AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

13 July 2018

Level 22
530 Collins Street
Melbourne VIC 3000

Postal Address:
GPO Box 2008
Melbourne VIC 3001

T 1300 858724
F 03 9609 8080

Mr John Pierce
Chair
Australian Energy Market Commission
PO Box A2449
Sydney South NSW 1235

Dear Mr Pierce,

Generator Technical Performance Standards Rule Change – AEMO submission

AEMO welcomes the opportunity to provide input to the Commission's Draft Determination and Draft Rule on Generator Technical Performance Standards.

AEMO is the independent market and systems operator for the National Electricity Market and Western Australian Wholesale Electricity Market, and the NEM National Electricity Transmission Planner, with primary responsibility for managing and maintaining power system security and reliability. This role is undertaken within the legislated policy and market frameworks and in adherence to the National Electricity and Gas Objectives and Rules.

Since the establishment of the NEM, the technical requirements imposed on new connections to the national grid have been designed to support power system security and the quality of the supply of electricity over the long term. AEMO's recommendations on revised (or new) performance standards will encourage all plant connected to the power system to have the capability of continuing to maintain power system security and quality of supply as the system undergoes widespread change. These standards will ensure the NEM's connections framework is forward-looking, cost-efficient and technology-neutral to adapt with the rapidly evolving power system.

The first part of AEMO's submission outlines our response to the Commission's approach to the setting of performance standards, the negotiating framework required to establish each Connection Applicant's standards and the transitional arrangements to apply the revised standards. The second part of our submission details AEMO's technical recommendations in response to those standards proposed by the Commission in its Draft Determination.

AEMO looks forward to continuing to work closely with the Commission to establish standards that deliver secure, reliable and affordable energy in the long-term interests of consumers.

Should you have any questions on the matters raised in this submission please contact Chris Davies, Manager Energy Systems Solutions on (03) 9609 8000.

Yours sincerely,

Brett Hausler
Executive General Manager, Regulation and Governance

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Generator technical performance standards: Rule change proposal

July 2018

Submission to the Australian Energy Market Commission's Draft Determination

Important notice

PURPOSE

This submission has been prepared by AEMO for the purpose of the Australian Energy Market Commission's National Electricity Amendment (Generator technical performance standards) Rule 2018, using information available at 13 July 2018.

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1. Approach to setting performance standards

1.1 Overview

Since the inception of the National Electricity Market (NEM), the technical requirements imposed on new connections to the national grid have been designed to support power system security and the quality of the supply of electricity under a range of existing, and long-term, power system operating scenarios.

AEMO's rule change proposal was predicated on five key principles:

1. **Forward-looking** – once installed, generating systems will remain connected for decades, so access standards need to be capable of operating in a variety of foreseeable, present and future operating scenarios.
2. **Shared responsibility** – all plant connected to, or forming part of, the national grid should contribute to maintaining power system security.
3. **Technology-neutral** – all generating systems should be subject to the same technical performance requirements, unless there are technical reasons why this should not be the case.
4. **Cost-efficient** – the NEM requires a NEM-wide, cost-efficient approach to establishing connections to the national grid. The corollary to this is a need to minimise intervention by state-based regulators in the regulation of connections.
5. **Limited exceptions** – in light of the growing trend of new generating systems with a capacity of less than 30 megawatts (MW) participating in the wholesale market, it is no longer appropriate that this threshold should apply to certain access standards.

The principles underpinning the AEMC's draft determination, on the other hand, exhibit three key differences to AEMO's approach:

1. Connection Applicants seeking to connect new generating systems should not bear costs associated with the management of future, uncertain power system developments, including the risk of generating system retirements[1].
2. Minimum access standards should be mandated only where a clearly identifiable power system need exists, irrespective of power system conditions at the point of connection[2].
3. Constraint equations are an operating tool for managing power system security, equivalent to the access standards and, hence, should be considered as an alternative to establishing performance standards[3].

1.2 Context to developing technical standards for the connection of new generating systems

The operation of the NEM so that it can deliver electricity from centres of production to centres of consumption is a complex task that requires the planning and co-ordination of disparate equipment, controls, and human interaction. The physics of the national grid that underpins the NEM mean everything is not just interconnected, but interdependent, and these interdependencies need to be considered, regardless of whether one is faced with an issue in real time (such as within a dispatch timeframe), pre-dispatch, or longer, planning timeframes.

In the context of power system security in the NEM, the National Electricity Code (as the precursor to the National Electricity Rules (NER)) was predicated on a 'schema' of the interaction between the system operator and owners/operators of each type of plant that either formed part of, or were connected to, the national grid. That 'schema' has carried through to the NER and remains intact to this day.

At a high level, the 'schema' that underpins the NER in the context of achieving power system security to the required standard, requires the following:

[1] AEMC. Draft Determination, p 16 & 35.

[2] AEMC. Draft Determination, p 112 & 173.

[3] AEMC. Draft Determination, p 26 & 38.

- As the system operator, AEMO has primary responsibility for maintaining power system security[4] in accordance with Chapter 4 of the NER, including by exercising powers of intervention[5] where the market does not respond to a need for corrective action.
- As owner/operators of the distribution and transmission networks in the NEM, network service providers (NSPs) are required 'to co-operate with and assist AEMO in the proper discharge of the AEMO power system security responsibilities'[6], and are subject to a range of more specific responsibilities, notably in the context of voltage control[7], stability[8] and system restart[9].
- As owner/operators of generating systems, Generators are required to meet certain technical requirements[10], including having appropriate remote control and monitoring devices as prescribed by schedule 5.2[11] and protection systems[12]. Moreover, they are not at liberty to generate at will and must comply with AEMO's dispatch instructions[13], or make operational decisions, such as to commit or de-commit without AEMO's approval[14].
- As owner/operators of electricity consuming plant, or aggregators of owner/operators of such plant, Market Customers are required to have interruptible load to assist in the management of power system security[15] and appropriate remote control and monitoring devices as prescribed by schedule 5.3[16], and to comply with AEMO's dispatch instructions[17].

The key focus of this rule change proposal, Chapter 5, imposes key obligations on Registered Participants, such as planning and network development on NSPs[18], the design of connected equipment on Registered Participants[19], on Generators when making alterations to generating systems[20] and, in the case of Connection Applicants, certain technical requirements[21], when connecting to the national grid[22]. These types of obligations and standards are designed to ensure power system security.

The system standards in Schedule 5.1a specify the levels of performance of each NSP's protection and control systems[23], yet Network Users bear some responsibility for ensuring they do not cause the NSPs to be in breach of those obligations[24]. In the case of Generators, there is an explicit requirement that their equipment be designed to withstand, without damage, the range of operating conditions that may arise consistent with the system standards[25].

It is apparent that, although AEMO has primary responsibility for the maintenance of power system security, other parties whose assets either form part of, or are connected to, the national grid have responsibility for supporting AEMO in its management of it, either through the installation of specific equipment, or how they operate their equipment and, finally, by being required to comply with dispatch instructions and directions.

1.3 Application of the National Electricity Objective

The National Electricity Objective (NEO) is framed in terms of the 'long term interests of consumers'. In the context of power system operational matters, AEMO interprets this to mean that investment decisions need to be considered not only by reference to what is occurring today, but also by reference to what is reasonably foreseeable into the future.

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[4] Clause 4.3.1 of the NER.

[5] Clause 4.8 of the NER.

[6] Clause 4.3.4(a) of the NER.

[7] Clause 4.5.1 of the NER.

[8] Clause 4.7 of the NER.

[9] Clause 4.8.12(d) & (e) of the NER.

[10] Clause 4.4.2(b) of the NER. These are in addition to any performance requirements required by Schedule 5.2.

[11] Clause 4.11.1(a) of the NER.

[12] Clause 4.4.3 of the NER.

[13] In the case of Scheduled Generators and Semi-Scheduled Generators, they can send out generation only in accordance with dispatch instructions, as required by clause 4.9.4 of the NER. Non-Scheduled Generators' generation output is subject to constraints, such as outages.

[14] Clause 4.9.6 & 4.9.7 of the NER.

[15] Clause 4.3.5 of the NER.

[16] Clause 4.11.1(a) of the NER.

[17] Clause 4.9.8 of the NER.

[18] Part D of Chapter 5 of the NER.

[19] Clause 5.4 of the NER.

[20] Clause 5.3.9 of the NER.

[21] See Schedules 5.1, 5.1a, 5.2, 5.3 and 5.3a.

[22] Clause 5.3 of the NER.

[23] Clause 5.7.4(a1) – (a4) of the NER.

[24] As, for example, in clause S5.1a.6 of the NER.

[25] Clause S5.2.1(d) of the NER.

AEMO's interpretation is reinforced by considering AEMO's functions in section 49 of the *National Electricity Law* 'to maintain and improve power system security'.

The technical requirements that are the subject of AEMO's rule change proposal were originally framed in the context of a power system that was dominated by large, synchronous generating systems[26]. AEMO's 2017 rule change proposal was developed because there has been a paradigm shift in the pattern of connection applications, which are now dominated by asynchronous generating systems, ranging in size from small to significant, with capabilities that continue to evolve.

