Australian Energy Market Commission

RULE CHANGE

DRAFT RULE DETERMINATION

National Electricity Amendment (Managing power system fault levels) Rule 2017

Rule Proponent(s)

South Australian Minister for Mineral Resources and Energy

27 June 2017

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About the AEMC

The AEMC reports to the Council of Australian Governments (COAG) through the COAG Energy Council. We have two functions. We make and amend the national electricity, gas and energy retail rules and conduct independent reviews for the COAG Energy Council.

Summary

The Australian Energy Market Commission (AEMC or Commission) has made a draft rule and draft determination to allocate responsibility for managing power system fault levels, also known as system strength, in the National Electricity Market (NEM).

The draft rule:

- provides an enhanced framework that requires network service providers (NSPs) to maintain the system strength at generating system[1] connection points above an agreed minimum level under a defined range of conditions
- introduces a requirement on new connecting generators to 'do no harm' to the minimum level of system strength being provided to any nearby generating system connection points
- includes a transitional process for existing generators, the relevant NSPs and the Australian Energy Market Operator (AEMO) to agree the level of system strength that the relevant NSP will be obligated to maintain at the relevant connection points in its network, on an ongoing basis.

The draft rule amends the National Electricity Rules (NER) to accommodate issues associated with reducing system strength. It does so by allocating responsibility for maintaining system strength in a manner that maintains system security, while providing appropriate incentives and efficiently allocating risk to the extent possible.

What is system strength?

System strength is a characteristic of an electrical power system that relates to the size of the change in voltage for a change to the load or generation at a connection point. When the system strength is high at a connection point the voltage changes very little for a change in the loading. However, when the system strength is lower the voltage would vary more with the same change in loading.

The system strength for a particular generating system can be referred to as the short circuit ratio, which is the ratio of the system strength in MVA to the capacity of the generating unit in MW.

Reducing system strength in the NEM

Historically, high fault levels (or a system that is 'too strong') have been the main concern regarding fault levels. However, falling system strength is now an emerging issue. System strength in some parts of the power system has been decreasing as traditional synchronous generators are operating less or being decommissioned. In addition, the short circuit ratio at some generating system connection points is falling as greater numbers of non-synchronous generators connect to the network.

1 Where this document refers to generators or generating systems, this is also a reference to market network service providers and market network service facilities.

Reduced system strength in a part of the power system can mean that the short circuit ratios at generating systems' connection points may be lower than required for the associated generators to be able to meet their performance standards. This introduces a risk that the generating systems may not remain connected to the power system following a major contingency in the power system, introducing the risk of a cascading outage and a major supply disruption (or widespread blackouts).

Managing reduced system strength

In developing the draft rule, the Commission has considered which party would be best placed to manage system strength such that generators are able to continue to meet their performance standards.

Existing generators could potentially address system strength at their connection point if they are connected to a part of the network with low system strength by installing a synchronous condenser or other dynamic reactive plant. However, existing generators have little capability to anticipate and address any further reductions in system strength. In addition, if there are multiple generating systems in an affected part of the network, one generator's investment in equipment would benefit other generators, who could "free ride" when the system strength constraint is relaxed. This is likely to lead to inefficient levels of investment in synchronous condensers and their inefficient use.

In contrast, NSPs are able to consider a range of issues associated with low system strength and are well placed to develop solutions that best address multiple system strength issues. Indeed, the existing NER makes NSPs responsible for the functioning of protection systems and the management of network voltages; both of which become more difficult as system strength reduces.

The Commission considers that NSPs are the best party to allocate the responsibility to maintain system strength such that generators are able to meet their performance standards. NSPs have a holistic perspective of their networks and are best placed to manage the risks associated with this obligation. Having system strength maintained by NSPs is likely to result in more efficient investment decisions that reduce costs for consumers.

Obligation on NSPs to maintain system strength

The draft rule requires a NSP[2] to plan and operate its network to maintain the short circuit ratio at the connection point for each generating system connected to its network to a level that is above the generating system's minimum short circuit ratio requirement. This would be under normal operating conditions including following a credible contingency[3] or protected event.[4] In addition, the NSP would be required to

2 AEMO, as the party responsible for planning network augmentation in Victoria, is allocated the responsibility for planning and operating its network such that the short circuit ratio at generator connection points on the declared shared network are at least equal to the registered short circuit ratio for those connection points.

3 A credible contingency is an event that AEMO considers is reasonably possible.

maintain the short circuit ratio at the connection points for each market network service facility[5] to a level that is above the facility's minimum short circuit ratio requirement. This obligation is technology neutral and requires the NSP to use existing planning and regulatory arrangements when acquiring or providing these services, while building on the existing arrangements for generators to meet their registered performance standards.

The draft rule applies to both transmission network service providers and distribution network service providers.

Under the draft rule, this minimum short circuit ratio requirement for each generating system and market network service facility would be agreed by the generator or market network service provider, the relevant NSP and AEMO through the connection process, and would be registered with AEMO.

Obligation on new connecting generators to 'do no harm'

The draft rule introduces a requirement on new connecting generators to 'do no harm' to the minimum level of system strength being provided to existing generators at their connection points. When negotiating its connection with the NSP, the new generator would have to agree with the NSP and AEMO:

- the minimum short circuit ratio to be provided by the NSP, which would be registered with AEMO at the end of the connection process
- the extent to which the new connecting generator impacts on the minimum short circuit ratios being provided to existing generators.

The new connecting generator would be required to fund the costs associated with the provision of any required system strength services to address the impact on the affected short circuit ratios of other generators. This would incentivise new connecting generators to be able to operate with low short circuit ratios, and connect to the network where there is sufficient system strength.

This obligation on new connecting generators only applies at the time the connection is negotiated, based on the information available at that time. After this has been established, it would be incorporated into the connection agreement between the generator and the NSP. The NSP would then be responsible for maintaining system strength on an ongoing basis.

New responsibilities for AEMO

AEMO would continue to be responsible for maintaining system security, including taking actions where necessary to maintain system security when fault levels are low due to unplanned outages of synchronous generating units or network elements.

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4 A protected event is a non-credible contingency that, following a declaration by the Reliability Panel, must be managed in a similar manner to credible contingencies.

5 The Basslink interconnector between Tasmania and Victoria is the only market network service facility currently in the NEM.

Therefore, the draft rule includes a requirement on AEMO to identify locations in the network where system strength is below, or likely to be below, the registered minimum short circuit levels. This requirement is a clarification of AEMO's existing role in monitoring and managing system security and is consistent with the current NER obligation for AEMO to monitor and manage high fault levels in the power system.

The draft rule also requires AEMO to develop and maintain short circuit ratio calculation guidelines that NSPs are required to follow when assessing their compliance with their obligations to maintain the system strength and when assessing the potential impacts of new connections on the short circuit ratios being provided to existing generating systems. The guidelines will provide greater certainty and consistency when the NSPs implement their obligation to maintain the short circuit ratios in their networks.

Transitional arrangements

The draft rule contains two transitional arrangements. Firstly, a process is established for each existing generator, the relevant NSP and AEMO to agree the minimum short circuit requirements of existing generating systems, and to register these with AEMO. This will enable the NSPs to then be able to perform its obligation of maintaining the necessary system strength. The agreed minimum short circuit ratios would be required to be registered with AEMO by 1 July 2018 which is when the NSP's obligations commence.

In addition, the draft rule contains interim short circuit ratio calculation guidelines that would apply until AEMO exercises its power to develop the guidelines. Interim guidelines are necessary so that the process of registering minimum short circuit ratios can be completed before 1 July 2018.

Reasons for making the draft rule

Having regard to the issues raised in the rule change request and during consultation, the Commission is satisfied that the draft rule will, or is likely to, contribute to the achievement of the National Electricity Objective (NEO) for the following reasons:

- Clearly allocating responsibility for maintaining system strength to NSPs allows the provision and maintenance of system strength to be coordinated throughout each network which is likely to support the long run efficient operation, use and investment in electricity services.
- Requiring new connecting generators to 'do no harm' to the operation of existing generators puts an incentive on them to connect to the NEM in a location where there is either sufficient system strength, or to fund remedial actions where it is efficient to do so.
- Requiring AEMO to develop guidelines for the calculation of a weighted short circuit ratio would also provide generators and NSPs with greater clarity and consistency of treatment regarding the process for determining short circuit ratios.

- Placing an obligation on AEMO to monitor and report on system strength would provide market participants with greater information relating to system strength throughout the network, which is likely to lead to more efficient operational and investment decisions.

Consultation

We invite stakeholders to provide submissions on this draft determination, which we will consider before making a final determination in September 2017.

Stakeholders wishing to meet with the AEMC should contact Julian Eggleston at 02 8296 7820 or Julian.Eggleston@aemc.gov.au. Submissions close on 8 August 2017.

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1 South Australian Government's rule change request

1.1 The rule change request

On 12 July 2016, the South Australian Minister for Mineral Resources and Energy (proponent) made a request to the Australian Energy Market Commission (AEMC or Commission) to make a rule regarding power system fault levels (rule change request).

The rule change request proposes to amend the National Electricity Rules (NER) to address issues associated with low fault levels arising from reduced levels of synchronous generation in the National Electricity Market (NEM). A reduction in fault current (the level of fault current is referred to as system strength) in certain areas on the network may result in generators being unable to meet performance standards and remain connected to the system at certain times.[6]

The rule change request did not include a proposed rule.

1.1.1 Approach to the draft determination

This draft determination and accompanying draft rule has been made in response to the rule change request and accompanies the Commission's final report on the *System security market frameworks review*.[7]

In making its assessment of the issues raised in this rule change request, the Commission has drawn upon work by the Australian Energy Market Operator (AEMO) as part of its *Future power system security program* (FPSS), initiated in December 2015.

AEMO has identified and prioritised the current and potential future challenges to maintaining system security. These challenges all stem from the transition to greater levels of non-synchronous generation in the NEM.

This draft determination specifically addresses issues relating to the operation of equipment in the power system with reduced system strength.

The draft rule implements the principal components the proposals relating to system strength that were set out in the directions paper on the *System security market frameworks review* that was published on 23 March 2017. The specific measures include:

6 Minister for Mineral Resources and Energy (South Australia), *Rule change request – Low fault levels*: Attachment D, 12 July 2016, p. 1.

7 The Commission has published a final report on the *System security market frameworks review*. This is available at http://www.aemc.gov.au/Markets-Reviews-Advice/System-Security-Market-Frameworks-Review

- an obligation on network service providers (NSPs) to maintain a level of system strength such that connected generators are capable of meeting their performance standards

- the requirement for new connecting generators to 'do no harm' to existing connected generators in terms of system strength.

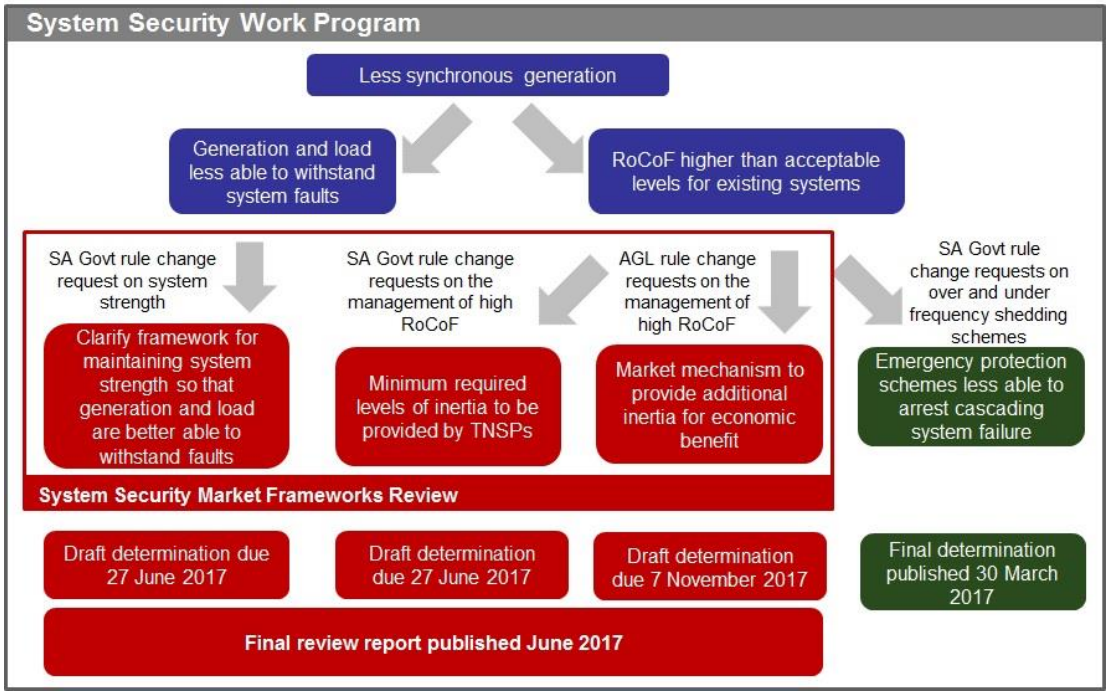
1.1.2 The System security market frameworks review

The AEMC initiated the *System security market frameworks review* on 14 July 2016 to consider changes to regulatory and market frameworks to complement the shift to non-synchronous forms of generation in the NEM.

The AEMC's system security work program comprises the *System security market frameworks review* and five related rule change requests received on system security matters. These rule change requests have been progressed concurrently and in coordination with the AEMC's review. Four of these rule changes requests were submitted by the South Australian Government, with the fifth submitted by AGL.

Figure 1.1 shows the relationship between the issues being considered under the system security work program and how these issues relate to the *System security market frameworks review* and the related rule change requests.

Figure 1.1 AEMC system security work program



The Commission initiated the *System security market frameworks review* as a vehicle to coordinate the assessment of these inter-related issues and develop appropriate recommendations for future policy changes.

At the same time as publishing this draft determination and draft rule, the Commission has also published a draft determination and draft rule on the South Australian Government's rule change request on managing rate of change of power system frequency. The draft rule introduces:

- an obligation on transmission network service providers (TNSPs) to procure, and make continuously available, minimum required levels of inertia to maintain the system in a secure operating state
- an ability for TNSPs to contract with third-party providers of alternative frequency control services, including fast frequency response (FFR) services, as a means of meeting the obligation to provide the minimum required levels of inertia.

The South Australian Government's rule change requests regarding over and under-frequency shedding schemes were progressed separately to the review and the other three rule change requests. A final determination and final rule on these rule change requests was published on 30 March 2017.

The final rule addressed some of the more immediate concerns in relation to the governance and operation of emergency protection schemes, particularly as they apply to managing the impact of a sudden separation of South Australia from the rest of the NEM.

Concurrent with the publication of this this draft determination and draft rule, the Commission published the final report of the *System security market frameworks review*. The final report makes a number of recommendations regarding the regulatory frameworks established in the NER that affect system security, in particular, the management of frequency and of system strength in a power system with reduced levels of synchronous generation.

1.2 What is system strength?

System strength is an inherent characteristic of an alternating current power system. It refers to the relative change in voltage for a change in load or generation. When system strength is high, the voltage will change less for a change in load (or generation) than it would if the system strength was low.

