 1% reduction in active power per 1% reduction in voltage below nominal?

Clause S5.2.5.4 does not provide scope for the connecting NSP or AEMO to undertake a materiality assessment of the impact of a reduction in active power for voltage operation within the normal operating range. Further, this would be undesirable, for the reasons discussed in section 3.3.

² Generator technical performance standards, available at: <http://aemc.gov.au/Rule-Changes/Generator-technical-performance-standards>.

2. Where is compliance with clause S5.2.5.4 assessed, at the connection point or generating unit terminals?

As with all performance standards, compliance with clause S5.2.5.4 is assessed at the connection point.

3. Does S5.2.5.4 require provision of active power headroom to account for marginal increases in reticulation losses when connection point voltage reduces to 90%?

In relation to a voltage reduction to 90%, AEMO does not consider an increase in connection asset and reticulation network I²R losses to be non-compliant with clause S5.2.5.4.

4. Does AEMO consider switching of load behind the connection point or transformer tap change operation in the assessment of whether the proposed generation performance will meet clause S5.2.5.4 requirements?

There may be scope to consider the continuous control of other connection point assets on a case-by-case basis and/or utilisation of inverter short-term overload capability. However, discrete switching of loads, reactive devices or transformer tap changes alone is not considered consistent with clause S5.2.5.4, as they are not sufficiently fast to ensure they do not exacerbate disturbances.

5. Does AEMO consider voltage dependence of other loads in the network in the assessment of whether the proposed generation performance will meet clause S5.2.5.4 requirements?

Whilst it would influence the overall system response, voltage dependence of loads elsewhere in the network is not considered in the assessment (and in any case, may further exacerbate the disturbance).

6. Can AEMO use NEMDE to constrain active power to facilitate compliance with clauses S5.2.5.1 and S5.2.5.4?

Whilst there may be specific circumstances where dispatch constraint equations are required, as a general rule, NEMDE is not intended to manage generator compliance (see also item 8).

7. Does AEMO have a preference of priority mode operation?

AEMO would expect applicants to decide priority mode in consultation with the manufacturer of the plant and the connecting NSP to best suit the voltage regulation requirements at the connection point. However, we note that there are potential issues with P-priority mode during/following cloud cover events.

8. Is the generating system required to comply with clause S5.2.5.4 for all ambient temperatures?

Generating systems are required to comply with their performance standards under all conditions and operating points. At higher ambient conditions where solar output is derated, the solar farm telemeters a local limit required to manage its output to ensure compliance.

4. FAULT RIDE-THROUGH PERFORMANCE OF INVERTER CONNECTED GENERATORS

4.1 Statement of issue

AEMO is aware of an emerging issue with some solar farm proposals with respect to their fault ride-through (FRT) performance, where control systems are configured to automatically limit active power to zero during disturbances, irrespective of the severity of the disturbance or the reactive current injected during that disturbance.

If inverter based generating systems within a part of the network reduce active power to zero during disturbances, it will reduce the likelihood of other, nearby, generation riding through the event and increases the likelihood of cascading failures. Additionally, the increased active power deficit due to a zero active power FRT mode increases the magnitude of the frequency disturbance experienced across the whole interconnected power system. The increased magnitude of a frequency disturbance will have adverse impacts on both power system stability and fault recovery.

4.2 NER requirements

The NER permit some reduction in active power for the duration of a fault on the network, but are not explicit on the permissible amount of that reduction. AEMO understands that reactive current is given priority over active current to improve voltage support during the disturbances events, so it is acceptable to reduce the active current injection to facilitate reactive current injection.

4.3 AEMO's interpretation of the Requirement

Programming inverter based generation to automatically reduce active power to zero for disturbances to, for example, 85% voltage and below, is not acceptable as it will adversely impact the system response to contingency's and therefore adversely impact system security. AEMO expects inverter based generation to provide active power output at least in proportion to the retained voltage at the connection point and to supply reactive current subject to apparent power capacity. As this is an emerging issue, AEMO may need to review and refine its approach to assessing this requirement. To discuss, please contact the connecting NSP or AEMO.