Industry has learned since 1998 that large, synchronous generating systems provide a range of benefits that were hitherto taken for granted and, by extrapolation, not valued. The changing generation mix necessitates a consideration of the capabilities that are being lost to the NEM and what they are being replaced with, and how current trends will impact the continuing ability to maintain power system security, or be in a position to improve it.

Being able to foresee how the decisions of today impact on the needs of tomorrow is critical, because access standards impose technical requirements on generating systems that are designed to support power system security, and new generating systems will remain connected and operational for decades to come. This means their performance obligations will endure, so AEMO must consider how new generating systems will adapt to the evolving power system.

To accept a regime that only looks at present needs at the connection point is inconsistent with the NEO, and inefficient.

1.4 Forward-looking performance standards

1.4.1 AEMC draft determination

The AEMC considers the most efficient approach is to require Generators with new connections to pay shallow connection costs, bearing no cost towards any uncertain future power system developments[27]. This is because Generators have no control over future developments that may impact their ability to earn spot market revenue and, therefore, should not bear any risk associated with uncertain future scenarios[28].

1.4.2 AEMO's approach

AEMO's rule change proposal was designed to improve the generation connection process and outcomes to deliver a resilient and adaptable power system for today and into the foreseeable future.

AEMO supports the principle that Generators should pay shallow connection costs, but these should be consistent with their obligations to support power system security, as outlined in Section 1.2. This means there needs to be appropriate levels of minimum performance requirements.

The real issue is: at what level should those minimum capabilities be set? The answer to this question needs to be addressed by reference to the NEO.

In addition to a system need triggered by a proposed connection, in AEMO's view, a Generator's performance standards should include the provision of capability, if that capability could deliver the network services required to address system needs more efficiently.

In the first instance, the efficiency of delivering certain capabilities by generating systems can be measured by reference to:

- **A network solution as an alternative** – there are some operational needs that can be met by generating systems, either through their inherent capability, or because they can be provided more cost-effectively than an NSP's installation of additional network equipment.
- **Generating systems' ability to deliver capabilities at each connection point** – the reason why, in an absolute sense, a specific capability might not be required at a specific connection point is because someone else is providing it at another connection point. Permitting generation connections without that specific capability, because there is no demonstrable need for it at a specific connection point, gives rise to a free-rider problem. This is an inefficient outcome, both now and in the longer term, because if every Generator did not have to provide a specific capability, because someone else is providing it, we will end up facing a situation exactly like we are facing today; namely, that the capability is taken for granted and may no be longer be available because the Generators who were providing it subsequently cease to do so (for whatever reason).

[26] An update occurred in 2007 with a change to the NER to accommodate a rush of wind farm connection applications.

[27] AEMC. Draft Determination, p 16.

[28] Ibid

Secondly, if a capability provided by a generating system is available at minimal, or no, incremental cost at installation, or minimal operational cost if it is utilised, it should be documented and made available to be utilised to support power system security where necessary.

1.4.3 The certainty of uncertainty

Even near-term power system operating scenarios can be unpredictable. During 2017, the Victorian transmission network operated with a significant load at partial capacity due to unforeseen circumstances. At the same time, the retirement of Hazelwood Power Station resulted in a significant change to the Victorian generation mix. The changes resulted in variations to normal power flows that caused high voltages in parts of Victoria – notably the south-west corridor around Geelong, Keilor, Portland, and Moorabool.

AEMO successfully managed the high voltages using non-standard and short-term operational procedures, generally reserved for emergency management. While available, such operational procedures are not intended for on-going day-to-day power system operations as they place additional wear on transmission equipment and reduce the flexibility that may be required during emergencies. This highlights the need for additional adaptability from generating systems.

Similar operating scenarios can arise due to unplanned maintenance, outages, weather events, and the type of plant being dispatched. Performance capabilities need to account for these eventualities.

Building on this example of voltage control, and considering AEMO's forecast transitioning energy mix, as illustrated in **Figure 1** and **Figure 2** from AEMO's *Integrated System Plan*, the predicted development indicates that there will be an increased need for future generating systems to provide at least some of the flexibility, adaptability, and overall technical capability that current synchronous plant provide to support system security.

Figure 1 NEM Generation Mix (MW) 2018 - 2019

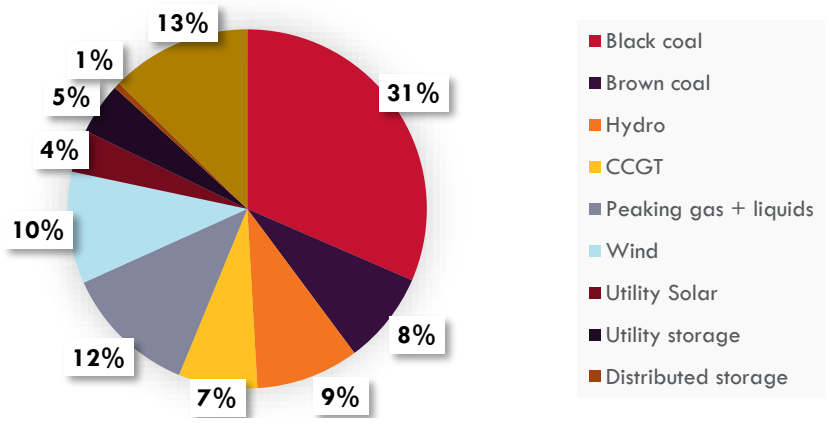
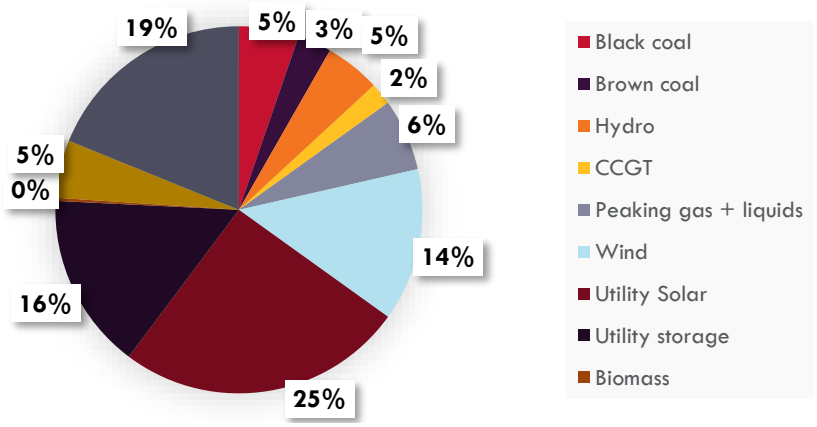


Figure 2 NEM Generation Mix (MW) 2038 - 2039

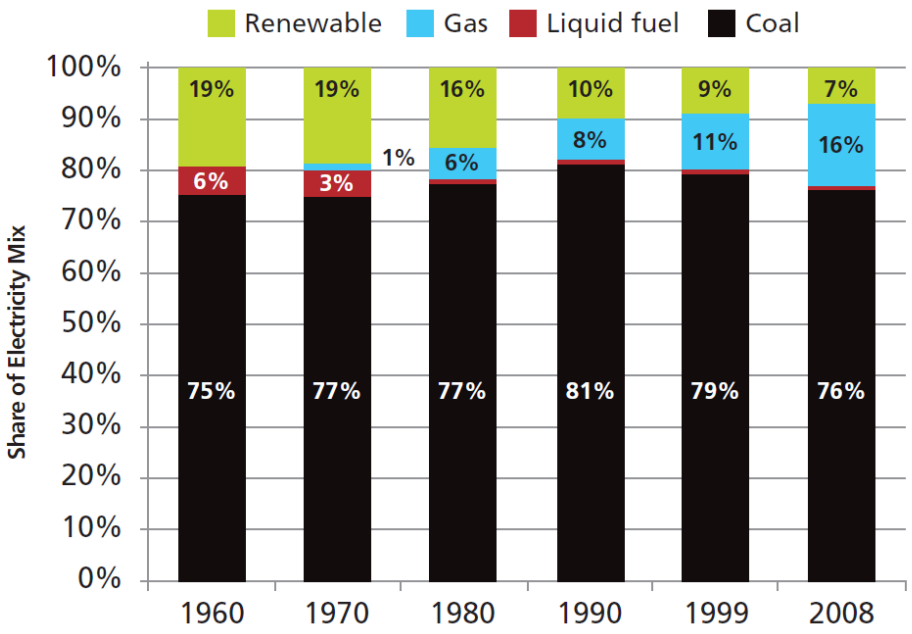


1.4.4 AEMO's response to draft determination

As referred to in Section 1.3, the current framework for the negotiation of technical performance requirements for new generation connections is partially based on an assumption that a range of security and quality of supply services are inherently being delivered by connected generation.

Figure 3 demonstrates the relative stability of the generation mix over almost five decades leading up to 2008. The assumption that traditional, coal-fired synchronous generation would always be there to provide baseload power largely held true.

Figure 3 Australian electricity generation mix, 1960-2008



Source: Electricity Supply Association of Australia & Australian Bureau of Agricultural and Resource Economics cited in http://environmentvictoria.org.au/wp-content/uploads/2011/05/Australiaenergymix1960-2009.pdf, p. 4.

The more recent economic displacement and exit of large, synchronous generation from the NEM means this assumption no longer holds true, as **Figure 1** and **Figure 2** show.