Box 1.1 Spider webs

The strength of a power system can be likened to the strength of spider webs. Consider two spider webs; one strong and one weak.

In the strong web, when some pressure is applied, the web will have limited flex and will hold its shape. In the weak web, the web will flex more and will hold less of its shape under the same pressure.

Similarly, in a strong power system a change in loading (generation or load) at

any point will result in a relatively small change in voltage. In a weak system, the change in voltage will be much more pronounced for the same change in loading.

We can also relate equipment that requires a level of system strength (such as non-synchronous generators) to insects held in a web.

A spider will build its web to accommodate the number of insects it expects to catch. A stronger web will be able to accommodate a larger number of insects than a weaker web of the same size. As the number of insects in a strong web increases, so does the strain placed on the web. This effectively makes the web weaker.

For both webs there will be a limit to the number of insects it can hold without breaking. When the web is at this limit, if another insect is caught it may break part of, or the entire web and cause multiple insects to fall from the web.

This problem is amplified if all the insects are located close together. If the insects caught in the web were evenly spread across the web, the strength of the web would spread between them.

If all of the insects in the web were located in one corner, they would have to share the strength in that corner of the web and this would place greater strain on the web itself.

In a power system, certain equipment, including generators, needs a level of system strength to operate properly. This equipment may experience issues with system strength if:

- the entire power system has insufficient system strength
- the equipment is located close to other sensitive equipment and is required to share system strength.

1.2.1 How is system strength expressed?

System strength is commonly referred to as the fault level. This is because the current that flows into a fault[8] is larger in a system with higher system strength. More commonly, the system strength at a connection point is measured as the product of the fault current and the nominal voltage. This is measured in megavolt amps (MVA). The system strength for a particular generating unit or inverter system can be referred to as the short circuit ratio,[9] which is that ratio of the system strength in MVA, and the capacity of the generating unit or inverter in MW.[10]

8 Faults in a power system are a short circuit between the conductors. This can occur between the conductors on a transmission or distribution line when they are struck by lightning or exposed to bush fires, or when an insulator is damaged. Faults can also occur within items of electrical plant such as transformers or generating systems when the plant is damaged.

9 Short circuit ratio is an established term that has been used when assessing the potential for the interactions between high voltage DC links and AC power systems. An example is J. Arrillaga

1.2.2 What affects system strength?

The system strength at any point in the network depends on the surrounding network. The system strength will be higher when:

- there are a number of synchronous generating units[11] connected nearby
- that point in the network is connected to these generating units with more transmission and/or distribution lines.

Non-synchronous generators[12] do not contribute to system strength as much as synchronous generating units, if at all. However, some modern inverter-based generation can provide a limited contribution to system strength.[13] It is possible that future inverter based generation will be able to make a greater contribution to the system strength.

1.2.3 Faults in the power system

In a power system, a fault is an abnormal condition. The most common type of fault is a short-circuit fault. This is when a conductor makes contact with the ground or another line. A short circuit fault can result from conditions such as lightning or bush fires. Faults can also occur within items of electrical plant such as transformers or capacitor banks when the plant is damaged.

When a fault occurs, the voltage around the fault will fall and the current flowing into the fault will increase.

It is important that the item of plant where the fault is located is isolated from the remainder of the power system. This is often referred to as clearing the fault. Clearing faults in a timely manner is essential so that:

- damage to equipment is limited
- safety is maintained
- the remainder of the power system can continue to operate.

"High Voltage Direct Current Transmission", The Institution of Electrical Engineers 1983. More recently, short circuit ratio has been used in studies of wind farms connecting to weak AC networks. An example is "Connection of wind farms to weak AC networks", CIGRE Working Group B4.62, December 2016.

10 A 200 MW generating unit at a connection point with a system strength of 1000 MVA would have a short circuit ratio of 5. This is derived from 1000MVA / 200MW.

11 Synchronous generators are large spinning units that have turbines that spin at the same speed as the frequency of the power system.

12 Generators that are not synchronised to the system frequency, typically wind turbines and PV cells

13 As noted in S & C Electric's submission to the direction paper, batteries and modern inverters can contribute to fault current. S & C Electric, submission to directions paper, p. 3.

There are protection systems in the transmission network that locate and clear faults. When protection systems detect a fault, usually due to a sudden increase in current flow, the system will open circuit breakers to isolate the fault.

The speed at which the faults are cleared is critical to both maintain safety and limit the risk of damage, as well as the continuation of the operation of the power system. The maximum allowable fault clearance times for different voltage levels are defined in the NER.[14] The NER specifies faster clearance times for high voltages as the consequences of prolonged faults are greater.

1.2.4 Emerging system strength issues

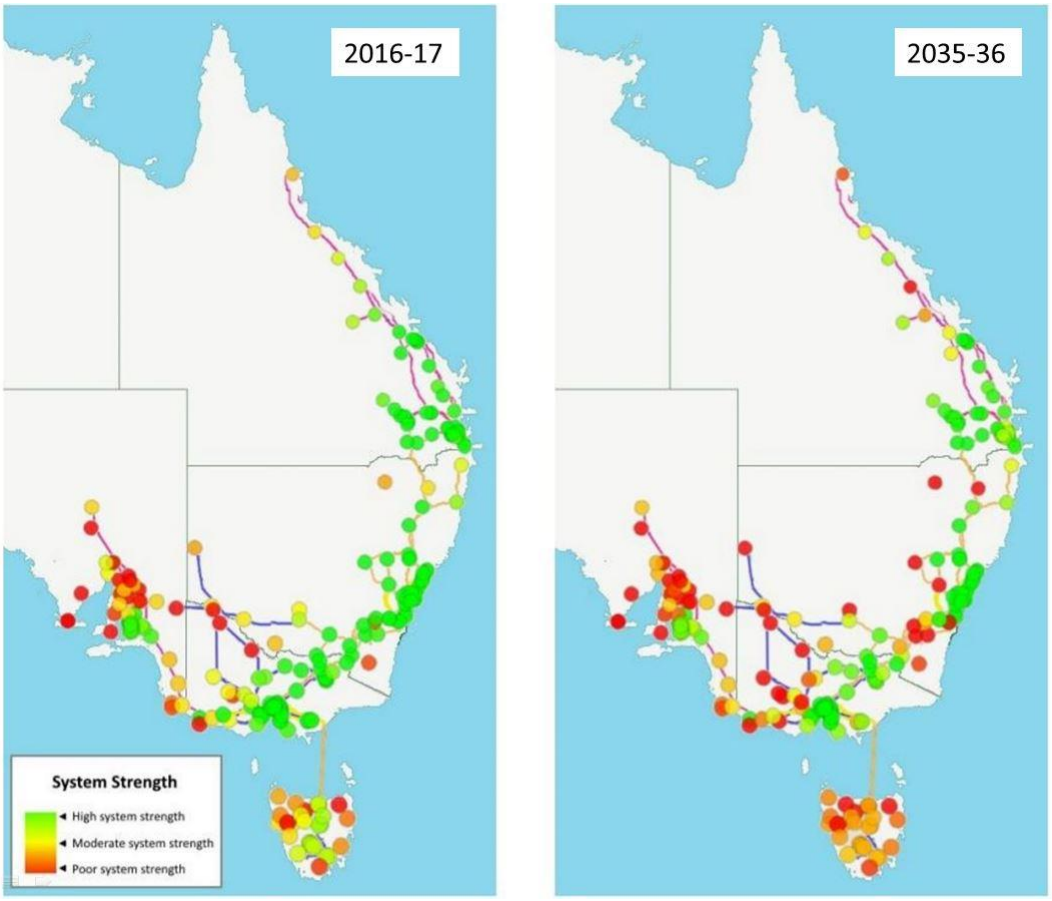
Historically, high fault levels (or a system that is 'too strong') have been the main concern. However, falling system strength is now an emerging issue. System strength in some parts of the power system has been decreasing as traditional synchronous generators are operating less or being decommissioned. The short circuit ratios at connection points are also falling as greater numbers of non-synchronous generators connect to the network.

In the 2016 *National transmission network development plan* (NTNDP), AEMO performed a high-level assessment to locate areas of low system strength.[15] An area of the grid was considered weak if the short circuit ratio dropped below three. AEMO's assessment showed system strength to generally decrease over the period from 2016-17 to 2035-36. The assessment also showed that system strength is currently low in parts of South Australia and Tasmania. These weaker areas of the grid are predicted by AEMO to experience lower system strength in the future. AEMO's assessment is shown in Figure 1.2.

14 Table S5.1a.8 of the NER.

15 AEMO, *National Transmission Network Development Plan*, December 2016.

Figure 1.2 System strength assessments in 2016-17 and 2035-36



Source: AEMO, *National transmission network development plan*, December 2016, figure 27.

The South Australian Government noted in the rule change request that low fault levels are becoming evident in South Australia and North Western Victoria.[16]

1.3 Existing arrangements

Currently, NSPs are required to provide for and operate protection systems for their networks. These protection systems require NSPs to clear network faults within certain clearance times. The protection systems used by NSPs typically include protection relays that depend upon a certain level of fault current to register when a fault has occurred.

NSPs also have a role in maintaining the power system voltage. NSPs are required to keep the voltage at connection points within technical limits, including:

- the absolute level of voltage, which must be in a defined range[17]

16 Minister for Mineral Resources and Energy (South Australia), *Rule change request – Low fault levels*: Attachment D, 12 July 2016, p. 1.

17 Schedule 5.1a.4 of the NER.

- step changes in the level of voltage, which must be smaller than the limits set in the Australian Standards[18]
- voltage unbalance,[19] which must be smaller than the limits required by the Australian Standards.[20]

To control the voltage in their networks, NSPs can:

- reinforce their network with additional lines and/or transformers
- install switchable capacitor and reactor banks
- install dynamic voltage control devices
- install synchronous condensers.

AEMO has an operational role in assisting with voltage control. While NSPs have responsibility for planning their individual networks to allow for the management of voltage,[21] AEMO is responsible for the dispatch of reactive power[22] from scheduled generating units.[23]

AEMO's responsibilities with regard to power system security include:[24]

- determining the level of reactive power reserve required to operate the power system
- maintaining an appropriate level of reactive power reserve
- arranging for the provision of reactive power capabilities
- taking all necessary action, including issuing directions, to return voltage to acceptable limits.

Box 1.2 Low system strength in South Australia

On 13 November 2016, the South Australian power system was operating with one synchronous generating unit in service for several hours.[25] Following a

18 Schedule 5.1a.5 of the NER.

19 Voltage unbalance refers to asymmetry of voltages or currents between phases in a three phase power system.

20 Schedule 5.1a.7 of the NER.

21 Schedule 5.1.4 of the NER.

22 Reactive power is a necessary component of alternating current electricity which is separate from active power and is predominantly consumed in the creation of magnetic fields in motors and transformers.

23 Reactive power can be dispatched from generating units to assist with voltage management.

24 Clause 4.3.1 of the NER.

preliminary analysis of the period, AEMO concluded that two large synchronous generating units are required to be online in South Australia to maintain a secure operating state.

System strength is essentially a localised power system characteristic. In South Australia, system strength is provided by local synchronous generation with a limited contribution from the Heywood interconnector. As a result, system strength in South Australia is largely dependent on the local synchronous generating units that are online at any given time.

AEMO considers that at a certain level of system strength, the South Australian power system is unlikely to be in a satisfactory operating state. AEMO considers that the equivalent of one Torrens Island B unit would allow the South Australian power system to operate in a stable manner, and two Torrens Island B units allow the South Australian power system to operate in a secure manner.[26]

AEMO has indicated that it will, in collaboration with ElectraNet, publish a report in 2017 to explore the requirement further. In particular, AEMO and ElectraNet will consider whether this requirement constitutes a new NSCAS gap.[27]

However, under the existing arrangements it is not clear which party is responsible for maintaining a minimum level of system strength at the generator's connection point. This is likely to become a more prominent issue as increasing levels of non-synchronous generation connect to the network and with increasing levels of synchronous generation being withdrawn.

1.4 Rationale for the rule change request

In the rule change request, the South Australian Government sought to amend the NER to accommodate issues associated with low fault levels.

The South Australian Government noted that low fault levels can:

- reduce the effectiveness of network protection settings
- affect the ability of inverter-connected plant to operate as designed
- result in greater difficulty in maintaining stable voltages.

The rule change request also highlights situations where it is unclear which party is responsible for maintaining fault levels. For example, a wind farm may be meeting its

25 AEMO, *Electricity industry conference: Secure operation of South Australia*, p. 1. Available at http://www.aemo.com.au/-/media/Files/Media_Centre/2016/SA-System-Strength.pdf

26 AEMO formed this view because clause 4.2.4 of the NER requires that the system must be expected to operate satisfactorily following a credible contingency, such as the tripping of the largest generating unit in South Australia.

27 AEMO, *National Transmission Network Development Plan*, December 2016, p. 98.

performance standards until the system strength at its connection point lowers, either because an inverter connected generator connects nearby or a nearby synchronous generator withdraws. In this example, the South Australian Government considers that it is unclear which party is responsible for maintaining system strength.

Box 1.3 Background to rule change request

The rule change request was largely based on issues identified by AEMO. AEMO worked with market institutions and energy officials through the Power System Implications Technical Advisory Group (PSI - TAG). Through this work, a number of emerging challenges were identified, including:

- reduced inertia
- low fault level
- reduced effectiveness of under frequency load shedding
- the potential for over frequency events.

The PSI-TAG was established to provide AEMO with expert technical input to identify and prioritise technical issues in the NEM.[28]

1.5 Solution proposed in the rule change request

The South Australian Government sought to resolve the issues discussed above by proposing to allocate responsibility for maintaining system strength. The South Australian Government noted that while the NEM had historically been designed to prevent fault levels becoming too high, a changing generation mix would result in challenges associated with low fault levels.

The rule change request proposes to amend the NER to address issues associated with low fault levels by allocating responsibility for setting fault levels throughout the network, taking into account cost, incentives and allocation of risk.[29]

1.6 The rule making process

On 8 September 2016, the Commission published a notice advising of its commencement of the rule making process and consultation in respect of the rule change request.[30]

28 More information on PSI-TAG is available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/FPSSP-Reports-and-Analysis

29 Minister for Mineral Resources and Energy (South Australia), *Rule change request – Low fault levels*, 12 July 2016, pp. 1-2.

30 This notice was published under s. 95 of the National Electricity Law (NEL).

A consultation paper for the *System security market frameworks review* and the rule change requests was published alongside the notice. Submissions closed on 13 October 2016.

The Commission received 15 submissions as part of the first round of consultation to the review and rule change requests.

On 15 December 2016, the Commission published an interim report on the review. Submissions closed on 9 February 2017 and 20 submissions were received. The Commission also published a notice under section 107 of the National Electricity Law (NEL) advising that the time for making the draft determination on the rule change requests had been extended to 29 June 2017. The extension was necessary due to the complexity of the issues raised in the rule change requests.[31]

On 23 March 2017, a directions paper on the review and rule change requests was published. Submissions closed on 20 April 2017. 21 submissions were received. A summary of the issues raised in submissions and the Commission's response is contained in appendix C.

All of these documents, and submissions to them, are available on the AEMC website.[32]

The Commission has considered the issues raised by stakeholders in submissions relating to the *System security market frameworks review* and the rule changes. Issues raised in submissions relating to system strength are discussed and responded to throughout this draft rule determination.

1.7 Structure of draft rule determination

This draft rule determination is set out as follows:

- Chapter 2 sets out a summary of the Commission's draft rule determination, including its assessment framework and summary of reasons for making the draft rule.
- Chapter 3 sets out the obligation on NSPs to maintain system strength on an ongoing basis.
- Chapter 4 describes the requirement connecting generators to 'do no harm' when connecting to the network.
- Chapter 5 describes the transitional arrangements for existing generators in the draft rule.

31 AEMC, *Notice under National Electricity Law*, 15 December 2016.

32 Available at: http://www.aemc.gov.au/Markets-Reviews-Advice/System-Security-Market-Frameworks-Review

- Chapter 6 describes the additional system strength monitoring obligations placed on AEMO in the draft rule.
- Appendix A provides more information on other issues arising from reduced system strength that the Commission does not consider require changes to the NER.
- Appendix B sets out the relevant legal requirements under the NEL for the Commission to make this draft rule determination.
- Appendix C provides the Commission's response to stakeholder comments that are not addressed elsewhere in the draft rule determination.

1.8 Consultation on draft rule determination

The Commission invites submissions on this draft rule determination by 8 August 2017.

Any person or body may request that the Commission hold a hearing in relation to the draft rule determination. Any request for a hearing must be made in writing and must be received by the Commission no later than 6 July 2017.

Submissions and requests for a hearing should quote project number ERC0211 and may be lodged online at www.aemc.gov.au or by mail to:

Australian Energy Market Commission
PO Box A2449
SYDNEY SOUTH NSW 1235

2 Draft rule determination

The Commission has developed the detail of the draft rule to achieve the intent of the South Australian Government's proposal. The draft rule introduces new provisions to set out a clear framework for responsibility for maintaining power system fault levels.

The Commission's reasons for making this draft determination are set out in section 2.4 and in more detail in the relevant chapters.

Further information on the legal requirements for making this draft rule determination is set out in appendix B.

This chapter outlines:

- the Commission's draft rule determination
- the rule making test for changes to the NER
- the assessment framework for considering the rule change request
- the Commission's consideration of the draft rule against the NEO.

2.1 The Commission's draft rule determination

The draft rule addresses the issues raised in the rule change request. The key features of the draft rule are:

- An enhanced framework that requires NSPs to maintain the system strength at generator connection points on their networks above an agreed minimum level. This builds on existing arrangements for generators to meet their registered performance standards. This enhanced framework is technology neutral and requires NSPs to use existing planning and regulatory arrangements when acquiring or providing services to assist in the maintenance of system strength above minimum levels. This aspect of the draft rule is discussed in chapter 3 of this draft rule determination.

- The introduction of a requirement on new connecting generators to 'do no harm' to the existing minimum level of system strength as previously negotiated by existing generators at their connection points. When a new generator is negotiating a connection to the network, the NSP and AEMO would need to be satisfied that the minimum level of system strength being provided at other generator connection points would be maintained so that nearby existing generators can continue to be able to meet their performance standards. If there needs to be any remediation works undertaken to maintain system strength in that part of the network, in order to accommodate the new generator, this would be funded by the new connecting generator. This is discussed in chapter 4 of this draft rule determination.

- A transitional process for existing generators to agree a registered short circuit ratio at their connection point with the relevant NSP. Generators and NSPs would be required to negotiate and agree to a minimum short circuit ratio which would then be registered with AEMO. This short circuit ratio would then be maintained as on ongoing obligation by the NSP. This is discussed in chapter 5 of this draft rule determination.
- The introduction of a requirement on AEMO to identify locations in the network where system strength is below, or is likely to be below, the registered minimum level of system strength. This is a clarification of AEMO's existing role in maintaining system security, including taking actions where necessary to maintain system security when system strength is low. This is also consistent with the existing NER treatment of high fault levels, which AEMO has a role in monitoring and managing. AEMO would also be responsible for establishing a guideline for calculating the short circuit ratio at connection points. This is discussed in chapter 6 of this draft rule determination.

The draft rule makes no changes to address network protection systems and network voltage management. The Commission considers that the existing provisions in the NER adequately allocate responsibility for addressing these issues to NSPs. This is discussed in appendix A of this draft rule determination. Where this draft determination refers to generators, it is specifically referring to both:

- generators that are connecting, or are connected, to the network under Chapter 5 of the NER
- market network service providers.

The draft rule introduces a number of new terms and concepts. These terms and concepts, explained in Box 2.1, are used throughout this draft determination.

Box 2.1 Definitions introduced in the draft rule

Short circuit ratio: the ratio of the three phase fault level (in MVA) at the connection points for the generating system to the active power output of the generating system (in MW). The short circuit ratio would be determined with the short circuit ratio calculation guidelines published by AEMO.

Minimum short circuit ratio: the lowest short circuit ratio that:

- is required for a generator or market network service facility to be able to meet its performance standards
- on AEMO's reasonable advice, does not adversely affect power system security
- in the NSP's reasonable opinion, does not adversely affect quality of supply for other network users.

Registered short circuit ratio: the lesser of the minimum short circuit ratio (as

determined above) and any short circuit ratio agreed under a system strength remediation scheme. The registered short circuit ratio is the level that the NSP would be required to maintain at relevant connection points.

Short circuit ratio calculation guidelines: a set of guidelines to be determined by AEMO to provide guidance to NSPs and connecting parties when determining a short circuit ratio.

System strength works: investment in a transmission or distribution system in order to establish or maintain the short circuit ratio and a connection point. System strength works are broken down into system strength connection works and system strength remedial works.

System strength connection works: system strength works undertaken by an NSP to accommodate the connection of a new generator.

System strength remedial works: system strength works undertaken by an NSP to meet its obligation to maintain system strength, except for system strength connection works.

System strength remediation scheme: a scheme proposed by a connecting party to:

- allow that generator to operate at a short circuit ratio less than the minimum short circuit ratio
- remediate the impact of that connection on the registered short circuit ratios of other generators.

2.2 Rule making test

The Commission may only make a rule if it is satisfied that the rule will, or is likely to, contribute to the achievement of the NEO.[33] This is the decision making framework that the Commission must apply.

The NEO is:[34]

> "to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to:
>
> (a) price, quality, safety, reliability and security of supply of electricity; and
>
> (b) the reliability, safety and security of the national electricity system."

33 Section 88 of the NEL.

34 Section 7 of the NEL.

2.3 Assessment framework

In assessing the rule change request against the NEO, the Commission has considered the following principles:

- **Risk allocation**: The regulatory arrangements designed to address issues relating to system strength should allocate the risk and accountability for investment decisions to the parties best placed to manage them. Additionally, risks relating to the security of the national electricity system should be clearly allocated to parties so that they can be adequately managed. In making this draft rule, the Commission considered how these risks are best allocated such that they can be appropriately managed.

- **Effective competition**: Competition and market signals, where feasible, generally leads to more efficient operational and investment decisions than prescriptive rules and central planning. These outcomes are generally more flexible to changing market conditions and provide consumers with the services in the most efficient manner possible. For competition to be effective, it must be able to deliver market signals to parties best able to respond to these signals in a manner that benefits consumers. In making this draft rule, the Commission has considered where competition can be introduced to effectively and efficiently address issues relating to system strength and if this competition is viable and effective in providing the required services. In considering where competition can be introduced, the safety, reliability and security of the system should not be compromised. Increased competition in the provision of services required to address system strength must, therefore, be considerate of the need to maintain the secure operation of the shared network.

- **Flexible and resilient market frameworks**: Regulatory arrangements must be flexible to changing market conditions. They should not be implemented to address issues specific to a particular time period or jurisdiction. In the draft rule, the Commission has considered which frameworks are best able to address issues associated with system strength over the long term and in a changing market environment.

- **Technological neutrality**: Regulatory arrangements should account for the full range of current and future solutions to technical issues. They should not be designed with the consideration of a limited set of technologies. This means that the widest range of technology of technology options will be considered, which ultimately should lead to lower costs for consumers in the long term.

2.4 Summary of reasons

Further detail on the rationale for making the draft rule can be found in chapters 3, 4, 5 and 6 of this draft determination.

The Commission considers the relevant aspects of the NEO to this rule change to be the security of the national electricity system. This is preserved in a manner that minimises the consequential costs to consumers.

Having regard to the issues raised in the rule change request and during consultation, the Commission is satisfied that the draft rule will, or is likely to, contribute to the achievement of the NEO for the following reasons:

- The enhanced framework in the draft rule clearly allocates responsibility for system strength to the party who is best placed to manage the risks associated with fulfilling that responsibility – that is, the relevant NSP. The framework enables NSPs to identify efficient solutions that support long run efficient operation, use and investment in electricity services.

- The draft rule provides for a holistic, flexible and technologically neutral solution to issues arising from reduced system strength by requiring NSPs to maintain system strength. As system strength is required throughout a network for the effective operation of the power system, it is most effectively co-ordinated be one party across that network. NSPs have a holistic perspective of their network and are able to address system strength in a manner that considers the best options for the entire network. The services required to address system strength are not suited to being delivered through a market.

- New connecting generators would be required to 'do no harm' to the existing minimum short circuit ratios agreed between existing generators and NSPs imposes the associated costs of maintaining system strength at the relevant connection point and neighbouring network upon the new connecting generator. This puts an incentive on connecting generators to seek to connect to the NEM in a location where there is either sufficient system strength, or a location where the generator is willing to fund the remediation of system strength to accommodate their connection. This would reduce the overall costs imposed on the system of that generator connecting.

- Placing an additional obligation on AEMO to monitor and report on system strength would provide market participants with greater information relating to system strength throughout the network. Requiring AEMO to develop guidelines for the calculation of a weighted short circuit ratio would also provide generators and NSPs with greater clarity. This dissemination of information would assist investment decisions made by generators and NSPs. This would also assist AEMO in continuing to maintain the security of the national electricity market.

2.5 Strategic priority

This rule change request relates to the Commission's strategic priority relating to markets and networks.[35]

35 AEMC, *Strategic priorities*, available at: http://www.aemc.gov.au/Major-Pages/Strategic-priorities

This strategic priority relates to the flexibility and resilience of energy market frameworks to respond to changes in technology and new business models. This includes changes in the generation mix, such as the increased penetration of non-synchronous generation and the subsequent retirement of large synchronous units. This links to the development of a robust framework to govern consideration and assessment of management of the system strength in the NEM. This framework is designed to support the maintenance of a resilient and secure power system as the generation mix changes.

3 Network service provider obligations to maintain system strength to generating system

This chapter outlines the issues relating to the reduction of system strength in the network, and explains how the draft rule addresses these related issues.

The Commission considers that the existing arrangements do not allocate clear responsibility for maintaining system strength throughout the network. The draft rule places this responsibility on NSPs.

3.1 Maintaining system strength so generators can meet their performance standards

3.1.1 Nature of the issue

The security of the power system relies on AEMO knowing the technical performance of the generating units in the NEM, or at least their minimum performance, and the generating units meeting these performance standards.

The generator performance standards are based on schedule 5.2.5 of the NER, which contains 14 specific technical performance requirements. Each of these technical requirements includes an automatic level and a minimum level.[36] A performance standard for a connecting generating unit for a specific technical performance requirement must be accepted by the NSP and AEMO if it equals or exceeds the automatic standard. Alternatively, the generator can negotiate with the NSP to a lower technical performance requirement, provided the performance exceeds the minimum level.

The proponent of a generating system must provide the NSP and AEMO with sufficient information to assess its expected impact on the operation of the power system. This will include the type and size of the generating system being considered, detailed models of the generating system and the associated control and protection systems.

AEMO provides the generator and NSP with advice when the technical performance requirement relates to its functions, including power system security.[37] Once the connection negotiations are finished, the agreed performance standards are included in the generator's connection agreement with the NSP, and registered with AEMO.

Generators are required to have programs in place to assess their ongoing compliance with the agreed performance standards.

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36 Schedules 5.2.5.6 and 5.2.5.8 for "quality of electricity generated and continuous uninterrupted operation" and "protection of generating systems from power system disturbances" only contain a minimum performance level that must be met.

37 Such technical performance requirements are referred to as AEMO advisory matters in the NER.

The Commission understands that some existing negotiated performance standards included in existing connection agreement may include a reference to maximum and minimum system strength levels, but this is not necessarily always the case. If they are included, the generator must continue to meet its performance standards whenever the system strength is within this range.

System strength reducing as synchronous generating units exit

System strength has been reducing in some parts of the NEM as a number of synchronous generating units exit the market or are operating less, and are replaced by new non-synchronous generation that does not contribute as much to system strength. As these synchronous generators reduce output or retire, the minimum fault current is reduced, thereby reducing system strength. The retirement of synchronous generators can result in parts of the power system that have traditionally been strong becoming weak.

Short circuit ratios reducing as new non-synchronous generation connect

When new generating units connect near existing generating units, the system strength available to each generator decreases. The reduction in effective system strength is exacerbated when it occurs in a weak part of the power system.

If a number of non-synchronous generators are connected in relative proximity to each other, their behaviour could be approximated by a single (large) equivalent non-synchronous unit. For example, two identical wind farms that connect adjacent to each other could be approximated as a single large wind farm.

As a result, the short circuit ratio at the connection point of existing generators (i.e. the ratio of the system strength to the rating of the connected non-synchronous generation) would decrease as additional new units are connected, even if the system strength was not decreasing. The lower short circuit ratio could lead to the affected units being unable to operate stably and ride through faults.

This is discussed further in chapter 4.

Issues arising from reduced system strength

Of particular concern in a power system with reduced system strength is the operation of the inverters such as those for modern wind farms, high-voltage DC interconnectors, solar PV and battery storage. This is because inverters require sufficient system strength to be able to meet their generator performance standards, such as being able to operate stably and to be able ride through a fault, i.e. continue operating after a fault in the nearby power system has been cleared.

The impact of low system strength also affects the operation of distributed energy resources such as distribution-connected and residential solar PV and battery storage

systems. These devices interface to the power system using inverters which require a minimum level of system strength to operate.

If the generating units in the NEM are no longer capable of meeting their performance standards at periods of low system strength, this could lead to a cascading outage or major supply disruption, or even potentially a black system condition.

3.1.2 Potential technical solutions when the system strength reduces

The potential technical solutions when a generator is unable to meet its performance standards depend on the nature of the non-conformance and the circumstances of the connection, but they include:

- Operating the generating unit at a reduced level of output. This may be an immediate solution in some instances but may be unacceptable as a long term solution, both from the perspective of the generator and given the wider consequences (see Box 3.1)
- Reinforcing the network with additional lines and/or transformers.
- Installing static VAr compensators (SVCs),[38] static synchronous compensators (STATCOMs)[39] or modern inverter-based generation can help in some instances. This is dependent on the weakness of the system and the extent that the equipment contributes to the system strength.
- Installing synchronous condensers or contracting with other synchronous generation to increase the system strength at the connection point.
- Installing other equipment that provides fault current.