Moreover, the exit of this generation has exposed weaknesses in the power system that new generation connecting on the basis of the current standards cannot address, and major supply incidents of late are a symptom of this[29].

As noted by the Energy Security Board in its inaugural *The Health of the National Electricity Market Report*:

> *The risk that essential requirements for security are not present is increasing, along with the market interventions then required by AEMO. The NEM is not fully optimized and economic inefficiencies are raising costs*[30].

The impact of foreseeable future scenarios now requires further consideration.

The experience of South Australia will be felt across the remainder of the NEM, with an expected significant increase of new renewable generation connecting to remote parts of the NEM, potentially displacing existing synchronous generation. Approximately 1.6 GW of large-scale solar PV is forecast to commission across the NEM during 2018-19, three times the current generating capacity of solar[31]. A large concentration on this new large-scale solar generation expected to be commissioned in 2018 is in remote parts of Queensland (over 1 GW). The expectation of the ongoing availability of existing synchronous generators to provide a range of grid services in Queensland should not be relied on. In total, AEMO now has approximately 15 GW of projects in advanced stages of the connection process, which is unprecedented in the history of the NEM.

While the timing and impact to the network from this new generation, along with the potential exit of existing synchronous generation, over the next decade cannot precisely be predicted, the trend is clearly visible.

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[29] As shown in AEMO's *South Australian System Strength Assessment*, available at: http://www.aemo.com.au/-/media/Files/Media_Centre/2017/South_Australia_System_Strength_Assessment.pdf.

[30] P30.

[31] AEMO, CER, Bloomberg New Energy Finance, 2018.

In South Australia, ESCOSA has considered it necessary that certain minimum levels of capability are required from generation to manage power system security and to address this, additional performance requirements were introduced through its licensing powers. The more rigorous technical standards applied by ESCOSA since 2005, and updated in 2010 and 2017[32], have not stifled investment in that State.

1.4.5 AEMO's recommendation

It is now necessary that the minimum capabilities of new generation address foreseeable operating scenarios, regardless of whether they are forecast for the short term. The connections landscape has fundamentally changed from the one that existed when the NER was designed.

It is now known that generation has hitherto provided, and will continue to provide, a minimum set of capabilities that support the operation of the power system. New generation will remain connected and operational for decades and so will need to exhibit resilience and adaptability. This approach is far more consistent with the NEO than not requiring new generation to address any future power system developments.

1.5 Minimum access standard

1.5.1 AEMC draft determination

The AEMC considers that minimum performance capabilities should only be mandated where a clearly identifiable need exists to require such a capability from every type of generation, irrespective of the power system conditions at the connection point[33]. This has led to the conclusion that, for some capabilities that are not required to be provided by all generating systems at all locations, it may be appropriate to set a minimum access standard of no capability[34].

1.5.2 AEMO's approach

AEMO's proposed minimum access standards are based on the fact that new generation does not inherently deliver the same levels of power system security services as the retired or exiting large synchronous generation. They were designed so that the required capabilities of new generation can be delivered at an efficient cost to ensure the long-term resilience of the power system. Therefore, new generation must be required to provide a minimum capability that supports the power system, where it is cost-effective to do so.

1.5.3 AEMO's response to draft determination

Exactly what constitutes a 'clearly identifiable system need'[35] is difficult to ascertain. What capability the power system will require, and where and when it will require it, cannot be predicted with absolute certainty, for three inter-related reasons.

Market dynamics

At present there are Generators with dispatchable capabilities contributing to strong present-day connection points that might not be dispatched in the near-term (because of changing unit commitment patterns due to economic displacement), or may exit in the long term, and, therefore, their services cannot be relied on to be available when needed.

This can result in AEMO having to issue directions that can create costly market imbalances. In 2018, AEMO issued more than 50 system security-related directions, an increase from zero five years ago[36]. The cost to consumers of this level of directions are estimated to be in the tens of millions of dollars annually[37].

Power system physics

As detailed in AEMO's rule change proposal, the transition to a predominantly asynchronous generation fleet will change the physical engineering of the power system in steady state conditions and in response to disturbances. The volume of new generation connections, the change in the operation of the power system, and a vast range of operating scenarios mean that the expected future performance of the power system is generally understood, but is not always clearly demonstrable at the time of negotiating a particular performance standard.

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[32] Referred to as the '2017 model licence conditions for new generators', available at: https://www.escosa.sa.gov.au/ArticleDocuments/1050/20170817-Inquiry-LicensingArrangementsforGeneratorsSA-ModelLicenceConditions.pdf.aspx?Embed=Y

[33] AEMC. Draft Determination, p 112 & 173.

[34] AEMC. Draft Determination, p 20.

[35] AEMC. Draft Determination, p 113 & 173.

[36] AEMO. *Coordination of Generation and Transmission Investment Review Discussion Paper – AEMO Submission*, p 12. Available at: https://www.aemc.gov.au/sites/default/files/2018-05/AEMO.pdf.

[37] Energy Security Board, The Health of the National Electricity Market. p 29. Available at: http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/The%20Health%20of%20the%20National%20Electricity%20Market_19122017.pdf.

Practical implementation

As the power system transitions, where and when power system management issues will arise is becoming increasingly difficult to forecast. In South Australia, mandatory voltage control capabilities from all plant were implemented in 2010. At the time, industry feedback was that these capabilities were being underutilised. More recently, they are utilised regularly by AEMO in real-time to manage the power system.

1.5.4 AEMO recommendation

Market dynamics, the physics of power system engineering and practical expertise demonstrate that minimum access standards should be determined by reference to which system support service can be delivered most efficiently in each context.

Consistent with the NEO and the 'schema' that underpin how the NER address power system security, AEMO considers that all plant (namely, both generating system and network plant) should actively contribute in a positive way towards management of power system security, rather than being passive[38].

1.6 Market constraints

1.6.1 AEMC draft determination

The AEMC notes that an NSP or AEMO might utilise constraint equations to mitigate the risks arising from less capable generating plant, and that:

> *The process to set performance standards for equipment connecting to the power system should also be considered in its broader context as one of a range of tools used by network businesses to meet the system standards and by AEMO to help maintain power system security…*

Included in the examples of other tools available to meet the system standards is the application of 'constraints'[39], although the AEMC later acknowledges that inadequate performance standards that lead to the need for constraint equations can result in higher costs[40].

1.6.2 AEMO's response to draft determination

AEMO considers that, while the application of constraint equations is an acceptable means of operating the power system, they should be considered as a complement to planning and power system design, rather than as an equivalent measure to the development or setting of appropriate performance standards.

AEMO typically applies constraint equations in central dispatch to manage issues that arise to allocate limited shared capacity, and to manage non-credible contingency events. Constraint equations are also invoked to balance the efficient dispatch of generation against the management of congestion and security risks in the near term where there is no economic, or feasible, option to provide any physical solution to a dispatch problem.

The more constraint equations are utilised, the less secure the power system becomes and the more complex (and inefficient) it is to operate it. Not every constraint equation may be satisfied in every dispatch interval. Due to competing priorities in terms of the system security measures to be satisfied and the range and complexity of issues managed via constraint equations, there are circumstances where AEMO must allow some to violate to satisfy the most critical ones.

1.6.3 AEMO recommendation

Constraint equations should not be used as an alternative to the setting of appropriate performance standards for a Connection Applicant.

[38] AEMO notes that, in very isolated cases, the impact of some, generally small, plant may be immaterial to the operation of the power system.

[39] AEMC. Draft Determination p 26.

[40] AEMC. Draft Determination p 38.

2. Negotiating framework

2.1 Overview

The negotiation of performance standards is extremely complex. It involves the interaction of many parties with differing objectives, some of which can be conflicting, with the complexity compounded by varying degrees of market and technical knowledge. Further, external pressures are applied (such as competing for limited government incentives, or project financier conditions) on each of the parties involved in the development of investments that reach into the hundreds of millions of dollars. Project milestones and next stage gateways vary widely and, consequently, so does the negotiation process for performance standards in Connection Applications. These external pressures should not unduly impact the overarching requirement for system security and appropriate operating standards.

2.2 AEMC draft determination

The AEMC has foreshadowed that the NER should provide an overarching objective of the connection process, such that "the automatic access standard be the starting point for negotiations and applies unless the applicant can justify a negotiated access standard"[41]. Further, the AEMC states:

> *AEMO and network service providers could help discipline the behaviour of connection applicants through their existing ability under the NER to reject a proposed negotiated access standard, clearly setting expectations on the levels of performance they consider will not adversely impact power system security or the quality of supply to other network users.*[42]

To apply this clarity to the existing framework, the AEMC has proposed including in the NER 'commercial feasibility' as a basis for Connection Applicants to propose a lesser standard than an automatic access standard, without requiring AEMO and the NSPs to take this into account when considering the appropriateness of any proposed performance standard based on a negotiated access standard.

2.3 AEMO's response to draft determination

While AEMO strongly supports making the automatic access standard the starting point for negotiations, it has serious reservations about the message that the AEMC's amendment to clause 5.3.4A will send, namely that a Connection Applicant can secure a negotiated access standard if it can justify it on commercial grounds.

Currently, there is no legal obligation for AEMO or NSPs to consider the commercial issues faced by a Connection Applicant when establishing the performance standards for a new generation connection. Nevertheless, AEMO acknowledges and readily accepts that commercial issues are an important priority for Connection Applicants when seeking to connect a new generating system to the national grid.