Box 3.1 Addressing insufficient system strength for generating systems under existing arrangements

If the short circuit ratio for existing generating systems is reduced by the connection of a new generator in that part of the network, it introduces uncertainty as to whether these existing generators will be able to meet their performance standards. This is particularly true when there are multiple generating systems within a weak part of the network and complex interactions between the individual generating systems. These generators effectively share system strength, meaning that as new generators connect, although the fault current may be constant, the fault current available to each generator is reduced.

38 An SVC is a fast acting power electronic device that provides reactive power generation or absorption in an power system. Typically a SVC consists of one or more thyristor controlled reactors that provide variable and a number of a switched capacitor banks. SVCs are generally used to control the voltage profile within the network under changes network loading conditions or following a contingency.

39 A STATCOM is similar to a SVC in its ability to provide fast acting voltage control but is based on a voltage source inverter, similar to that used in modern wind or solar generation.

Because of these interactions, a reduction in the output of any of the individual generating systems is likely to improve the performance of all the affected generating systems. However, each generator would rely on the other generators to reduce output to maintain system strength. While there is a need for maintaining system strength, there is currently very little incentive for generators to collectively manage reductions in system strength.

System strength needs to be maintained to a certain level so that generators are able continue to meet their performance standards. Operationally this could result in the NSPs and AEMO developing constraint equations to maintain system security by limiting the output of the affected generating systems so that they would be expected to meet their performance standards. Alternatively, AEMO could issue directions, or reclassify the loss of multiple generating units as credible in low system strength conditions.

However, as the system strength reduces, the interactions between the affected generating systems become more complex and the models used to simulate the behaviour of the power system become less accurate.[40] This means that unless the system strength is maintained there would be increasing uncertainty as to whether the system is in a secure operating state.

In addition, if AEMO did rely on these measures to maintain system security, it could be difficult to enforce generator compliance with their performance standards. This is because when a generator does not meet its performance standards it could be due to the accuracy or implementation of the solution rather than an actual failure of the generator to maintain its technical performance.

3.1.3 Existing allocation of roles and responsibilities

The Commission understands that some connection agreements[41] only require generators to comply with their performance standards when the system strength is above a minimum level agreed at the time the connection agreement was negotiated. However, the NER does not place a clear obligation on any party to maintain the system strength above a minimum level, particularly when:

- synchronous generating units exit the market, or are operating less
- new inverter-connected generation connects to the network
- planned or unplanned network outages occur that reduce the system strength at a connection point.

40 On 20 June 2017 the Commission published a draft determination and draft rule on the generating system model gridlines which clarifies the obligations on market participants to provide models data information to AEMO.

41 Connection agreements are commercial contracts between the NSP and the generator, and their contents are confidential.

When the system strength drops below the minimum level considered during the connection process, it is possible that some generators would not meet their performance standards if a major contingency event were to occur.

3.2 South Australian Government's view

The South Australian Government notes that low fault levels can reduce the ability for inverter connected plant to operate effectively. Falling system strength can impact of the ability for inverter connected generation to ride through faults or operate properly during normal system operation.[42]

The South Australian Government also acknowledged the issues arising from new generator connections and generator withdrawals. In particular, there are circumstances where a wind farm, for example, may be meeting its performance standards until either:

- an inverter-connected generator connects nearby or
- a nearby synchronous generator may not be online.

This may reduce the fault level for the wind farm to the point where it is not able to meet its performance standards. In this situation, the wind farm may now not be compliant through no fault of its own. The South Australian Government considers that this highlights a gap in roles and responsibilities.[43]

The rule change request proposes that the NER should be amended to allocate responsibility for fault levels in the network.[44]

3.3 Stakeholder views

3.3.1 Consultation paper

On 8 September 2016, the Commission published a consultation paper on the *System security market frameworks review*.[45]

In the consultation paper, the Commission asked stakeholders for their views on the issues arising from reduced system strength and whether there should be a role for maintaining system strength.

In submissions to the consultation paper, a number of issues associated with reduced system strength were noted including:

42 Minister for Mineral Resources and Energy (South Australia), *Rule change request – Low fault levels*, 12 July 2016, p. 1.

43 Ibid.

44 Ibid.

45 AEMC, *Consultation paper - System security market frameworks review*, September 2016.

- the absence of clear responsibility for managing system strength[46]
- a generator becoming non-compliant with its generator performance standards through no fault of its own[47]
- short circuit ratios falling below design levels of power electronic interfaced equipment[48]
- the performance of traditional protection settings becoming compromised[49]
- issues relating to the quality of power supply becoming more prevalent[50]
- distributed energy resources may not behave as expected.[51]

3.3.2 Interim report

On 15 December 2016, the Commission published an interim report on the *System security market frameworks review*.[52]

In submissions to the interim report, stakeholders provided additional feedback on the issues resulting from reduced system strength.

S & C Electric suggested that only NSPs and AEMO would have sufficient oversight over the power system to manage fault levels. S & C Electric considered it critical that clear responsibility for system strength be allocated.[53] AEMO submitted that system strength could reasonably be seen as a network service. If it is viewed as a network service, an obligation could be placed on NSPs to maintain some minimum level of system strength.[54]

The South Australian Government noted in its submission that system strength issues in South Australia may be exacerbated by the connection of new inverter connected generation.[55] AEMO suggested that the minimum access standard could be amended to require connecting parties to not cause any existing network users to not meet their performance standards. Further, AEMO suggested that generator performance standards could be reviewed to improve the overall resilience of the future power

46 SEA Gas, submission to the consultation paper, p. 3.

47 ENGIE, submission to the consultation paper, p. 2.

48 Submissions to the consultation paper: Hydro Tasmania, p. 7; South Australian Government, p. 8.

49 Submissions to the consultation paper: Hydro Tasmania, p. 7; ENA, p. 3; South Australian Government, p. 9.

50 Submissions to the consultation paper: Hydro Tasmania, p. 7; ENA, p. 3;

51 ENA, submission to the consultation paper, p. 3.

52 AEMC, *Interim report - System security market frameworks review*, December 2016.

53 S & C Electric, submission to the interim report, p. 7.

54 AEMO, submission to the interim report, p. 6.

55 South Australian Government, submission to the interim report, p. 7.

system to operate with lower system strength. This would lead to modifications of converter control settings for new power electronic converter connected plant.[56]

Energy Networks Australia (ENA) considered that it was important that the proposed approach to procuring inertia also consider system strength.[57] However, RES Australia considered that combining system strength with inertia significantly constrains the market for any potential services and would be technology biased. RES Australia considered that system strength issues arise locally and would be more appropriately managed by the network planner.[58] Delta Energy agreed, submitting that the technical characteristics of inertia and voltage control differ significantly and it would be more appropriate for separate mechanisms be employed for each service.[59] Further, the South Australian Government suggested that it may be prudent to consider system strength as a separate issue.[60]

3.3.3 Directions paper

In the directions paper published on 23 March 2017,[61] the Commission outlined a proposed approach to addressing issues arising from reduced system strength. This included a proposal to address the impact of reduced system strength on the ability of generators to meet their performance standards. In submissions to the directions paper, this proposal received a varied level of support from stakeholders.

In the directions paper, the Commission proposed that NSPs would be responsible for maintaining a minimum level of system strength as agreed with generators. Some stakeholders supported the proposed allocation of responsibility for system strength.[62]The South Australian Government considered that the NER should include provisions for the new connecting generators to register their minimum fault level at their connection point.[63]

SEA Gas considered that potential improvements to system strength are an integral part of the incentive framework to be developed in relation to any additional inertia provided by the TNSP above the required operating level.[64]

Both ENA and Energy Queensland also remarked on the impact of increasing penetrations on non-scheduled and exempted generation.[65] ENA noted that under

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56 AEMO, submission to the interim report, p. 6.

57 ENA, submission to the interim report, p. 5.

58 RES Australia, submission to the interim report, p. 5.

59 Delta Energy, submission to the interim report, p. 1.

60 South Australian Government, submission to the interim report, p. 7.

61 AEMC, *Consultation paper - System security market frameworks review*, September 2016.

62 Submissions to the directions paper: S & C Electric, p. 2; South Australian Government, p. 8;

63 South Australian Government, submission to the directions paper, p. 8.

64 SEA Gas, submission to the directions paper, p. 1.

65 Submissions on direction paper: Energy Queensland, p. 6; ENA, p. 13.

existing regulatory arrangements, real-time management of these generators with a view to addressing system strength may not be feasible.[66]

S & C Electric considered that the proposal should make it clear that generators should have the ability to address system strength at its connection point by placing equipment on its site.[67] S & C Electric was also concerned by the potential under the Commission's proposal for generators to 'free-ride', that is - the last connecting generator would be required to pay costs that exceed its impact. S & C Electric instead suggested that a more fair cost sharing approach should be developed.[68]

In its submission, the Australian Energy Council considered it is reasonable not to recover any costs caused by a retiring generator, as this will unduly affect its retirement decision-making processes for no economic benefit.[69]

Energy Queensland submitted that the issue of reducing system strength in distribution networks is not insignificant in comparison to transmission networks. This point was reiterated by the ENA.[70] Energy Queensland noted that the short circuit ratio within the distribution network is likely to be affected by new generator connections or generator retirements from the transmission network. In this case, Energy Queensland suggested the minimum short circuit ratio may be met in the transmission network but the short circuit ratio in the distribution network may be adversely affected or further connections to the distribution network may be inhibited. To address this, Energy Queensland suggested that information sharing should be expanded to provide greater visibility of transmission connections to DNSPs in order to achieve effective management of system strength and appropriate recovery of associated costs.[71]

Energy Queensland noted that the proposal in the direction paper would impact on the size of a generator that can be connected without affecting the minimum short circuit ratio. It also noted that this would impact on various generator registration classes.[72] Energy Queensland noted that there may be instances where a synchronous generator retirement is known and a non-synchronous generator is looking to connect prior to the retirement date. It recommended that following a generator publically announcing its pending retirement, this should be considered in determining short circuit ratios for new connection applications.[73]

66 ENA, submission to the directions paper, p. 13.

67 S & C Electric, submission to the directions paper, p. 3.

68 Ibid, pp. 3-4.

69 Australian Energy Council, submission to the directions paper, p. 3.

70 Submissions to the directions paper: Energy Queensland, p. 5; ENA, p. 10.

71 Energy Queensland, submission to the directions paper, p. 6.

72 Ibid, p. 5.

73 Ibid.

3.4 Analysis

3.4.1 Obligation to maintain the system strength

As discussed in section 3.1.3, it is important to maintain sufficient system strength for existing generating facilities so that they can continue to meet their performance standards if a major contingency event were to occur.

In the Commission's view, it is necessary to allocate responsibility for maintaining system strength when it reduces due to synchronous generation retiring or operating less.

The three parties with the capacity to address this responsibility are:

- retiring synchronous generators
- the existing generator that operates the generating system
- the NSP operating the network the generating system is connected to.

These options are discussed below.

Ability for existing generators to manage reducing system strength

Generators are able to address system strength when connecting by installing a dynamic reactive power controller (such as a SVC or STATCOM) or a synchronous condenser.[74] However, these generators have limited ability to anticipate changes to the level of system strength inherent in the system. Consequently, if a generator were to install plant to assist with low system strength, it would face uncertainty as to whether that plant would remain adequate.

When there are multiple generating systems in an affected part of the network, investment in plant would also benefit the other generators, who could "free ride" off the system strength provided. That is, the generator that installs the new equipment may not be able to capture all its benefits. This is likely to lead to inefficient:

- investment in equipment to address low system strength, as each generator would be incentivised to free ride on others' investments
- operation of equipment addressing low system strength, as the owner would be incentivised to turn off this equipment[75] when its generating system is not operating, thus reducing the system strength and the ability of other generators to meet their performance standards.

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74 The Commission notes that in its submission to the directions paper, S & C Electric submitted that batteries are able to deliver fault current, among other system services. S & C Electric, submission to the directions paper, p. 3.

75 Turning off equipment would reduce the cost of losses and is likely to reduce maintenance costs.

In addition, relying on affected generators to install equipment could be problematic when the reducing system strength is causing protection or voltage control issues for the NSP. In this situation, efficient investment in equipment providing system strength might not occur if the generators and the NSP are incentivised to wait for the other to invest first.

Therefore, the Commission does not consider that existing generators are best able to manage and address the impacts of reduced system strength. The draft rule does not place any responsibility on existing generators to maintain a level of system strength.

Ability for retiring generators to replace system strength

The Commission does not consider that retiring generators have the capacity to address system strength issues caused when they retire. Existing synchronous generators have provided system strength to the power system as a by-product of energy generation. Requiring retiring synchronous generators to provide system strength would impose a non-trivial cost when withdrawing from the market. This would be despite these generators providing a service that has not historically been valued.

Additionally, an obligation on retiring generators would not remediate reductions in system strength resulting from reduced operation of these synchronous generators. Therefore, the Commission does not consider generators should be responsible for remediating system strength when retiring from the market. The draft rule does not place any responsibility on retiring generators to maintain a level of system strength.

Ability for NSPs to manage reducing system strength

In contrast to existing generators, NSPs are able to consider a range of issues associated with low system strength and are well placed to develop solutions that address all the issues being experienced across its network. In addition to impacts on generators, NSPs will be considering the effectiveness of their protection system and their ability to manage network voltages with low system strength and would be able to coordinate investment decisions across all of these needs.[76]NSPs, in conjunction with AEMO, also have oversight of fault levels across their entire networks, which individual generators do not have. A broad perspective of fault levels across whole networks means that the solutions chosen by the NSP to address system strength issues are likely to also address the broader issues arising from reduced system strength.

An obligation on NSPs to maintain the system strength for existing generating systems would be similar to their existing obligation to manage the quality of supply to all their network users, including both generators and customers.[77] That is, the NSP is required

76 As discussed in appendix A, NSPs currently have obligations to maintain the operation of their protection systems and manage the voltages in their networks. While meeting these obligations the NSPs may be required to restore the system strength in portions of their networks and this could be coordinated with other NSP obligations.

77 Clause 5.1.3(d) of the NER.

to provide for the quality of the voltage at generators' connection points meeting the requirements set out in the NER. Therefore, obliging NSPs to provide a minimum short circuit ratio to existing generators is consistent with NSPs' existing obligations with respect to quality of supply.

As NSPs currently have a role in assessing system strength and coordinating investment to address network protection and voltage management, as discussed in appendix A, the Commission considers that NSPs are the party best able to maintain short circuit ratios for generators at their connection points. Requiring NSPs to manage system strength such that generators are able to meet their performance standards is likely to lead to more efficient investment decisions in the required services or works.

Therefore, the draft rule places an obligation on NSPs to maintain an agreed registered short circuit ratio at all connection points for the generating systems connected to their networks.

Application in Victoria

The arrangements for the provision of shared transmission services, and connections to the transmission network in Victoria are different to those in other NEM jurisdictions. In Victoria, AEMO pursuant to its declared network functions under the NEL is responsible for providing shared transmission services in relation to the Victorian declared shared network. AEMO is also responsible for planning, authorising and directing augmentation of the declared shared network. AEMO has network agreements with the Victorian declared transmission system operators (DTSOs) under which the DTSOs provide electricity network services to AEMO to enable it to perform its declared network functions.

Under the draft rule, AEMO, as the party responsible for planning network augmentation in Victoria, is allocated the responsibility for planning and operating its network such that the short circuit ratio at generator connection points on the declared shared network are at least equal to the registered short circuit ratio for those connection points. If system strength works are required on the declared shared network in order to maintain system strength in accordance with the draft rule, AEMO may direct the DTSOs to undertake these works if the works required are not contestable augmentations under the NER. When there is a new connection to the Victorian declared shared network, AEMO in its capacity as TNSP in Victoria would be required to agree a registered short circuit ratio with that generator, although it is expected to do so in consultation with the affected declared transmission system operators.

3.4.2 Expressing the minimum system strength as a short circuit ratio

The level of system strength that the NSPs would need to maintain could either be expressed as a fault level (measured in MVA) or normalised as a short circuit ratio based on the size of the generating system at the connection point.

Specifying the system strength in fault level or as a short circuit ratio would be the same for a given level of system strength and mix of generating systems. However, if additional generating systems commence operation, the short circuit ratio for an existing generator would be reduced[78] while fault current would stay constant. As the short circuit ratio, rather than the absolute fault level, better reflects the operation of a generating system, the Commission considers that the NSP maintaining the registered short circuit ratio at the relevant connection points would be more effective.

Determining a registered short circuit ratio

The requirement to determine a registered short circuit ratio to be maintained by the NSP for each of the generating system connection points is discussed:

- in chapter 4 for new generating systems
- in chapter 5 for existing generating systems.

It is important that a consistent methodology is used by the NSPs to calculate short circuit ratios when assessing whether they have met their obligations to maintain the registered short circuit ratios at the generating system connection points within their networks. The use of a consistent approach would:

- provide the NSPs with greater certainty as to whether they have met their obligation to maintain registered short circuit ratios
- provide the relevant generators with greater certainty that they will be supplied with sufficient system strength to be able to meet their performance standards
- mean that generators that are connected to different networks are treated similarly.

To achieve this consistency, the draft rule requires AEMO to develop short circuit ratio calculation guidelines. A NSP would be required to calculate short circuit ratios for generating system connection points in accordance with these short circuit ratio calculation guidelines.

The development and maintenance of the short circuit ratio calculation guidelines by AEMO is discussed further in chapter 6 on AEMO obligations.

78 This is because the short circuit ratio is the ratio of the system strength in MVA, and the capacity of the generating unit or inverter in MW. The system strength in MVA may remain approximately the same following the connection of a new generator. However, the connection of a new generator, particularly if it is electrically close to other generators, may effectively 'share' that available system strength. This has the effect of reducing the short circuit ratio at the connection point of the new generator and the affected generator.

3.4.3 NSPs to maintain system strength on an ongoing basis

Schedule 5.1.14 of the draft rule obligates NSPs to use reasonable endeavours to plan and operate their networks so as to maintain the short circuit ratio at the connection point for each generating system connected to its network is at least equal to the registered short circuit ratio for the generating system.

Conditions for which the minimum short circuit ratio would be maintained

Under the draft rule, NSPs would need to maintain a level of system strength such that:[79]

- the short circuit ratio at generator connection points was at least the minimum short circuit ratio
- network protection systems would be able to operate properly
- the NSP is able to adequately manage network voltages.

On an ongoing basis, the NSP may need to undertake works to meet its system strength obligations. This may arise in circumstances including:

- a synchronous generator reducing output or retiring
- a major planned outage occurring on the network.

As discussed earlier, these impacts on system strength would be best anticipated and addressed by the NSP.

The system strength varies significantly under different conditions and could potentially get very low if there were unplanned network outages when a limited number of synchronous generating units are operating. It is likely to be neither practical nor efficient for NSPs to restore the relevant short circuit ratios to the required levels under all possible scenarios as it may require a very large level of the services or works to be deployed.

However, the obligation on the NSPs to maintain short circuit ratios should maintain the security of the power system without the need for large restrictions to the output of the affected generating systems. To achieve this, the obligation for NSPs to maintain registered short circuit ratios should apply following credible major disturbances to the power system, without accounting for non-credible events. Therefore, the draft rule requires the NSPs to maintain the registered short circuit ratio:[80]

- when the power system is in a satisfactory operating state

79 Clause S5.1.14 of the draft rule.

80 Ibid.

- following a credible contingency event when the system was in a secure operating state
- following a protected event when the system was in a secure operating state.

The NSP would need to consider this obligation when both planning and operating its network.

This means that whenever the system is operating under normal conditions short circuits ratios would be high enough so that the associated generating systems would be expected to be able to meet their performance standards in the absence of a contingency and following a credible contingency event or a protected event.

However, NSPs would not be obligated to maintain the short circuit ratio following a non-credible contingency event. Under all conditions, including the aforementioned, AEMO would be required to manage the secure operation of the power system. The obligation on AEMO to maintain power system security when the system strength is low is discussed in chapter 6.

Options for NSP to provide system strength

The obligation on the NSP to maintain the minimum short circuit ratios at the connection points of generating systems in its network may require the NSP to undertake system strength remedial works.[81] Options available to the NSP when providing system strength remedial works could include:

- installing synchronous condensers, or other equipment that can provide a fault current contribution
- contracting for system strength services from synchronous generators, or other parties that can provide a fault current contribution
- re-enforcing the network that supplies the connection point
- negotiating with an existing generator to upgrade its facilities to be able to operate at a lower minimum short circuit ratio.

3.4.4 Cost recovery

As discussed earlier, the Commission considers that NSPs are the party best placed to respond to, and manage the risk of, reduced system strength. While system strength has primarily been seen as a service required by generators, a level of system strength is needed by all users of that network and is necessary for the overall functioning of the power system. The level of system strength needed varies by location and voltage level. The Commission considers that the need for, and the associated costs of, system strength cannot be attributed to a single party, or group of parties.

81 Clause 5.12.1(b)(5) of the draft rule for TNSPs and clause 5.13.1(d)(2) of the draft rule for DNSPs.

In the Commission's view, under all circumstances (except for the connection of new generation, discussed in chapter 4), the maintenance of system strength would be provided by the NSP as a regulated service, the costs of which are borne by all customers. This is consistent with cost recovery for the existing obligations on NSPs to maintain protection systems and manage network voltages.[82]

As such, under the draft rule, TNSPs would undertake system strength remedial works as a prescribed transmission service, and the costs of these works would be recovered through transmission use of system (TUOS) charges.[83]

Unlike the classification of transmission services,[84] which is given effect through the NER, the classification of distribution services[85] is determined by the AER through the regulatory determination process for each DNSP. As such, the draft rule does not specify how system strength remedial works undertaken by DNSPs are to be classified. However, to support consistency with the approach for system strength remedial works undertaken by TNSPs at the transmission level, the Commission considers that system strength remedial works undertaken by DNSPs at the distribution level should be classified by the AER as a standard control service for each DNSP, and costs recovered through distribution use of system (DUOS) charges.[86]

Providing system strength remedial works as a regulated service (for example, a prescribed transmission service) would impose regulatory oversight from the AER regarding expenditure to provide these services. Regulated services have a much higher degree of regulation than negotiated services, as the revenue that can be recovered for the provision of regulated services are subject to approval by the AER through the regulatory determination process. The established framework for the provision of prescribed services encourages efficient investment and maintenance of infrastructure to meet reliability and quality of supply standards, while seeking to prevent monopoly pricing.

When considering investments needed to maintain system strength, NSPs will be required to undertake regulatory investment tests to determine the optimal investment.[87] These tests would assist the NSP in making the most efficient investment decisions to address system strength, ultimately reducing costs for consumers. Under this incentive-based regulation regime, NSPs have an incentive to minimise the costs of providing these services.

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82 This is discussed in more detail in appendix A.

83 TUOS charges are recovered from transmission customers, including DNSPs.

84 That is, as a prescribed transmission service, negotiated transmission service or non-regulated transmission service.

85 That is, as a direct control service (and subsequently either a standard control service or alternative control service), negotiated distribution service or unclassified distribution service.

86 DUOS charges are recovered from distribution customers.

87 These tests are RIT-Ts for investment in transmission and RIT-Ds for investment in distribution.

3.4.5 Joint planning between neighbouring networks

In an interconnected power system made up of multiple TNSPs and DNSPs, the system strength at a given generating system connection point can depend on the actions of more than one NSP. For example:

- increasing the system strength in a transmission network will increase the system strength within the distribution networks that it supplies
- a synchronous generator or synchronous condenser near a network boundary will to increase the system strength in the neighbouring network
- a distribution connected synchronous generator or synchronous condenser will also increase the system strength in the transmission network supplying it, as well as neighbouring distribution networks.

Given the interaction between NSPs' networks, it is important that they undertake effective joint planning to coordinate the most effective and efficient solution. The Commission considers that the existing planning arrangements in the NER are adequate to facilitate this.[88]

3.5 Conclusions

The Commission has considered a number of issues in developing the obligation for NSPs to maintain the system strength to generating systems within their networks.

3.5.1 Maintain system security

There is a need to be able to maintain power system security in the presence of reducing system strength. It is also important that generating systems are able to meet their performance standards to reduce the risk of cascading failures of generators. Therefore, the enhanced framework in the draft rule would clearly allocate responsibility for system strength to the NSP, as the appropriate party. Maintaining a sufficiently high level of system strength throughout the networks would improve the security of the NEM power system by allowing generators to meet their performance standards without needing to operate the power system in a significantly constrained manner.

3.5.2 Delineation of responsibilities

The provision of system strength is best provided by an NSP as opposed to being delivered through a market. The services or works required to address system strength issues should be centrally coordinated by an NSP so that requirements of the generators can be considered together with the NSP's other obligations such as

88 Rule 5.14 of the NER.

maintaining secure operation of its network and reliability of supply to the customers supplied by the network.

In addition, the draft rule for *Managing the rate of change of power system frequency* rule change request includes an obligation on TNSPs that requires TNSPs to maintain minimum levels of inertia.[89]The sources of inertia that the TNSPs will need to provide or contract for are also likely to increase the system strength. Therefore, NSPs maintaining both the system strength and inertia levels means that the associated works and services can be more effectively coordinated, and any investment decision made by the NSP can take into account these two obligations.

The obligation on NSPs to maintain system strength is expressed in a technology neutral manner, which will allow NSPs flexibility in determining the most efficient solution to meet their obligations regarding system strength.

3.5.3 Efficient investment decisions

Any investment decisions made by the NSPs to meet their obligation to maintain the short circuit ratios at generating system connection points will be subject to the existing arrangements under the NER for regulating the revenue or prices that an NSP can earn or charge for the provision of regulated services during a regulatory control period. That is, the AER will continue to set a ceiling on these revenues or prices, having regard to the revenue requirement of the NSP to cover its efficient costs (including operating expenditure and capital expenditure) to meet its regulatory obligations. The NSP investment decision will also be subject to either the RIT-T or RIT-D if it exceeds the relevant cost threshold.

89 AEMC, *Managing the rate of change of power system frequency rule change,* Draft determination, June 2017.

4 New generator connections

This chapter outlines the issues relating to the connection of new generators and their impacts on other connected generators. This chapter explains how the draft rule addresses these related issues.

The draft rule requires new connecting generators to 'do no harm' when connecting to the network. Under the draft rule, new connecting generators would have to:

- negotiate with the relevant NSP to agree a short circuit ratio that would be registered with AEMO and maintained by the relevant NSP
- meet the costs of any system strength connection works undertaken by the NSP or provide their own equipment to maintain the registered short circuit ratios for existing generators.

4.1 Ability for generators to meet performance standards

4.1.1 Nature of the issue

When new generators connect to the network, they will potentially impact on the system strength available to existing generators. If the impact is large enough, existing generators may no longer be able to meet their registered performance standards, and so increasing risks to system security.

4.1.2 Potential solutions to address system strength impacts of connecting generators

There are a number of potential solutions to reduced system strength when a generator connects to the network. The most efficient solution would depend on the nature and extent of the impact on system strength. Some options include:

- operating the generating unit at a reduced level of output
- reinforcing the network with additional lines and/or transformers
- SVCs and STATCOMs
- installing synchronous condensers or other equipment that can provide fault current
- contracting with other synchronous generation to increase the system strength at the connection point
- upgrading control systems to improve the ability of affected generators to operate at lower short circuit ratios .

4.2 South Australian Government's view

The South Australian Government notes that low fault levels can reduce the ability for inverter connected plant to operate effectively. Falling system strength can impact on the ability for inverter-connected generation to ride through faults or operate properly during normal system operation.[90]

The rule change request proposes that the NER should be amended to allocate responsibility for maintaining fault levels in the network.[91] When allocating responsibility for system strength, the South Australian Government requested that the Commission consider the incentives, cost and allocation of risk.

4.3 Stakeholder views

4.3.1 Consultation paper

In the consultation paper, the Commission asked stakeholders for their views on the issues arising from reduced system strength and whether responsibility for maintaining system strength needed to be more clearly allocated. Stakeholder views on this issue are outlined in section 3.3.1.

4.3.2 Interim report

In submissions to the interim report, stakeholders provided additional feedback on the issues resulting from reduced system strength as new generating systems are connected.

The South Australian Government noted in its submission that system strength issues in South Australia may be exacerbated by the connection of new inverter connected generation.[92] AEMO suggested that the minimum access standard could be amended to require connecting parties to not cause any existing network users to be unable to meet their performance standards. Further, AEMO suggested that generator performance standards could be reviewed to improve the overall resilience of the future power system at weaker systems strength. This would lead to modifications of converter control settings for new power electronic converter connected plant.[93]

4.3.3 Directions paper

In the directions paper, the Commission proposed that new connecting generators should agree to a minimum short circuit ratio when connecting to the network that the

90 Minister for Mineral Resources and Energy (South Australia), *Rule change request – Low fault levels*, 12 July 2016, p. 1.

91 Ibid.

92 South Australian Government, submission to the interim report, p. 7.

93 AEMO, submission to the interim report, p. 6.

NSP would be required to guarantee. The Commission also proposed that new connecting generators should be required to bear the costs associated with remediating the impacts on the short circuit ratios provided to other generators.

Stakeholders provided a range of responses to the Commission's proposals in submissions to the directions paper.

Reach Solar suggested that new entrant generators should not be required to remediate impacts on the short circuit ratio for existing generators because this impact is assessed by AEMO and the TNSP as part of the generator performance standard process.[94]

S & C Electric considered that the proposal should make it clear that generators should have the ability to address system strength at its connection point by installing and operating equipment on its site.[95] S & C Electric was also concerned by the potential under the Commission's proposal for generators to 'free-ride' as the last connecting generator would be required to pay costs that exceed its impact. Instead, S & C Electric suggested that a cost sharing approach should be developed, which in its view would be fairer.[96]

Both the ENA and Energy Queensland also remarked on the impact of increasing penetrations on non-scheduled and exempted generation.[97] The ENA noted that under existing regulatory arrangements, real-time management of these generators with a view to addressing system strength may not be feasible.[98]

Energy Queensland noted that the proposal in the direction paper would impact on the size of a generator that could be connected without affecting the minimum short circuit ratio. Energy Queensland also noted that this would impact on various generator registration classes.[99] Energy Queensland suggested that when generators announce their intention to retire, this should be factored into the minimum short circuit ratio for new generator connections.[100]

4.4 Analysis

4.4.1 Treatment of connecting generators

Under the draft rule, when a new generator connects to the power system, the relevant NSP will be required to maintain sufficient system strength such that:

- the connecting generator is able to meet its performance standards

94 Reach Solar, submission to the directions paper, p. 2.

95 S & C Electric, submission to the directions paper, p. 3.

96 Ibid, pp. 3-4.

97 Submissions to the direction paper: Energy Queensland, p. 6; ENA, p. 13.

98 ENA, submission to the directions paper, p. 13.

99 Energy Queensland, submission to the directions paper, p. 5.

100 Ibid.

- nearby generators are able to continue to meet their performance standards following the connection of that generator.