AEMO is concerned that the inclusion of commercial considerations in the negotiating framework undermines an important principle that the AEMC appears to support, namely, that the levels of performance that AEMO and NSPs can accept are those that will not adversely impact power system security or the quality of supply to other network users, a principle that is preserved in the amendment to clause 5.3.4A(b).

AEMO submits that the technical requirements of the power system and the need to support and enhance power system security and the quality of supply to other Network Users should in no way be seen as subordinate to the issue of the costs incurred by Connection Applicants when seeking the connection of new generating systems.

With this overarching principle in mind, AEMO recommends a negotiating framework that encourages cost-effective sufficiently-performing plant where technically required. Specifically, a framework where:

- Power system security remains AEMO and NSPs' overriding consideration when considering a connection application. The requirement that AEMO, especially, consider how best to maintain power system security requires a degree of foresight into future developments.

[41] AEMC draft determination, p40.

[42] AEMC draft determination, p41.

- While encouraging the negotiating parties to arrive at efficient solutions to the power system security implications of proposed new connections, the resilience of the power system is not compromised to manage a Connection Applicant's cost of connection.
- Divergence from the automatic access standard should only be acceptable if it is either technically acceptable, or the capability can be sourced more efficiently from, for example, the connecting NSP.
- Plant design that meets the security and quality of supply needs of the power system most cost-effectively is encouraged.

The AEMC's draft rule could imply that a Connection Applicant can seek a trade-off between the performance of a proposed generating system against what is necessary to maintain power system security or maintain the quality of supply to other Network Users. By calling out the 'commercial and technical feasibility of complying with the automatic access standard with respect to the relevant technical requirement' in the proposed clause 5.3.4A(b1)(3), each Connection Applicant may put forward a case that treats its cost of compliance with the automatic access standards as having equal weight with what is necessary to maintain power system security or maintain the quality of supply to other Network Users.

While neither AEMO, nor NSPs are required by the proposed clause 5.3.4A(b) of the NER to take into account the commercial feasibility of a Connection Applicant's compliance with an automatic access standard, AEMO is concerned that Connection Applicants will interpret the rule differently. If Connection Applicants do so, they will give their own 'commercial feasibility' considerations undue prominence and expect AEMO and the NSPs to do likewise when assessing the proposed negotiated access standard.

In this way, the integrity of the power system could be compromised to manage the cost of private asset owners who could see their cost considerations as being of greater importance than the common good of enabling the continuous operation of a resilient power system.

2.4 A practical approach

The AEMC's response to these risks is for AEMO to "discipline the behaviour of Connection Applicants[43]" and reject a proposed performance standard if it adversely impacts power system security or the quality of supply to other Network Users. Disciplining Connection Applicants is difficult in the context of the AEMC's draft rule that puts their commercial considerations squarely in the mix. At best, it sends mixed signals to Connection Applicants about what is an appropriate criterion for acceptance of a proposed standard and, at worst, creates legal uncertainty that could result in costly, lengthy negotiations or even lead to litigation.

In response to the rule change proposal and the AEMC's consultation paper, Ergon and Energex noted that, at present, negotiations can "become controversial and commercial and/or political influences can be brought to bear, which can result in a less-than-optimal outcome".[44]

AEMO concurs with this and considers that to elevate the status of the 'commercial feasibility' of compliance with the automatic access standard when proposing a lesser standard, is to invite Connection Applicants to bring even greater complexity to the negotiations. This will result in greater commercial and or political pressures on AEMO and NSPs to accept a lesser standard of performance simply because of this change to the NER.

The AEMC considers that the inclusion of commercial considerations recognises a practical reality. While AEMO agrees that this practical reality exists, its inclusion in the NER as a basis for proposing a performance standard that is lesser than the automatic access standard undermines the need for Connection Applicants to genuinely aim for the automatic access standard. This is because there will always be a commercial reason not to acquire or design higher performing plant, regardless of the needs of the power system. This practical reality contrasts with the policy stated in the AEMC's draft determination that costs should not drive the level of performance required[45].

2.5 AEMO recommendation

AEMO recommends removal of the specific reference to commercial considerations from the connection framework. A framework with a focus on technical performance is more appropriate, and better supports the long-term security of the power system by ensuring performance requirements remain the priority of network connection.

Such a framework is more likely to deliver high performance plant with cost minimisation where technically feasible.

[43] AEMC draft determination, p41.

[44] Ergon and Energex, submission to the AEMC's consultation paper, p. 11 – noted in AEMC draft determination on p32.

[45] AEMC draft determination, p 41.

3. Transitional arrangements

The AEMC has acknowledged the importance of implementing the new rule as soon as possible by proposing an eight-week period after the release of the final determination before the new rule commences.

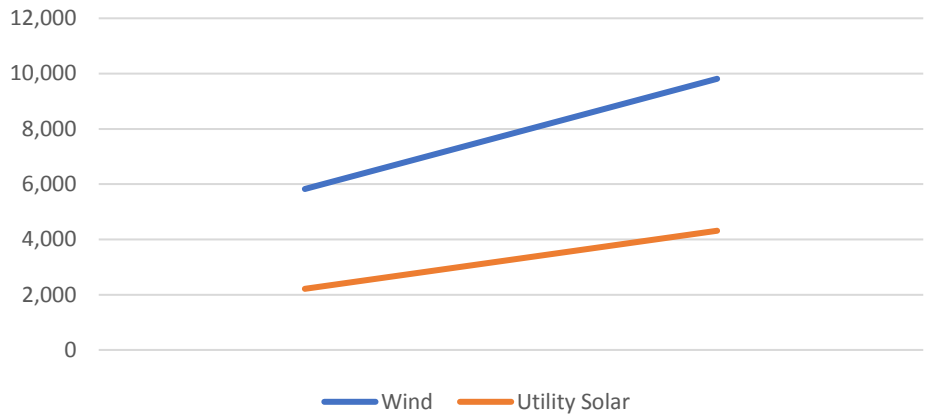
AEMO is strongly of the view that it is not in the long-term interests of consumers to delay commencement of the new rule any further than the period proposed by the AEMC.

The AEMC released its Consultation Paper in September 2017. From that time, the industry was aware that it would take approximately a year for a new rule to be implemented.

One year is more than sufficient for Connection Applicants with plans for a new generation connection to submit and finalise their connection application based on the current framework. When it comes to the new rule, the date for submission or revision of a connection application is open ended, and thus a further extension to the commencement date is not warranted as Connection Applicants are able to submit or revise proposals according to their own timeframes.

AEMO is currently assessing approximately 15 GW of projects in the advanced stages of the connection process. In May 2017, less than 300 MW of utility solar was installed in the NEM[46]. By mid-2019 that figure is forecast to be around 2000 MW and in around 5 years the level of wind and utility solar in the NEM is forecast to increase by around 50% for wind and over 100% for solar[47].

Figure 4 NEM Utility scale wind and solar installed capacity (MW): 2018/2019 – 2023/2024



The higher the proportion of generation connected under the existing standards today, the less support it will provide when the penetration of utility wind and solar reaches 20% of installed capacity, expected to occur around 2023/24[48]. This will then give rise to:

- More uncertain power system operating scenarios.
- Reduced ability for AEMO to address such scenarios in as efficient a manner as possible, potentially leading to costly market interventions.
- Potentially, further installation of network equipment to support safe operation of the national grid, as is currently being pursued with the installation of synchronous condensers in South Australia to support system strength and inertia.

AEMO is committed to working closely with Connection Applicants and NSPs to ensure a flexible approach, within the bounds of the new rules, is applied to the application of the new access standards without the need for delaying the commencement date of the new rule any further.

[46] AEMO. Generation Information web page at 19 May 2017.

[47] ISP, excludes rooftop PV.

[48] ISP, excludes rooftop PV.

4. Active power capability

4.1 Technical summary

AEMO had proposed a range of measures on the control of active power by generating systems to manage dispatch outcomes and power system security during normal operation and disturbances. The proposed measures included requiring facilities to:

- Support dispatch (e.g. provision of AGC control for scheduled and semi-scheduled generation),
- Manage congestion (active power limit control for non-scheduled generation), and
- Support market expansion (provision of frequency response capability).

4.2 AEMC draft determination

The AEMC has generally supported these proposals with minor amendments and clarifications.

Although there appears to have been some degree of misinterpretation not aligned to AEMO's original intent, the outcome of the draft determination satisfies AEMO's objectives.

4.3 Further amendment proposal

In the proposed clause 5.2.5.11(i)(2)(ii), AEMO recommended that generating systems have the *capability* to set a droop within the range of 2% - 10%. The AEMC has endorsed this recommendation.

AEMO first started investigating the need for droop settings in early 2017, with the requirement based on historical setting practice with synchronous generation. Since submission of AEMO's rule change proposal, large scale battery storage systems have connected to the NEM providing new practical operating experience, which indicates that a minimum level of 2% may place unnecessary restriction on their operation.

Two recent battery storage systems have applied a setting of less than 2%, and given the commercial incentives involved[49], this trend may continue. In agreeing to such an aggressive droop setting, AEMO has considered the benefits and impacts to the power system. Further, a minimum setting of 2% may also interfere with a fast-responding generating units' ability to meet the clause S5.2.5.8 performance obligations via the use of proportional droop controls, where a setting of less than 2% may be required. Historically, this was often met via switched control, where droop was not relevant. To provide the balance required, AEMO recommends adding some flexibility to the draft clause 5.2.5.11(i)(2), as shown in red:

> (i) For the purposes of subparagraph (b)(2), and with respect to a *negotiated access standard* proposed for the technical requirements relevant to this clause S5.2.5.11:
>
> …
>
> (2) a *generating system* must be capable of setting the deadband and droop within the following ranges:
>
> (i) the deadband referred to in subparagraph (1) must be set within the range of 0 to ± 1.0 Hz. Different deadband settings may be applied for a rise or fall in the *frequency* of the *power system* as measured at the *connection point*; and
>
> (ii) the droop must be set within the range of 2% to 10%, or other setting as agreed with the *Network Service Provider* and *AEMO*.

In this manner, the clause still provides guidance on typical droop ranges expected, but also allows the flexibility required to account more appropriately for new technologies.

[49] Namely, participation in the FCAS market.

5. Remote monitoring and control

5.1 Technical summary

AEMO had proposed a range of amendments to the remote monitoring and control requirements to ensure that:

- The technical standards formally outline the requirements necessary to facilitate market and power system operations in accordance with the NER, such as remote control for voltage/reactive power control[50] and AGC purposes[51], and
- Increased clarity in terms of expectation regarding remote monitoring and control requirements.

5.2 AEMC draft determination

In its determination, the AEMC considered that a number of the proposed recommendations should not be adopted. These related to the provision of a signal from energy storage facilities to inform AEMO of energy reserves, and improved clarity in terms of the way the minimum access standard was expressed.

5.3 AEMO's response to draft determination

5.3.1 Minimum and automatic access standards

As noted in AEMO's rule change proposal, the increasing complexity of the power system and the necessity for faster operational actions lead to the need for greater automation and coordination of many different power system elements. Real-time information allows AEMO to specify the technical envelope[52] to maintain power system security more effectively, and to understand better the real-time ancillary services requirements and other capabilities required to maintain power system security[53]. Understanding the status of plant and control equipment is essential to achieving more efficient power system operation.

AEMO proposed the inclusion of remote control capabilities in the minimum access standard and, for both the minimum and automatic access standards, a list of remote monitoring and control capabilities that generating systems **may** need to provide if required by AEMO to discharge its market and power system security functions. AEMO's proposal is designed to provide flexibility and signal to industry the type of communications and control infrastructure to be considered in the design phase. AEMO understands such control equipment is standard in the installation of remote monitoring equipment, with any additional signals dependant on quantities that AEMO **may** subsequently require. Such minimum signal sets then align with the requirements set out in other technical requirements, for example those in clause S5.2.5.13 (control modes and set points) and clause S5.2.5.14 (AGC, ramp rates).

AEMO, therefore, disagrees with the AEMC that AEMO's proposed minimum access standard may require all Generators to incur material costs by installing this type of infrastructure where it might not be required[54]. AEMO's proposal is consistent with the approach preferred by the AEMC, namely, the negotiating process remains the appropriate manner to determine the capabilities required from generating systems and generating units at specific connection points[55].

AEMO notes concerns on the appropriateness of AEMO being involved in the control of plant connected to distribution networks. As generating systems may create bi-directional flow patterns throughout a distribution network that affect power flows on the transmission network, greater observability and controllability to capture power system impact and operation is required, particularly as a significant number of connections are connecting to the sub-transmission and distribution networks.

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[50] Clause 4.9.5(a)(2) of the NER.

[51] Clause 3.8.21(d) of the NER.

[52] Refer to clause 4.2.5 of the NER.

[53] Refer to clauses 4.3.1(e) and (i) of the NER.

[54] AEMC. Draft Determination, p 96.

[55] AEMC. Draft Determination, p 97.

Moreover, AEMO and the NSPs have a clear delineation between their respective scopes of control as a matter of operational practice. Where it is necessary for AEMO to control plant connected to any network, this is done according to protocols agreed between the affected parties.

AEMO recommendation

AEMO recommends that the AEMC reinstate the mirroring between draft clause S5.2.6.1(a) and (c) to cover both remoting monitoring and remote control.

5.3.2 Remote monitoring of battery storage facilities

The AEMC rejected AEMO's recommendation that energy storage systems provide real-time information on the available energy of the storage system because Generators are responsible for their own unit pre-commitment decisions and, in doing so, take into account their own capability to generate[56].

Subject to the requirements in clause 4.9.6 and 4.9.7 of the NER, AEMO acknowledges this principle, however, greater consideration needs to be given to the entire dispatch chain, the consequences of error, each technology's capabilities (and in this case, limitations) and participant responsibilities, notably:

- AEMO must monitor and advise the market about energy reserves. AEMO has experienced occasions when committed energy has been unavailable.
- The signal sought by AEMO will allow AEMO to manage dispatch more effectively and efficiently if an energy storage system is suddenly, or unexpectedly, depleted or charged.
- An energy storage system is a highly complex facility and the provision of a single monitored quantity about the available energy should present little more than a marginal cost, particularly as it would be expected to be already measured and potentially sent back to the battery operator's control facility, while delivering significant benefit to the market.

This is not a request for capacity to be made available. To date, battery energy storage systems have provided this fundamental information to AEMO. The request for these data points is line with global standards; the California Independent System Operator has introduced requirements[57] in this regard to manage the projected and targeted increase of battery energy storage systems in their network.

AEMO strongly supports a technology-neutral approach to the technical performance requirements of generation and, to the extent that this was feasible, the rule change proposal was designed on that basis. As noted by the AEMC, at times there are physical capabilities of plant that are technology specific that must be taken into account. For energy storage systems, where their available energy is highly variable, additional information outside of the market system is vital to ensuring power system security and reliability.

AEMO recommendation

AEMO recommends that the original proposal for information relating to energy storage be retained as was submitted by AEMO in its proposed new clause S5.2.6.1(b)(7), namely, that Generators with energy storage systems be subject to a requirement to provide the systems' available energy (in MWh), if required by AEMO.

5.3.3 Clarification regarding application of this clause

AEMO's proposal for clause S5.2.6.1 included a consolidation of the types of generation to which each of the automatic and minimum access standards applies. The use of a consolidated term was intended to reduce unnecessary text, align more closely with other parts of Schedule 5.2 and recognise the increasing complexity of generating systems with many more hybrid installations comprising a mixture of scheduled, semi-scheduled and non-scheduled generating systems and generating units.

The AEMC has retained the old drafting.

AEMO does not consider it necessary to list each type of generating unit/system. The collapse of the sub-paragraphs into the singular description 'generating system', might not have been adequate as it did not refer to 'generating units', as well, but any other delineation of the type of generation would seem superfluous. It is more efficient if all generation were referred to generically, rather than by classification, as well as in the singular (generating unit) and collectively (generating systems).

[56] AEMC draft determination, p. 99.

[57] California Independent System Operator, available at http://www.caiso.com/Documents/NGR-REMOverview.pdf, slide 35.

Finally, there appears to be a drafting error in draft clause S5.2.6.1(c), as there does not seem to be any technical reason why non-scheduled generating units should not be included. AEMO recommends that the AEMC reconsider this and align the description to ensure all generation is covered, as with AEMO's preferred clause S5.2.6.1(a).

AEMO recommendation

AEMO recommends that all generation be covered by the automatic and minimum access standard. Hence, it is preferable that the generation to which clause S5.2.6.1 applies be drafted using the more efficient, generic description of 'each generating unit and generating system'.

6. Reactive power capability

6.1 Technical summary

AEMO had proposed an amendment to the reactive power capability requirements for generating systems. The existing minimum access standard is, other than for extremely rare cases, insufficient to manage a power system that must adapt to a dispersed and highly variable generation fleet.

The current minimum access standard allows a Connection Applicant to propose no reactive capability. This means that a generating system may be connected to the network with no ability to contribute towards the management of network voltages.

6.2 AEMC draft determination

In its draft determination, the AEMC recognised that the current minimum access standard lacks clarity. Nevertheless, the AEMC considered that there may be circumstances where there is no need for reactive power capability.

The AEMC has determined that it is preferable to rely on voltage (reactive power) control and support services that can be delivered by existing generation and network plant.

Furthermore, because clause S5.2.5.1 is not currently an AEMO advisory matter, AEMO cannot advise on the appropriate level of reactive power capability to support the maintenance of power system security and the AEMC have proposed to address this.

6.3 AEMO's response to draft determination

Generation connections are currently dominated by variable renewable generation connecting to remote and constrained parts of the network.

This type of generation can strongly influence the management of network voltage. Fast and continual changes in power flow can and do affect network voltages and the impact of this must be mitigated – either by generation or other sources via dynamic voltage control or reactive power plant. It cannot be adequately managed with plant typically utilised by networks.