The connecting generator would be responsible for meeting the costs associated with remediating any impact of its connection on the short circuit ratios at the connection points of affected generating systems.

New connecting generators should 'do no harm' to existing generators

The connection of new generators has the potential to reduce the short circuit ratios of existing generators. This may mean that existing generators are unable to meet their performance standards, which can adversely affect system security. Existing generators have limited opportunity to plan for and address these impacts.

For example, an existing generator might be operating with sufficient system strength such to meet its performance standards. Following the connection of a new generator nearby, the short circuit ratios for both generators may be at a level where neither generator would be able to meet their performance standards, posing a risk to system security. The effects of insufficient system strength being available for existing connected generators may not have clear impacts during normal operating conditions. However, they may have catastrophic impacts following a disturbance on the power system, including triggering a cascading outage leading to a major supply disruption.

NSPs would encounter substantial difficulty in maintaining system strength at sufficient levels for connected generators if there was no clear process for remediating the impacts of new generators connecting. It would also be very difficult for AEMO to continue to operate the system securely if the system strength was not maintained as new generating systems connect, as this may require AEMO to undertake more severe operational actions following the new generator connection.

The Commission therefore considers that there should be explicit consideration of the impact of a new generator connecting to the network prior to its connection. The draft rule introduces this consideration into the process of negotiating a connection, as explained below.

Connecting generators should fund the system strength works attributed to its connection

Under the draft rule, the ongoing obligation to maintain system strength lies with NSPs. As discussed in chapter 3, the costs associated with system strength remedial works would be recovered from all consumers.[101] The draft rule also requires NSPs to maintain system strength as new generating systems connect to the network, with the new connecting generators to meet the costs of maintaining the short circuit ratios to existing generating systems. This would either be provided to the connecting party by

101 For transmission networks, this would be provided as a prescribed transmission service. For distribution networks, the classification of services would be determined by the AER.

the NSP as "system strength connection works"[102] or provided by the connecting party in a "system strength remediation scheme"[103] if the scheme is accepted by the NSP.

The new connecting generator is in the best position to respond to incentives relating to system strength. A generator would be required to factor the remediation of its impacts on system strength when connecting into its investment decision. To reduce the costs associated with connection, a generator could choose to locate in an area of the network where there is sufficient system strength to accommodate their connection, or invest in facilities that are able to operate at low system strength. Equally, a generator may decide to connect in a part of the network with low system strength and fund the associated works required to enable it to meet its performance standards.

Requiring generators to fund costs associated with their connection would drive generators to connect where it is most efficient, as well as connecting equipment that can operate to low levels of system strength.

How the NSP can address the impact on other generators

When a generator is connecting to the network, it may be necessary for the NSP to provide system strength connection works.[104] In order to provide these works, there are a number of options available to the NSP including:

- installing and operating equipment that provides additional system strength
- upgrading or augmenting the network
- contracting with synchronous generators to provide system strength
- working with affected generators to reduce their minimum registered short circuit ratio requirements.

Alternatively, the impact of a new connection on nearby generators could be addressed by the generator itself through a system strength remediation scheme it proposes.[105]

More detail on system strength connection works and system strength remediation schemes is provided in Box 4.1.

Generators' ability to address system strength individually

The impact of a new generator connecting on system strength could be addressed by that generator. However, the ability for a generator to address this would be

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102 Under the draft rule, system strength connection works are system strength works undertaken by an NSP to accommodate the connection of a new generator.

103 Under the draft rule, a system strength remediation scheme is a scheme proposed by a connecting generator as an alternative to system strength connection works. The scheme would: allow that generator to operate at a short circuit ratio less than the minimum short circuit ratio; and remediate the impact of that connection on the registered short circuit ratios of other generators.

104 Clause 5.3A.3(b)(6)(xi) of the draft rule

105 Clause 5.3.4B(c) of the draft rule.

contingent on the NSP agreeing that the proposal made by the generator would allow the NSP to continue to meet its obligations to maintain registered short circuit ratios with existing generators.

The most efficient resolution to impacts on system strength may occur behind the connection point of the new connecting generator. For example, a generator could install and operate equipment to provide voltage stability within the generating system. This equipment could be upgraded to also address any impacts of that generator connecting on other connected generators. Alternatively, if low system strength was expected to only infrequently occur in a certain part of the network, a connecting generator may opt to be required to reduce its output under low system strength conditions.

The draft rule outlines a process through which connecting parties would be able to propose a system strength remediation scheme as an alternative to the NSP providing system strength connection works.[106] A system strength remediation scheme would be instigated by a generator's proposal to allow the NSP to continue to meet its obligations regarding system strength to other connected generators by the generator:

- installing and operating equipment to provide fault current
- reducing output under low system strength conditions.

The NSP, following consultation with AEMO, may accept or reject the proposed scheme. The NSP must reject a scheme if:

- it would not be sufficient to allow the facility to meet its performance standards with the system strength remediation scheme operating, determined by reference to the technical capability of the facility
- in the reasonable opinion of the NSP, adversely affect quality of supply for other network users or
- on AEMO's reasonable advice, adversely affect power system security.

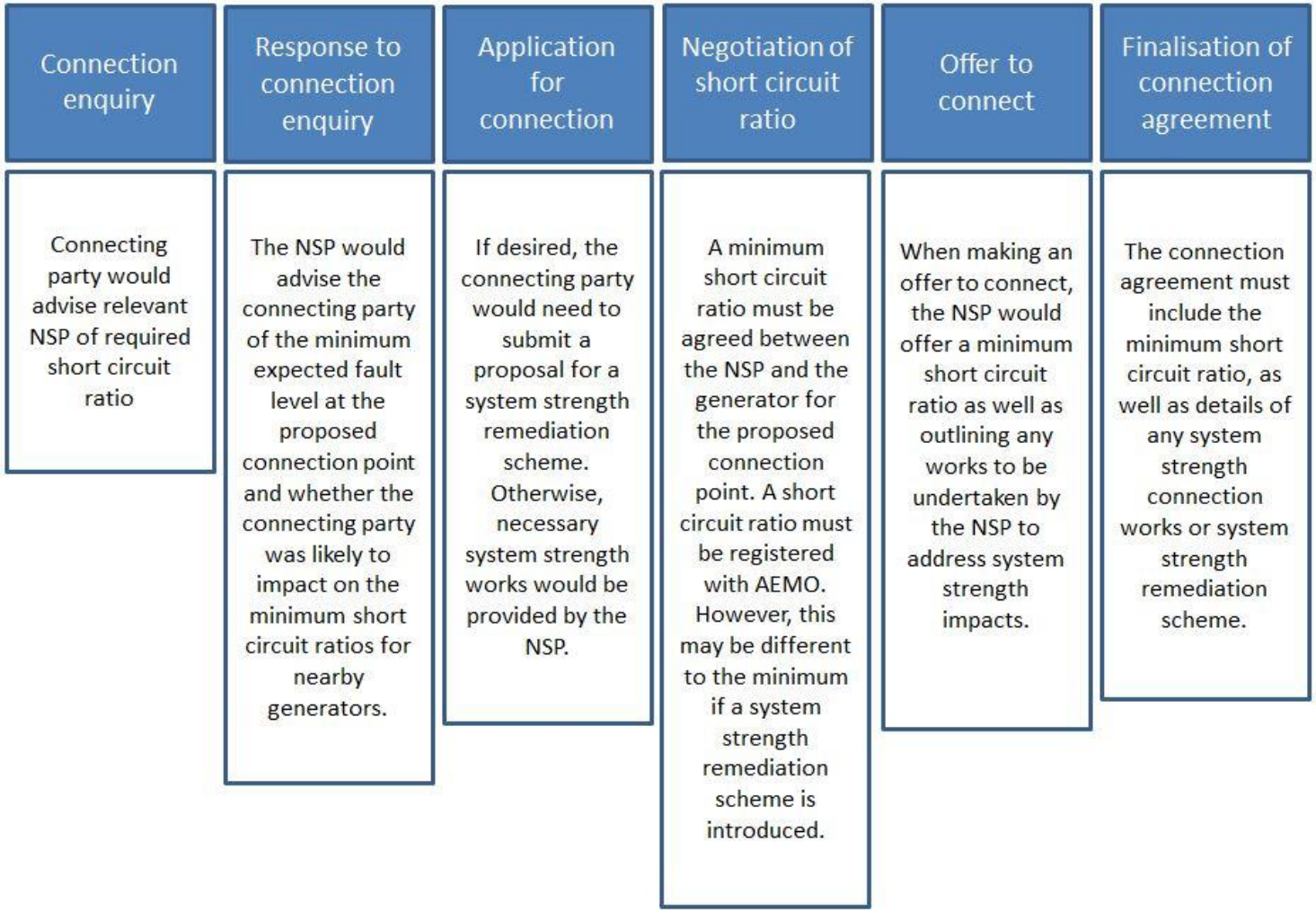
If the scheme was accepted, it would then be incorporated into the connection agreement between the generator and the NSP.

4.4.2 Determination of how to address system strength for connecting parties

As outlined above, the Commission considers that generators should address impacts on system strength during the connection process. New connecting generators should not reduce the short circuit ratio of any other generator below the level registered with the NSP. The process of determining how system strength would be addressed for new connecting parties is outlined in Figure 4.1.

106 Clause 5.3.4B(d) of the draft rule.

Figure 4.1 Addressing system strength in the connection process



Under the draft rule, in the process of connecting, generators would need to agree with the relevant NSP:

- a registered short circuit ratio that would allow the generator to meet its performance standards and which would be maintained by the NSP
- how to remediate any impacts on other generators due to the connection of the new generator.

The draft rule also makes clear that any costs associated with the remediation of system strength are to be met by the connecting generator.

Information available to the connection applicant

Prior to connecting to the network, new generators would have access to upfront information regarding the minimum short circuit ratios for existing connected generators. This is because, under the draft rule, AEMO would be required to publish the registered short circuit ratios for existing generators which would be available to assist prospective generators in making an informed decision prior to submitting a connection application. This register is discussed in more detail in chapter 6.

Additionally, generators connecting to the distribution network would be able to access information published by DNSPs in their distribution annual planning reports about fault levels in their networks.[107]

Connection enquiry

Under the existing framework for connection in Chapter 5 of the NER, a connection applicant must submit a connection enquiry to the relevant NSP to start the process of connecting to the network.

When a generator makes a connection enquiry, generators are required to advise the NSP of the type, magnitude and timing of the proposed connection. The draft rule requires the generator to submit a minimum short circuit ratio it needs to operate if required by the NSP.[108]

Response to connection enquiry

Under the connection process, following the receipt of a connection enquiry, an NSP is required to respond within a specified timeframe.[109] Under the current arrangements, the response from the NSP includes a preliminary program and information on access standards.

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107 Clause 5.13.1(d)(2)(iv) and clause S5.8(b)(5) of the NER.

108 Clause 5.3.2(b) and clause S5.4(g1) of the draft rule.

109 Clause 5.3.3 of the NER.

The draft rule requires the NSP's response to the connection enquiry to inform the connection applicant of expectations of system strength at the proposed connection point. The NSP is required to provide the connecting party with details of:[110]

- the minimum expected fault current at the proposed connection point
- whether the NSP expects the connection to reduce the short circuit ratio at the connection point for any other facility below its registered short circuit ratio.

Application for connection

After making a connection enquiry and receiving a response from the NSP, a connection applicant may make an application to connect.

When making an application for connection, the generator would be able to submit a proposal for a system strength remediation scheme.[111] The content of a system strength remediation is discussed below. Any works required to remediate system strength that are not provided in a system strength remediation scheme would be provided by the NSP.[112]

Negotiation of short circuit ratio

Under the draft rule, the NSP and the generator are required to determine a short circuit ratio that would be maintained by the NSP on an ongoing basis. The NSP is required to provide the agreed level under normal operating conditions and following a credible contingency or protected event when the power system was in normal operating conditions. The minimum short circuit ratio must be the lowest level that:[113]

- is required for the generator to meet its performance standards as determined by its technical capability
- on AEMO's reasonable advice, does not adversely affect power system security
- in the NSP's reasonable opinion, does not adversely affect quality of supply for other network users.

The NSP and the connection applicant must register a short circuit ratio with AEMO. This "registered short circuit ratio" must be the lesser of:[114]

- the minimum short circuit ratio
- a lower short circuit ratio agreed as part of a system strength remediation scheme.

110 Clause 5.3.3(b5) and clause S5.4B(e1) of the draft rule.

111 Clause 5.3.4(g) and clause 5.3A.9(h) of the draft rule.

112 Clause 5.3.4B(d) of the draft rule.

113 Clause 5.3.4B(b) of the draft rule.

114 Clause 5.3.4B(a) of the draft rule.

In addition to determining and registering short circuit ratios, the NSP is required to determine whether the connection of the new generator would impact on its ability to maintain minimum short circuit ratios for existing generators. In some circumstances, the connection of a generator may not require system strength works. For example, if a generator was connecting in a part of the network where the NSP expected that system strength would remain sufficient for the life of the generating system, the NSP could offer to maintain a short circuit ratio that was sufficient for that connecting generator.

However, some form of system strength works would be required if:

- the NSP is not able to provide the connecting party with a level of system strength that it needs to operate or
- the connection of the generator would impact on the minimum short circuit ratios for nearby generators.

These system strength works would be provided at the cost of the connecting generator and could either be provided:

- by the NSP as system strength connection works[115] or
- by the generator in a system strength remediation scheme.[116]

Box 4.1 System strength works

System strength works can either be provided by the NSP or by the connecting generator.

System strength connection works

System strength connection works are the provision of works or services by the NSP required to:

- provide the registered short circuit ratio to the generator or
- maintain the registered short circuit ratios for other connected generators.

In these circumstances, the NSP and the connecting party would need to negotiate a resolution. For connections to the transmission network, these system strength connection works would be provided to the connection applicant as a negotiated transmission service. For connections to the distribution network, the Commission notes that the AER would classify these services.

115 Clause 5.3.5(f) and clause 5.3A.10(f) of the draft rule.

116 Clause 5.3.4B of the draft rule.

System strength remediation scheme

Under the draft rule, a system strength remediation scheme could be proposed by the generator as an alternative to system strength connection works.