For example, traditionally, on-load transformer tap changers, and switched capacitor and reactor banks have been utilised by NSPs to regulate their distribution network voltages in-line with changing customer demand. Due to the nature of distribution system impedances (highly resistive), fluctuations in active power can significantly impact variations in voltages. With the increasing number of distribution connected generators, the coordination of voltage control has thus become more important due to the increase in fluctuation of active power. This places more importance on the participation of those new generators in voltage control. Furthermore, voltage control becomes increasingly difficult to maintain in the absence of sufficient reactive capability. This is further exacerbated by the predominance of asynchronous generation supplying intermittent and complex, active and reactive power load in the distribution networks.

AEMO does not agree that existing facilities will have the capability to sufficiently manage the voltage control issues introduced by new generation. The reliance on existing generation is only valid when it is operating (i.e. dispatched) and in locations appropriate to manage voltage control issues. Given the vast increase in supply capability delivered by new generation capacity coupled with limited demand growth, it is not practical to expect that all (or at least sufficient levels of) existing generation will be dispatched at all times. Further, reliance on network plant is also limited by its capability, which was designed to support the need at the time when it was installed. The need will have changed significantly as a result of the installation of new generation.

AEMO recognises that the amount of reactive capability required to support adequate voltage management will vary with the characteristics of each generating system and its connection location, but contends that there is rarely a circumstance where no capability is required. If there is no immediately demonstrable need for it, this is likely because the network is receiving it from other plant. As such, rather than a zero minimum as proposed by the AEMC, a more practical approach is to require all plant to deliver reactive capability, unless this capability is not required by AEMO and the NSP.

AEMO therefore proposes a minimum access standard that results in a power factor of 0.99, and would, at a low short-circuit ratio of 3, provide capability to influence voltage by approximately 5%.

6.4 AEMO Recommendation

AEMO recommends that the minimum access standard in clause S5.2.5.1 be as follows:

Minimum access standard

(b) Unless *AEMO* and the *Network Service Provider* agree that a lesser *reactive power* capability is acceptable at the *connection point* of a *generating system*, the *minimum access standard* is a *generating system* operating at any *voltage* at the *connection point* within the limits established under clause S5.1a.4 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 0.143.

Finally, AEMO supports the AEMC's proposal to include reactive power capability as an AEMO advisory matter as it will facilitate agreement on a suitable reactive power capability for newly connecting facilities.

7. Reactive power (voltage) control

7.1 Technical summary

AEMO had proposed an amendment to the voltage control requirements for generating systems to remove ambiguity, to ensure that voltage control capability is delivered by all new generating systems while recognising that there may be some circumstances where a Generator and an NSP may agree that other reactive power control modes could be utilised for normal operations, and to provide a clear negotiating path between the automatic and minimum access standards.

The requirement that all generating systems be capable of delivering voltage control was proposed in recognition of the fact that management of voltage across all parts of the network (from large transmission to small distribution networks) is becoming increasingly complex due to a variety of changing operational circumstances. Unpredictable and highly variable generation and load profiles mean that management of voltage requires greater flexibility than required in the past; reliance on switched capacitor banks and transformer tap changers alone no longer provides sufficient responsiveness.

AEMO considers the existing minimum access standard is insufficient to manage a power system that must adapt to a dispersed and highly variable (intermittent) generation fleet supplying a continually changing demand profile.

7.2 AEMC draft determination

In its draft determination, the AEMC considered that active voltage control capability should not be a requirement for all generation. The AEMC considered that the additional flexibility AEMO had proposed as part of the minimum access standard represented an increase in capability and should more appropriately be included in the automatic access standard.

7.3 AEMO's response to draft determination

7.3.1 Inclusion of additional control modes in automatic access standard

AEMO does not agree that the inclusion of three modes of control capability (voltage, power factor and reactive power) meets the objective of an automatic access standard, which is to represent an acceptable level of performance because there is no adverse impact to power system security no matter where a new connection is being proposed. The provision of voltage control capability from a generating system represents sufficient security, while the alternative modes, which appear to offer greater flexibility to Connection Applicants, do not, in fact, deliver improved power system security outcomes and are not appropriate for the automatic access standard.

The addition of alternative modes of operation are more appropriate in the minimum (and, therefore, negotiated) access standard, where, depending on the proposed connection point, other modes could be acceptable, or required in addition to voltage control.

AEMO recommendation

AEMO remains committed that its original proposal, whereby only voltage control is included in the automatic access standard. AEMO recommends that the AEMC reinstate AEMO's proposal for the automatic access standard, as this represents the acceptable level for maintaining power system security[58].

7.3.2 Removal of requirement for voltage control from minimum access standard

AEMO's ongoing concern is the lack of flexibility designed into generating systems recently connecting to the national grid. The lack of consideration given to a fast-changing operational environment, and foresight on the potential benefits of flexibility have delivered a power system that is increasingly unable to adapt to everyday circumstances. It is imperative that as the NEM continues to evolve, the plant connected to it must adapt with it.

[58] AEMC. Draft Determination, pg. 20

Recent operational experience has demonstrated how sudden changes in supply and demand can impact power system operations. For example, the special licensing conditions for wind generation implemented by ESCOSA since 2010 have required these Generators to have voltage control capability (alongside other forms of reactive power control). Until 2016, most wind farms in South Australia operated under fixed power factor control. Changes in generation and load profiles since then have required more adaptable control to be applied and a number are now normally operating in voltage control mode. Had the capability to switch mode been unavailable, voltage management across the South Australian transmission network would be substantially more complex and meeting system standards during particular operational scenarios very challenging, potentially breaching operating limits.

AEMO recommendation

AEMO reiterates that the voltage control mode should be included as a minimum capability from all generating systems, where reactive capability is required under clause S5.2.5.1. AEMO acknowledges that there may be circumstances[59] where other control modes are acceptable in the right circumstances and accepts that provision to operate in those modes be included. Further, in addition to AEMO's original proposal that such modes be accepted only for embedded generation, they might also be applied to sub-transmission-connected plant, provided there is always the capability to revert to voltage control mode.

Any transmission-connected generating system must operate in voltage control mode and be able to have its set point adjusted to ensure coordination of voltage and reactive plant across the network. Any switching between modes must only ever take place in accordance with operational guidelines agreed with the NSP and the Generator, and AEMO strongly supports this approach.

7.3.3 Specification of accuracy of control for alternative control modes

AEMO notes that a specification for control characteristics consistent with those applied to voltage control has been included with respect to the alternative power factor and reactive power control modes and strongly supports this additional clarity.

In relation to power factor control in particular, given that power factor is not a linear relationship between active and reactive power, specification of accuracy is more appropriately made with respect to the required reactive power to meet the power factor obligation.

AEMO recommendation

AEMO recommends that an alternative specification of accuracy requirements for power factor control mode be included. The required accuracy should be such that it applies to the reactive power quantity required to achieve the power factor set point.

[59] Such as a small generating unit connected in a low voltage network, or a relatively small sized generator connected to a transmission network

8. Reactive current response during disturbances

8.1 Technical summary

AEMO proposed amending the automatic access standard and minimum access standard in clause S5.2.5.5 to specify that reactive current injection is required from all generating systems during disturbances. The need for this was driven by the observed behaviour of a range of asynchronous generating systems that could lead to detrimental impacts to power system security. This proposal was accompanied by a proposed amendment to the active power recovery criteria (addressed in sections 9.1-9.4).

AEMO proposed a revision to the way reactive current injection during and subsequent to disturbances was specified to relate more practically to the manner in which asynchronous generating systems respond to disturbances. The proposal was intended to apply to all generating systems, with the primary objective being to ensure that generating systems act to support the power system by withstanding and recovering from disturbances.

AEMO's proposal also included minimum access standard requirements to facilitate more transparent negotiations where a negotiated access standard was proposed by a Connection Applicant.

8.2 AEMC draft determination

In its draft determination, the AEMC considered that the technological differences between synchronous and asynchronous generation necessitated specifying separate requirements for each type of technology and that a minimum access standard was not required for synchronous generation.

Further, the AEMC determined that for asynchronous generation, it was necessary to specify activation thresholds for reactive current injection (or activation of fault ride-through mode of plant) and that the default reference point for measuring the response of asynchronous generation would be the plant terminals rather than the connection point.

8.3 AEMO's response to draft determination

AEMO's objective in proposing amendments to clause S5.2.5.5 was to ensure that generating systems are designed and operated to withstand and recover from certain disturbances. The criteria set to achieve this relate to provision of reactive current during disturbances, and to the control of active power and reactive power following disturbances, to achieve voltage recovery.

8.3.1 Technological neutrality

AEMO recognises that the manner in which both synchronous and asynchronous generation respond to disturbances is different – one is a 'natural' response based on physics and plant design, the other is a controlled (or programmed) response that can be precisely managed (within the rating of the plant and the limitations of measurement systems). While the way each type of response is delivered is different, the desired outcome is the same; network voltage is supported during disturbances and managed post-disturbance. For this reason, AEMO considers that there is little merit in segregating the requirements for synchronous and asynchronous generation to the extent proposed by the AEMC.

However, the AEMC has determined that there is no need to amend the minimum access standard for synchronous generation on the basis that it is expected to inherently deliver the required performance. AEMO contends that this does not sufficiently recognise the consequences of the lack of a clear specification of performance outcomes. As plants need to compete in a technologically neutral market, even synchronous technologies will offer fewer of the previously delivered 'inherent' and 'assumed' characteristics that are being lost from the power system. Therefore, it is no longer sufficient to assume that the capability delivered in the past will be maintained or delivered in the future, and it is imperative that the technical requirements specify the required performance outcomes, regardless of whether these are inherent to plant performance. Further, if a detrimental impact on the power system is caused by a generator, the absence of a minimum access standard means that there is no opportunity for recourse.