A system strength remediation scheme could consist of:

- The installation and operation of equipment by the generator at its connection point that provides fault current and maintains the minimum short circuit ratio at other generators' connection points. The generator would be provided some level of system strength by the NSP but would need to provide additional fault current behind its connection point in order to operate at full output and meet its performance standards. It may be the case that the additional fault current provided by the generator behind its connection point would not be required at all times for the generator to be able to operate at full output.
- Opt to reduce output under low system strength conditions and make clear to the NSP the level at which the connection applicant is able to operate at and meet its performance standards. In this case, the generator would be provided with some level of system strength by the NSP but would need to reduce output or turn off under low system strength conditions.

Following the receipt of a proposal for a system strength remediation scheme, the NSP would be required to consult with AEMO. The NSP would be able to reject the proposal if the NSP was not satisfied that it would allow the NSP to meet its obligations. AEMO would be able to withhold its approval if it thought that the system strength remediation scheme would impact on power system security.

A system strength remediation scheme may be agreed between a connecting generator and the NSP when the NSP is satisfied that it would enable the NSP to meet its obligations to other connected generators.

If a system strength remediation scheme is rejected, the NSP would need to provide the generator with its reasons. The generator would then be able to propose an alternative scheme or request negotiations between with the NSP and AEMO to negotiate a system strength remediation scheme.

Offer to connect

Following the receipt of an application to connect, an NSP must prepare an offer to connect.

When the NSP is preparing an offer to connect, the NSP would be required to specify in reasonable detail any system strength connection works to be undertaken.[117]

117 Clause 5.3.5(e) of the draft rule.

Finalisation of connection agreement

Under the existing arrangements, if the applicant accepts an offer to connect, the final stage of the connection process is the negotiation of a connection agreement.

Under the draft rule, the connection agreement would need to contain details of any system strength connection works, the registered short circuit ratio and details of any agreed system strength remediation scheme.[118]

4.4.3 Amending the minimum short circuit ratio of connected generators

The NER allows the registered performance standards that apply to a generating system to be amended by the agreement of AEMO, the relevant generator and the NSP.[119] The NER does not restrict when this can occur but it is likely to be associated with modification to the generating system such as the replacement of a control system. When the performance standards are amended it may be appropriate for the minimum short circuit ratio requirements of the generating system to also be amended, provided this is also with the agreement of AEMO, the generator and the NSP.

Therefore, the draft rule provides the ability for the minimum short circuit ratio to be amended whenever the generator performance standards are reviewed, and with the agreement of AEMO, the relevant generator and the NSP.[120]

If there are costs associated with amending the registered short circuit ratio, these costs would be met by the generator.

4.5 Conclusions

The Commission has considered a number of issues in developing a proposal to address system strength as new generators connect to the network.

4.5.1 Maintaining system security

The connection of new generators has the potential to reduce the short circuit ratios of existing generators to the extent that system security is adversely affected. The effects of insufficient system strength may not have clear impacts during the normal operation of the NEM but may have catastrophic impacts following a disturbance on the power system. The draft rule allocates responsibility for maintaining the system strength to NSPs as they are best placed to coordinate this with their other obligations to operate and plan their networks.

The draft rule places a requirement on new connecting generators to 'do no harm'. In conjunction with the obligation on NSPs to maintain system strength on an ongoing

118 Clauses 5.3.7(d) and 5.3.7(g)(6) of the draft rule.

119 Clause 4.14(p) of the NER.

120 Clause 5.3.9 of the draft rule.

basis, this requirement would maintain system strength such that the connection of new generators does not degrade the security of the power system.

4.5.2 Efficient investment decisions

The draft rule would allow new connecting generators to determine, in negotiation with the NSP, the preferred method for addressing the system strength implications of their connecting generating systems.

By requiring them to fund the costs associated with their connections, generators would be encouraged to make more efficient investment decisions regarding the location and type of their generating systems. The benefits of these more efficient investment decisions are likely to reduce the costs passed through to consumers.

5 Existing generator connections

As discussed in chapter 3, the draft rule requires NSPs to maintain registered short circuit ratios at the connection points for existing generating systems so to maintain the security of the power system. While chapter 4 explains how short circuit ratios would be agreed with future new connections, existing generators may not have agreed short circuit ratios nor does the NER currently provide a process to determine and record the minimum short circuit ratio requirements for existing generating systems. Without an appropriate process to do so, it would not be possible for these levels to be maintained by the NSPs.

5.1 Determining the minimum short circuit ratios for existing generators

The draft rule creates an ongoing obligation on NSPs to maintain system strength as well as the requirement for new connecting generators to 'do no harm' to existing short circuit ratios in the surrounding network.

However, in order for these obligations to be met, an initial level of system strength would need to be established. This level would predominantly be set by the short circuit ratios needed for existing generators to be able to continue to meet pre-existing performance standards.

Therefore the Commission intends for there to be a transitional period during which the short circuit ratios for existing generators will have to be negotiated and agreed between the generator and with the relevant NSP and registered with AEMO.

5.2 Criteria for determining the minimum short circuit ratio for existing generating systems

The minimum short circuit ratio that is agreed for a generating system needs to be both:

- high enough so that the generating system is likely to be able to meet its performance standards, thus reducing the need to constrain its output
- low enough so that the cost of maintaining the system strength is not excessive.

The Commission considers that this is most efficiently achieved when the minimum short circuit ratio to be maintained is based on the lowest level of short circuit ratio that is required for the facility to meet its performance standards, determined by reference to the technical capability of the facility.

For some generators that have connected more recently, a minimum system strength or short circuit ratio may have been considered at the time of the connection. If this is the case then this would inform the assessment of the short circuit ratio to be maintained at the generator's connection point.

5.3 Negotiation process for determining the minimum short circuit ratio

Agreeing a minimum short circuit ratio for each existing generating system connection point and an associated process for negotiating and agreeing the short circuit ratio will be set out in transitional provisions in the NER. This negotiation process needs to address the concerns of the relevant generator, the NSP and AEMO. The process for all existing generating systems would commence as soon as the final rule was published, and would need to be completed before the remaining provisions of the final rule commence (at this stage expected to be 1 July 2018) so that NSPs can plan the required investments, if any, and so that any relevant contractual agreements can be adjusted accordingly.

Transitional provisions in the draft rule include a requirement on the NSP to initiate the process of determining short circuit ratios for existing generators. Generators would be able to prepare in advance of the request for information from the NSP.

As AEMO is responsible for system security, the agreed minimum short circuit ratio would be an AEMO advisory matter under chapter 5.[121] That is, in addition to the relevant generator and the NSP, AEMO would need to agree that the minimum short circuit ratio meets the criteria in section 5.2.

A dispute resolution process also needs to be available where the NSP, generator and AEMO cannot agree on the minimum short circuit ratio that should apply at the connection point. The Commission considers that the existing dispute resolution in the NER is appropriate.[122]

At the completion of the process the agreed short circuit ratio for each generating system connection point needs to be registered with AEMO in a similar manner to the generator's registered performance standards, as well being published by the NSP as described in chapter 3.

The process of determining the minimum short circuit ratio would need to be completed before the commencement of the final rule on 1 July 2018.

5.4 AEMO exemption

Some generating systems are reaching the end of their operating lives and are located in relatively strong parts of the system. Consequently, these generators may be unlikely to experience operational issues with a low system strength. Other generating systems in the NEM are either very small or otherwise unlikely to impact system security. In both these cases there may be little benefit in requiring the relevant generator, the NSP and AEMO to undertake the process of agreeing a minimum short circuit ratio to be maintained.

121 Clause 5.3.10(b) of the draft rule.

122 Rule 8.2 of the NER.

To reduce the administrative burden on relevant generator, the NSP and AEMO for such generating systems, clause 11.100.1 of the draft rule includes an ability for AEMO to grant an exemption from the requirement to negotiate and register a minimum short circuit ratio. Such an exemption should only be granted if AEMO and the NSP agree that the generating system not meeting its performance standards is unlikely to impact power system security. This exemption would only apply to existing generators and would apply when any of the following apply:

- the generating unit was small and isolated and unlikely to impact on system security
- the generating unit was reasonably not expected to experience issues with reduced system strength in its lifetime
- the generating unit does not need to have registered performance standards.

In may be possible that the circumstances of a generating system that has been exempted may change. In such a case the decision to grant the exemption should be able to be revisited to assess whether the reason for granting the exclusion still applies. Therefore, the draft rule includes the ability for AEMO to revoke an exemption when the exemption criteria no longer apply.

5.5 Treatment of generators connecting during the transitional period

There may be generators that intend to connect to the network during the transitional period for this rule. The Commission considers that any generator that has a connection agreement with the relevant NSP by 1 July 2018, ought to have determined a minimum short circuit ratio as set out for existing generators in this chapter 5. If a connecting generator has not finalised its connection agreement by 1 July 2018 would be required to follow the process established for new generators under chapter 4 of this determination.

This will have cost implications for the connecting generator if its connection will impact on the short circuit ratios for other generators at their connection points.

6 AEMO obligations

As system strength reduces throughout the NEM, this will increasingly pose a risk to system security. The draft rule places a clear obligation on NSPs to maintain a certain level of system strength in their networks under normal operating conditions and following a credible contingency or a protected event. However, there may be circumstances where this obligation is not sufficient to keep the power system in a satisfactory operating state, including:

- following a non-credible contingency, such as the loss of multiple generating units
- if NSPs fail to meet their obligation to maintain system strength
- where detailed modelling shows complex interactions between various co-located generating systems reduce the system security of the power system.

Under these circumstances, AEMO would need to take the actions necessary to keep the power system in a satisfactory operating state. This is consistent with AEMO's current obligations to maintain power system security.

6.1 Current allocation of roles and responsibilities

Under the existing arrangements, AEMO is responsible for operating the power system in a secure operating state. AEMO's responsibilities in regards to power system security include:[123]

- maintaining power system security
- monitor the operation of the power system
- keeping the operation of the power system within the limits of the technical envelope.

AEMO also has processes in place that allow it to determine the short circuit fault current levels in real time.[124] AEMO is required to calculate the system strength during normal operation of the power system, and in anticipation of all credible contingency events, so that AEMO can identify any locations in the power system where the system strength exceeds the ratings of the relevant circuit breakers.[125]

123 Clause 4.3.1 of the NER.

124 AEMO, *Power system security guidelines*, p. 45.

125 Clause 4.6.1 of the NER.

6.2 South Australian Government's view

In the rule change request, the proponent did not propose any specific change to AEMO's role. The rule change did note that AEMO had:

- amended its internal procedures for managing power system security in South Australia when South Australia is at risk of islanding
- implemented internal procedures to manage power system security in South Australia post separation.[126]

The rule change request also proposed that clarity in roles and responsibilities for maintaining fault level is introduced.[127]

6.3 Stakeholder views

6.3.1 Consultation paper and interim report

Stakeholder submissions to the consultation paper and interim report did not provide comments on AEMO's role in regards to system strength.

6.3.2 Directions paper

In the directions paper, the Commission outlined a position that AEMO should have a role in maintaining system security in regards to reduced system strength.

Energy Queensland noted that, in the directions paper, the Commission suggested that AEMO could constrain the output of affected generators in its real time management of system strength. However, Energy Queensland suggested that this may not be effective where the generator is exempt or non-scheduled and AEMO lacks visibility or control.[128]

The ENA suggested that the Commission should clearly define the relationship between system strength and short circuit ratio. In addition, the ENA considered that the Commission may wish to consider using weighted short circuit ratio, as it used in the national transmission network development plan by AEMO.[129]

The ENA also suggest that it would likely be more efficient and effective if the process of determining short circuit ratios avoids the need for all minimum short circuit ratio values to be determined without approximating some of the calculation. It may for instance, mitigate the risk of potentially protracted negotiations between networks,

126 South Australian Government, Managing power system fault levels, *Rule change request*, pp. 4-5.

127 Ibid, p. 2.

128 Energy Queensland, submission to the directions paper, p. 6.

129 ENA, submission to the directions paper, pp. 12-13.

generators and AEMO on the required minimum circuit ratio, without compromising customer security outcomes.[130]

6.4 Analysis

AEMO is currently responsible for maintaining system security. The Commission considers that as system strength reduces, there may be some impacts on system security that are not likely to be mitigated by placing an obligation on NSPs to maintain a certain level of system strength. Consequently, and as discussed further below, AEMO should undertake the necessary actions to operate the power system in a secure manner.

Additionally, the draft rule introduces requirements for AEMO to:

- monitor low fault levels and issues a notice when the short circuit ratio at the generator's connection point is below the minimum short circuit ratio
- publish and maintain guidelines to assist NSPs in determining short circuit ratios for generator connection points
- published a register of minimum short circuit ratios for connected generators.

The Commission acknowledges that AEMO is currently undertaking further work to increase its understanding of what is required to maintain the secure operation of the power system when the system strength is low.

6.4.1 AEMO operational role

In order for AEMO to meets existing obligations to maintain system security, AEMO must take actions it considers necessary when the system strength is low to operate the power system in a secure operating state including by:

- constraining the output of the affected generating system(s) to a level that mitigates the risks to system security
- reclassifying the loss of multiple generating units affected by low system strength as credible
- advising the NSP of the low system strength, to provide an opportunity for it to identify any possible means of restoring the system strength
- directing a registered participant (NSP or generator) to take an action to increase the system strength at the affected connection point.

130 Ibid, p.13.

6.4.2 New obligations on AEMO

Additional monitoring

Clause 4.6.1 of the draft rule clarifies AEMO's role in monitoring system strength to explicitly consider low fault levels. AEMO would be required to identify the locations in the network where the system strength is below, or likely to be below, the registered minimum short circuit ratio at a generator's connection point. This would include for system normal, credible contingencies and protected events. AEMO must advise the relevant NSP and generator if the fault current at a generator's connection point is below, or will be below following a credible contingency or protected event, the registered short circuit ratio.[131]

The Commission considers it necessary to clarify AEMO's role in monitoring low system strength. This complements those parts of the draft rule discussed in chapters 4 and 5 which provide AEMO with increased information regarding the technical capability of plant in low system strength conditions. As discussed in chapter 4, the impacts of low system strength are not always immediately obvious. By requiring AEMO to monitor low fault levels and inform affected parties of low system strength conditions, it would provide increased awareness of system strength in an operational timeframe. This would assist NSPs in meeting their obligation to maintain system strength and allow AEMO to continue to operate the power system in a secure manner.

Short circuit ratio calculation guidelines

The Commission considers that AEMO should develop guidelines for determining the short circuit ratio at the connection point. These guidelines would provide generators and NSPs with clarity regarding the method for calculating the short circuit ratio, particularly in parts of the network which are highly meshed or which have a large number of generating systems.

The purpose of the guidelines would be to:[132]

- define the methodology that the NSPs should use to:
  - calculate the short circuit ratio when assessing their obligation to meet the minimum short circuit ratios at the generators' connection points
  - assess the impact of connecting a new generator.
- include a method for calculating the short circuit ratio from a given set of fault levels within the network

131 Clause 4.6.1(c) of the draft rule.

132 Clause 4.6.7 of the draft rule.

- provide guidance to NSPs as to the different network conditions and dispatch patterns that should be examined by the NSP when determining the fault levels within the network

By introducing the requirement for AEMO to produce and maintain these guidelines, this would:

- provide the NSPs with greater certainty as to whether they have met their obligation to maintain sufficient short circuit ratios
- provide the relevant generators with greater certainty that they will be supplied with sufficient system strength to be able to meet their performance standards
- mean that generators that are connected to different networks are treated similarly.