8.3.2 AEMO recommendation (technological neutrality)

The AEMC has specified requirements for reactive current injection and active power recovery in the automatic access standard, but there are no equivalent requirements in the minimum access standard for synchronous generation. If this is accepted, Connection Applicants will give little consideration to meeting an appropriate negotiated level of performance where the automatic access standard cannot be met.

AEMO considers this to be a material issue and posits that it is essential that the NER include these matters in the consideration of an appropriate negotiated access standard. The different approach in each of the automatic and minimum access standards implies that the performance capability is required of one type of generation but not the other. In AEMO's view, this is not correct; all generation technology must deliver reactive current injection and active power recovery to a level necessary to support power system security.

8.3.3 Reactive current injection

The AEMC is concerned that a reactive current injection response requirement on synchronous generation (which is potentially less able to alter its inherent response), when compared to the capability to deliver a more controllable response from asynchronous generation, will create a barrier to entry for synchronous generation.

AEMO considers that the AEMC's objective can be achieved by ensuring that the required response is specified to be "at least" in place of an absolutely precise response.

8.3.4 AEMO recommendation (reactive current injection)

AEMO has reviewed the capability of a range of connected generating systems to confirm whether the proposed requirements could be achieved and did not identify any limitation that would prevent them from being able to meet such a standard. AEMO considers that an appropriately structured technical requirement would not present a barrier to entry to generation that does not present a power system security risk.

For all generation, the required response should be specified such that performance exceeds a certain threshold. The use of the term "at least" (similar to the terminology presently used in the automatic access standard) would enable the performance requirements for both synchronous and asynchronous generation to be specified in the same manner.

8.3.5 Appropriate reference point for performance requirements

The performance standards derived from the Schedule 5.2 technical requirements also form the basis of the agreed technical performance of a generating system as described in a connection agreement[60]. A connection agreement governs the contractual relationship between a Generator and an NSP and covers the technical issues arising from the interface between the Generator's facilities and the NSP's at the connection point. The Generator is responsible for the design and operation of all plant behind the connection point, while the NSP is responsible for the planning, design and operation of all plant external to the generating system. One of the matters that concerns the NSP is the coordination of the performance of a range of connected facilities so that the Generator's facilities have no adverse impact on other facilities. It is, therefore, appropriate that the manner in which compliance with the technical requirements are measured is at the connection point.

By assessing performance at a connection point, the combined performance of all plant within a generating system, including auxiliary equipment such as reactive support devices, can be integrated. Assessing performance at discrete points within the generating system introduces unnecessary complexity in coordinating performance and assessing compliance.

In proposing more comprehensive requirements for reactive current injection during disturbances, AEMO recognises the functionality generally used by asynchronous generating systems today whereby under normal operations, a multitude of individual generating units (inverters or wind turbines) are managed by a central plant controller, but to expedite their response during disturbances, individual generating units resume individual control upon detection of a disturbance above a specified threshold to initiate fault ride-through mode. Some auxiliary reactive support devices operate in a similar manner.

AEMO, therefore, proposed an allowance that, where necessary, the reactive current performance could be specified at the generating unit level. This was intended to facilitate the use of current technology, while recognising that performance should still be assessed at the connection point and would facilitate more accurate modelling of the reticulation system of aggregated plant.

To do so also provides an avenue for innovation and improvement over time as plant and control systems mature and are upgraded to suit international requirements. AEMO considers that the way the draft rule is proposed is based largely on current control system implementation and has the potential to inhibit plant development.

[60] See clause 5.3.4A(i) and Schedule 5.6, for example.

8.3.6 AEMO recommendation (appropriate reference point for performance requirements)

AEMO recommends that the rule be based on the desired outcome rather than a description of current design. Such an approach enables future developments to accommodate the preferred outcome while allowing current technology to continue to be acceptable.

AEMO recommends that the preferred reference point for assessing generating system responses to disturbances remains the connection point, with appropriate allowance to use generating unit terminals as a reference point where necessary.

8.3.7 Activation thresholds

The AEMC draft determination has nominated a precise activation threshold for asynchronous generating systems to enter a fault ride-through mode intended to deliver the required reactive current injection appropriate for under- and over-voltage situations.

This activation threshold provides a precise reference point for accurately specifying the required reactive current injection rate for a certain disturbance.

This level of prescription is based on the known functionality of currently available asynchronous generating units. Ongoing development is already surpassing this approach with generating systems adopting 'smarter' contingency detection methods that consider both static voltage thresholds as well as step changes in voltage.

8.3.8 AEMO recommendation (activation thresholds)

The AEMC's approach will prevent evolving generating system technology from being utilised in the NEM, which is not an efficient outcome. The description of the required technical performance should be outcome-focussed so that technological developments can be accommodated without the need for further rule changes.

This approach can be supported by the recommendations made in section 8.3.2 whereby a less precise reactive injection specification is made via the use of the term "at least".

Further, the general requirement in clause S5.2.5.5 is necessary, such that performance under the reactive injection requirement is assessed only for contingencies of sufficient magnitude to require additional reactive current support. This might be for contingencies where there is a voltage disturbance that causes voltage at the connection point to drop to less than 80% or less, or to increase to more than 115%, of normal voltage. A Generator can then determine the appropriate activation thresholds to apply to its plant to meet these requirements. In some cases, asynchronous generators provide continuous control and the rules should not restrict this.

AEMO notes that this requirement assumes that prior to activation of any fault ride-through mode, appropriate voltage control is maintained to offer the relevant support to any voltage disturbance.

9. Continuous uninterrupted operation

9.1 Technical summary

AEMO proposed a range of amendments that the AEMC has considered under the broad umbrella of 'continuous uninterrupted operation'. The proposed amendments relate to the definition of 'continuous uninterrupted operation' together with the requirements related to frequency disturbances, voltage disturbances and load rejection events and the active power recovery response of a generating system following contingency events.

9.2 AEMC draft determination

In its draft determination, the AEMC has generally supported AEMO's proposals. The main difference is the lack of specification for a minimum access standard on active power recovery for synchronous generating systems.

9.3 AEMO's response to draft determination (active power recovery)

Active power recovery by any plant – be it synchronous or asynchronous – is fundamental to the power system's ability to withstand a disturbance. Failure to recover active power can result in a range of detrimental local and global impacts on the power system and can be a precursor to voltage collapse – if local power supply does not recover, increased power transfer into a region can further suppress local voltages. Lack of local voltage recovery can lead to wider impacts if such a voltage depression propagates. Equally, lack of power recovery can result in under-frequency operation and further disconnection of generation due to under-frequency protection tripping.

The AEMC has determined that, as active power recovery by a synchronous generating system is a function of its inherent design, it is not necessary or appropriate to specify minimum performance requirements for synchronous generation. The lack of a minimum access standard in clause S5.2.5.5 has hindered efficient negotiations in respect of both reactive current injection and active power recovery for generation that could not meet the automatic access standard. In its proposed amendments to the minimum access standard, AEMO sought to resolve this issue by nominating a standard that could reasonably be achieved and proposed it as the minimum acceptable level of performance. AEMO considers it reasonable that all generating systems contribute to the efficient recovery of the power system from disturbances; for each generating system that offers no support, additional support must be sourced from other connected generating systems.

9.4 AEMO recommendation (active power recovery)

AEMO recommends that the active power recovery requirements imposed on asynchronous generating systems be applied to synchronous generating systems in the minimum access standard.

9.5 AEMO's response to draft determination (multiple voltage disturbance)

AEMO supports the AEMC's draft determination with respect to multiple disturbance capability for new generation.

9.5.1 Measuring disturbances

AEMO refers to its report entitled *Updated proposed multiple fault withstand obligation*[61] that deals with a number of scenarios to demonstrate how compliance may be assessed, and how the proposed criteria leave scope for ensuring that a generating system can apply appropriate protection systems to protect its integrity. AEMO considers that the supporting criteria relating to total fault duration and minimum time during disturbances offer sufficient flexibility to accommodate the needs of generating systems in general, and synchronous generation, in particular.

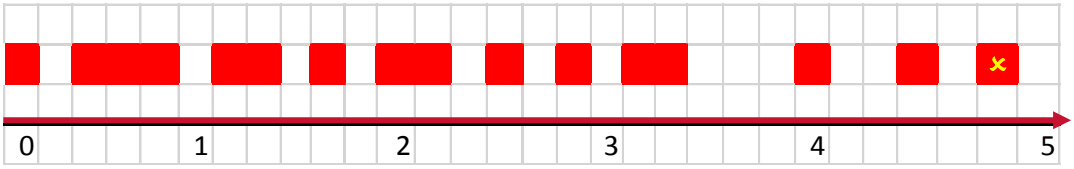
[61] Available at: https://www.aemc.gov.au/rule-changes/generator-technical-performance-standards

In regards to how 'up to 15 disturbances within any five minute period' in proposed clause S5.2.5.5(b)(1A), and 'up to six disturbances within any five minute period' in proposed clause S5.2.5.5(c)(1A), are to be measured, AEMO will update the *Guidelines for Assessment of Generator Proposed Performance Standards*[62] to reflect the assessment methodology in the *Updated proposed multiple fault withstand obligation* report. In its assessment of whether this requirement can be met, AEMO would expect to assess several representative event sequences, rather than all possible scenarios ad infinitum.

9.5.2 AEMO recommendation (measuring disturbances)

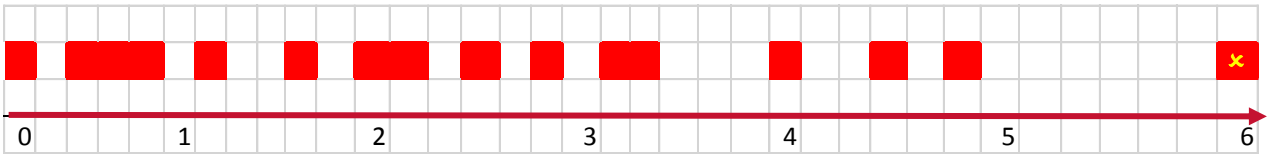
AEMO considers that, as an improvement to the drafting, the AEMC consider including examples of how these requirements should be interpreted.

For example, in the case of the automatic access standard proposed in clause S5.2.5.5(b)(1A), the figure below illustrates that if the first disturbance occurs at t = 0, the standard will be met if, within the next 5 minutes, the generating system can ride through 15 disturbances, represented by the red dots (the sixteenth with the yellow 'x' representing disconnection).



Time (min) not to scale

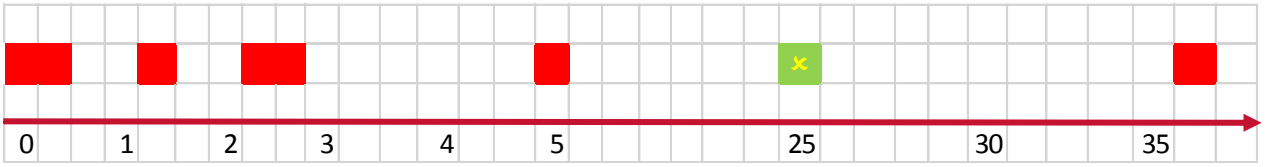
If another generating system displayed the following performance, by riding through the fifteenth disturbance just before the 5-minute mark, and disconnected exactly one minute later in response to another disturbance, the automatic access standard would not be met because the five minutes would be measured from the t=1 minute, as shown in the figure below.



Time (min) not to scale

In the case of the minimum access standard requirement that a generating system and each of its generating units withstand 'up to six disturbances within any five minute period' in proposed clause S5.2.5.5(c)(1A), there is a further condition, namely, that there is a 'minimum of 30 minutes where no disturbances occur following a five minute period of multiple disturbances'. AEMO interprets this as meaning that there is no rolling 5-minute period for counting disturbances as there is with the automatic access standard.

If the disturbances illustrated in the figure below were to occur, to meet the minimum access standard, a generating system would be required to ride through the six disturbances up to the 5-minute mark. The 30-minute grace period would then commence after the 5-minute mark, which means that the generating system would not breach the minimum access standard if it were to trip at the 25th minute mark.



Time (min) not to scale

[62] Available at: https://www.aemo.com.au/-/media/Files/PDF/guidelines_for_assessment_of_generator_proposed_performance_standards.pdf.

10. System strength

10.1 Technical summary

To ensure that new generation has the capability to maintain stable operation in the face of eroding system strength, AEMO had proposed a new technical requirement that generating systems operate stably under certain network conditions – namely with a short circuit ratio of 3.0 measured at the connection point.

10.2 AEMC draft determination

The AEMC noted that the *Managing power system fault levels* rule (Fault Levels Rule) was recently implemented to address the declining levels of system strength in the NEM[63]. With this new framework in place, the AEMC requires clear evidence that the Fault Levels Rule will not address the "security issues raised by AEMO" in the rule change proposal[64].

In the absence of such evidence, the AEMC determined there is currently no identifiable security need to implement AEMO's recommendation.[65]

10.3 AEMO's response to draft determination

As outlined in AEMO's rule change proposal[66], a system strength standard was not developed as a system security measure, but as a complementary measure to the Fault Levels Rule as a quality of supply (resilience) and cost efficiency measure in the long-term interests of consumers.

While the AEMC considers there is insufficient evidence that there is a clear need for such an access standard, AEMO considers that the absence of such an access standard gives rise to a free-rider problem. This is an example where the absence of a need for a specified capability at a specific connection point is it is being provide by other generating systems that are electrically close to the proposed generating system.

10.4 AEMO recommendation

AEMO recommends the AEMC reconsider AEMO's suggested minimum system strength access standard as part of work underway to co-ordinate transmission and generation investment. We anticipate that definition of capability will lay a foundation for future standards relating to generator performance in low system strength conditions.

AEMO notes there is a need for Generators, NSPs and AEMO to include information within a connection agreement relating to the applicable minimum and maximum short circuit ratio at a connection point for which the plant has been designed to meet its performance standards. Further information relating to any improved capability limits that might be achieved from retuning would also deliver benefits in ensuring that in situations where a system strength impact has been identified, the option of retuning plant to mitigate this impact can be considered alongside other options in seeking to access the most efficient outcome.

[63] AEMC. Draft Determination p 252.

[64] AEMC. Draft Determination p 252.

[65] AEMC. Draft Determination p 254.

[66] AEMO. Rule change proposal, p 39.

11. Further minor amendment

11.1 Background

The level of new generating system connection enquiries continues to outpace AEMO's expectations, even since AEMO lodged its rule change proposal in August 2017.

AEMO has limited visibility of proposed new generating systems at the 'enquiry' stage. It is formally notified of proposed new connections after they reach the 'application' stage. For example, Powerlink has publicly stated that as at May 2018, it had received more than 150 connection enquiries and applications, representing more than 30GW of new generation[67]. AEMO, however, is only formally aware of a much smaller amount of proposed new capacity because it has only been informed of connection applications only.

11.2 Visibility of new connections

Given the volume of connection enquiries and AEMO's responsibilities for broader network and integrated system planning, it is necessary that AEMO be formally notified by NSPs of proposed new connections at the 'enquiry' stage.

AEMO is experiencing occasions where new plant has commenced development during the connection enquiry stage, before AEMO has been notified of the project. An understanding of the scope of connection-related interest in a particular part of the network will provide greater clarity in assessing connection applications and will inform the setting of appropriate performance standards. Such an understanding is consistent with AEMO's existing information requirements to meet its security and reliability obligations and, therefore, promotes the NEO.

This information will also support AEMO's proposed development of a map of network capacity/capability. AEMO is aware Connection Applicants have little insight into proposed neighbouring connections and the aggregated information will help them, NSPs and governments to make more informed decisions.

11.3 AEMO recommendation

AEMO submits that this recommendation gives rise to a minor notification obligation that can be achieved by providing AEMO with a copy of each completed connection enquiry form received by each NSP with the only pre-requisite being that it meet the requirements of Schedule 5.4.

AEMO recommends that this notification occurs within 10 business days of a connection enquiry being received by the NSP. Preliminary discussions with some NSPs suggest that they have no objections to this new process.

A proposed draft provision addressing this recommendation is included in AEMO's recommended changes to the AEMC's draft rule.

[67] Powerlink. 2018. *Renewables flow for Queensland*. Available at: https://www.powerlink.com.au/news-media/renewables-flow-queensland.

Glossary

This document uses many terms that have meanings defined in the National Electricity Rules (NER). The NER meanings are adopted unless otherwise specified.

Term	Definition
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AGC	As defined in the NER.
Connection Applicant	As defined in the NER.
DNSP	Distribution Network Service Provider
Fault Levels Rule	National Electricity Amendment (Managing power system fault levels) Rule 2017 No. 10
FCAS	Frequency Control Ancillary Services
Generator	A person who owns/operates a generating system and is registered as such by AEMO under the NER.
GPS	Generator Performance Standards
GW	gigawatt
HV	High voltage
LV	Low voltage
Market Customer	A type of Registered Participant, generally made up of electricity retailers.
MW	megawatt
NECA	National Electricity Code Administrator
NEL	National Electricity Law
NEM	National Electricity Market, as defined in the NER.
NEO	National electricity objective, as defined in section 7 of the *National Electricity Law*.
NER	National Electricity Rules
Network User	A person who uses an electricity network. As defined in the NER.
non-scheduled generation	Generation by a generating unit that has been classified as a non-scheduled generating unit in accordance with Chapter 2 of the NER.
Non-Scheduled Generator	A Generator who owns/operates non-scheduled generation.
NSP	Network Service Provider
Registered Participant	As defined in the NER.
SCADA	Supervisory Control and Data Acquisition

scheduled generation	Generation by a generating unit that has been classified as a scheduled generating unit in accordance with Chapter 2 of the NER
Scheduled Generator	A Generator who owns/operates scheduled generation.
semi-scheduled generation	Generation by a generating unit that has been classified as a semi-scheduled generating unit in accordance with Chapter 2 of the NER.
Semi-Scheduled Generator	A Generator who owns/operates semi-scheduled generation.
SCR	Short circuit ratio
TNSP	Transmission Network Service Provider