Interim guidelines

The transitional provisions in the draft rule contain a set of interim short circuit ratio calculation guidelines. These guidelines will be in place until AEMO determines and publish guidelines. The interim guidelines are contained in clause 11.100.5 of the draft rule.

The Commission considers that it is necessary to include interim guidelines in the draft rule so that the process of registering minimum short circuit ratios can be completed by before the NSPs' obligations commence on 1 July 2018.

The interim guidelines provided in the draft rule outline:

- how to calculate the short circuit ratio for a set of adjacent generating systems
- the level of fault current that should be assumed in short circuit ratio calculations
- a process for determining which generating system would be regarded as adjacent
- how the guidelines apply to market network service facilities and static reactive devices.

Register of short circuit ratios

The draft rule requires AEMO to maintain and publish a register of the registered generator minimum short circuit ratios.[133] This register would provide prospective connecting parties information about the system strength requirements of connected generators throughout the NEM. Providing this information to prospective connecting generators would assist them to make more informed decisions on the location of their

133 Clause 4.6.6 of the draft rule.

connection. This should lead to more efficient investment decisions on behalf of generators.

6.5 Conclusions

The draft rule clarifies that AEMO's responsibility for maintaining system strength covers the issues arising from low system strength. AEMO would also be responsible for monitoring system strength and informing the affected parties. While the Commission considers the existing arrangements continue to place responsibility on AEMO to operate the power system securely, the draft rule would provide AEMO with additional information to undertake this role more accurately. The Commission considers that the extension of AEMO's role will contribute to maintaining the secure operation of the power system.

The draft rule also requires AEMO to:

- develop a guideline for calculating short circuit ratios at generator connection points
- publish a register of minimum short circuit ratios.

This would provide market participants with additional information regarding how short circuit ratios are determined and the level of system strength that is being maintained by the NSP. Consequently, this should assist connecting parties in making informed decisions about where to connect to the network. As a result, this should lead to more efficient investment decisions on behalf of generators.

Abbreviations

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
Commission	See AEMC
MCE	Ministerial Council on Energy
NEL	National Electricity Law
NERL	National Energy Retail Law
NGL	National Gas Law
NEO	National electricity objective
NERO	National energy retail objective
NGL	National gas objective

A Network protection settings and voltage management

This chapter outlines the Commission's draft conclusions relating to the operation of network protection systems and the management of network voltages with reduced system strength.

The Commission considers that the existing arrangements place a clear obligation on NSPs to maintain the effective operation of the network protection schemes and manage network voltages within their networks.

A.1 Issues resulting from reduced system strength

A.1.1 Nature of the issue

Network protection settings

As discussed in chapter 1, large fault currents flow in a network when a fault occurs. It is important to clear the fault so that damage to affected equipment is limited, safety is maintained and the remainder of the power system can continue to operate. The presence and location of faults in the power system are detected using automatic protection systems that operate the appropriate circuit breakers to isolate the affected equipment while minimising the impact on the operation of the power system.

The performance of transmission and distribution network protection systems may deteriorate if the system strength reduces over time. This is because many of the algorithms used in the protection relays rely on the presence of large currents flowing into a fault to determine its location. If one or more of the protection systems in the network are no longer fit for purpose due to the system strength reducing, these protection systems may:

- not always detect the presence of a fault on the component of the power system that it is required to protect, resulting in an extended duration of the fault
- falsely detect the presence of a fault on another component of the power system, resulting in a larger part of the power system being isolated which is likely to affect more generators and customers.

Network voltage management

NSPs are required to keep the voltage at network users' (including customers' and generators') connection points within technical limits, including:[134]

- the absolute level of voltage must be in a defined range

134 These requirements are specified in Schedule 5.1 of the NER, as well in Australian Standards and in jurisdictional licensing conditions.

- step changes in the level of the voltage must be smaller than the limits required by Australian Standards
- voltage unbalance must be smaller than the limits required by Australian Standards.

This becomes increasingly difficult as the system strength at the connection point decreases. This is because the voltage at the connection point changes more for a given change in the load or generation at the connection point, or the switching of a capacitor or reactor bank. Of particular concern is that automatic voltage control systems can become unstable at low fault levels.

A.1.2 Potential technical solutions when the system strength reduces

Isolated protection issues

The cheapest way to rectify a protection issue that is localised to an isolated part of the power system is likely to be upgrading the protection system. This may simply consist of adjusting the settings on existing protection relays to be able to operate over a larger range of system strengths. However, it also could require new relays (with more sophisticated algorithms) so that the protection system continues to be fit for purpose when the system strength is low.

In some cases it may be necessary to also install new current and voltage transformers to provide additional information to the relay. In addition, some more sophisticated transmission line protection systems require a high speed communication link between the substations at each of the lines.

Widespread protection issues

While individual localised protection issues may be corrected at a reasonable cost, this approach may not be cost-effective where the system strength is reduced across a large portion of the power system, i.e. the majority of a region. To address such systemic protection issues would require extensive studies, and would potentially be very expensive to replace and test the protection systems. In some cases it may not be possible to provide adequate protection, even with upgraded systems.

Therefore, it may be necessary to restore the system strength within the affected portion of the power system. System strength could be restored by installing synchronous condensers or contracting existing synchronous generators. Restoring the operation of the protection systems using synchronous machines would likely:

- be lower cost, especially if the synchronous machines were also required to rectify other system strength issues within the affected power system
- present a lower risk as the protection systems would continue to operate in the manner in which they were designed.

Distribution protection issues

The mal-operation of protection systems at low fault levels is not restricted to transmission networks. Distribution networks consist of many thousands of individual transformers, overhead lines and cables, and each of these requires some form of protection system. In most cases, protection is provided by the use of fuses. These fuses are the simplest form of protection that operates when the current exceeds a threshold which is chosen such that:

- the normal currents that flow in the network do not exceed the threshold
- the currents that flow during a fault exceed the threshold, which results in the fuse operating to isolate the item of faulted equipment.

However, when the system strength in the distribution network reduces, the fault currents reduce making it more difficult or impossible to distinguish between normal operating conditions and when a fault occurs. A lower than anticipated fault current can mean that the fuses do operate but much slower than desired, resulting in unnecessary risk or damage to the affected network equipment. Therefore, in order for distribution system fuses operate correctly, system strength should be maintained to a sufficiently high level.

The system strength could be maintained by either the distribution network service provider (DNSP) or the TNSP that supplies the network distribution network. Currently most of the system strength within the distribution networks comes from their connections to the transmission network and could therefore be maintained when the TNSP maintains the system strength of its network. Alternatively, the system strength of the distribution network could be maintained by the DNSP itself such as with synchronous condensers or contracting with synchronous generation. It is important that the joint planning processes between the TNSPs and the DNSPs consider the most efficient options to address the system strength issues in both networks.

Voltage management issues

The potential technical solutions for voltage control problems depend on their severity and include:

- reinforcing the network with additional lines and/or transformers
- switchable capacitor and reactor banks
- dynamic voltage control devices such as SVCs and STATCOMs
- synchronous condensers.

Reinforcing the network

Increasing network connections can increase its system strength. This could consist of additional transmission lines or transformers, or by connecting to the network at a high voltage. The other advantage of reinforcing the network supplying a connection point is that it increases the size of the load or generating unit that can be connected.

Switched capacitor and reactor banks

Less severe voltage control issues can be resolved by installing switchable capacitor or reactor banks. These banks are normally switched automatically in response to the voltage but can be switched manually. A typical voltage control scheme using switched capacitor and/or reactor banks would include multiple capacitor banks to inject reactive power and may include reactor banks to absorb reactive power.

When the voltage at the connection point is lower than a threshold, an additional capacitor bank would be switched on, injecting reactive power into the network causing a step increase to the voltage at the connection point. Similarly, when the voltage is higher than a threshold, one of the capacitor banks can be switched off, reducing the injection of reactive power causing a step decrease to the voltage. The effect of switching reactor banks is the opposite.

The size of the voltage step is proportional to the size of the capacitor or reactor bank (in MVAr) being switched and inversely proportional to the system strength (in MVA). Therefore, the size of the switched capacitor or reactor banks needs to be sufficiently small so that the voltage step does not exceed the relevant standards for the minimum foreseeable system strength. If the system strength falls below this minimum level then, as well as the voltage steps exceeding the allowable standard, the associated voltage control scheme could be unstable.[135]

Dynamic voltage control devices

SVCs and STATCOMs are power electronic devices that provide dynamic reactive support at a connection point by automatically adjusting the reactive power injected or absorbed at the connection point as the system conditions change, such as the voltage at the connection point.

The advantage of SVCs and STATCOMs over switched capacitor and reactor banks is that the level of reactive power is infinitely variable between the maximum levels of absorption and injection. This means that they are inherently more stable and can be used to improve the stability of the power system. Also, the operation of SVCs and

135 A voltage control scheme that is based on switched capacitors and/or reactors would go unstable if the voltage step when a capacitor or reactor bank switches exceeds the difference between the thresholds to switch banks in and out. For example, if switching in a capacitor caused the voltage to increase from below the lower voltage control threshold to above the higher voltage control threshold then the control scheme would respond by switching the capacitor back out, thus becoming unstable.

STATCOMs is much less affected by the system strength, compared to switched banks, but such devices still require a minimum system strength to operate. An SVC or STATCOM could be used to stabilise the operation of a switched capacitor and reactor bank scheme.

The disadvantage of SVCs and STATCOMs is that they cost significantly more than a similarly sized switched capacitor and reactor banks scheme. An SVC does not contribute to the system strength of the power system where it is connected, while a STATCOM may provide a limited contribution to the system strength.

Synchronous condensers

As referred to elsewhere in this paper, a synchronous condenser (sometimes called a synchronous capacitor or synchronous compensator) is a spinning device, similar to a synchronous generator or motor, but whose shaft is not connected to a generating unit or motor load, instead spinning freely. Synchronous condensers can both inject and absorb reactive power at their connection point and their output is infinitely variable within their capability.

While the cost of synchronous condensers is approximately twice that of SVCs and STATCOMs,[136] they also contribute directly to the system strength at their connection points. That is, as well as providing an ability to control the voltage at its connection point, a synchronous condenser also increases the system strength in that part of the power system.

In addition, synchronous condensers also provide inertia when they are operating, and thus contribute to the ability to manage the system frequency.

An alternative to installing additional synchronous condensers would be to contract with synchronous generators to operate their units at times when the voltage is difficult to control.

A.1.3 Current allocation of roles and responsibilities

NSPs are currently are responsible for the provision and operation of the protection systems for their networks.[137]

In addition, rule 5.14 of the NER includes provisions for TNSPs and DNSPs to undertake joint planning of their respective networks to assess the adequacy of their existing transmission and distribution networks. This requires the TNSPs and DNSPs to use best endeavours to work together to ensure efficient planning outcomes and to identify the most efficient options to address the identified needs.

136 ElectraNet, Northern South Australia Region Voltage Control, RIT-T: Project Control Specification Consultation Report, August 2016, p. 4.

137 Schedule 5.1 of the NER requires NSPs to maintain the performance of the protection systems within their networks.

NSPs are also responsible for the management of the voltage within their network. As with issues associated with protection systems, it is not clear that there is any reason to change this allocation of responsibility in the future for parts of the network where the system strength is reducing over time.

Box A.1 AEMO's role in the dispatch of reactive power

While NSPs have clear responsibility for planning their networks to allow for the management of voltage, AEMO has an operational role at a transmission level, being responsible for the dispatch of reactive power from scheduled generating units with the objective of setting the profile of the voltage throughout the high voltage network (needed to maximize the transfer capability of the network while maintaining the power system in a secure operating state). AEMO dispatch instructions to scheduled generating units, semi-scheduled generating units, scheduled network services and scheduled loads can include reactive power outcomes (clause 4.9.5(a)(2)).

AEMO is required to determine the levels of reactive power reserve that are required to operate the power system (clause 4.5.2(a)). AEMO is also required to ensure that appropriate levels of reactive power reserves are available (clause 4.3.1(k)). AEMO further determines NSCAS needs that include the provision of reactive power reserves, including arranging the provision of reactive power facilities through ancillary services contracts (clause 4.5.1(f)). This can includes reactive power from synchronous generating units and synchronous condensers (clause 4.5.1(g)).

If the available reactive power reserves prove to be insufficient to keep voltages within acceptable limits, AEMO is required to take all reasonable actions to the extent necessary to return the voltages to acceptable limits (clause 4.5.2(b)). Such actions could include directing participants such as generators to reduce their output or limiting flows within the transmission network

A.2 South Australian Government's view

In the rule change request, the South Australian Government highlighted concerns relating to the operation of network protection systems. In particular, it noted that low fault levels (low system strength) can reduce the effectiveness of some network and protection systems. Low faults levels can make it more difficult to locate and clear faults within the network. The South Australian Government recognised that this impacts on both distribution and transmission networks.[138]

The rule change request did not propose a specific solution to address this issue. Instead, the South Australian Government has proposed that changes should be made to the NER to accommodate issues associated with low fault levels. The rule change

138 Minister for Mineral Resources and Energy (South Australia), *Rule change request – Low fault levels*, 12 July 2016, p. 1.

request proposes changes that would allocate responsibility for fault levels at different parts of the network, considering cost, incentives and allocation of risk.[139]

A.3 Stakeholder views

A.3.1 Consultation paper and interim report

Submissions in response to the Commission's consultation paper, which was published on 8 September 2016, agreed the importance of maintaining the capability of network protection systems and adequate voltage management in the NEM.[140]

In submissions to the interim report, no comments on the operation of network protection settings or management of network voltages were made.

A.3.2 Directions paper

In submissions to the directions paper, stakeholders did not provide many comments on the specific issues of network protection settings and network voltage management in low system strength conditions. Stakeholders generally supported NSPs being responsible for system strength.[141] RES supported the Commission's proposed approach to not make changes to the NER in relation to network protection settings. RES noted that NSPs must be sufficiently resourced to manage these emerging risks.[142]

A.4 Analysis

There are existing NER obligations that allocate responsibility to TNSPs and DNSPs to:

- maintain the operation of the protection systems for their respective networks[143]
- undertake joint planning to achieve efficient planning outcomes[144]
- management of the voltage within their network.[145]

The issues resulting from reduced system strength, and the consequential impacts on network protection systems and network voltage management, do not fall beyond the current responsibilities on NSPs. As a result, the Commission does not consider there is

139 Ibid, p. 2.

140 Submissions to the consultation paper: Ausgrid, p. 2; SEA Gas, p. 1; Hydro Tasmania, p. 7; ENA, p. 3.

141 Submissions to the directions paper: ENGIE, p. 5; RES Australia, p. 5.

142 RES Australia, submission to the directions paper, p. 5.

143 Schedule 5.1.9 of the NER.

144 Clause 5.14.1 of the NER.

145 Schedule 5.1 of the NER, Australian Standards and jurisdictional licensing conditions place obligations on NSPs to control the voltages within their networks to maintain the quality of supply to the users of their networks, in accordance with the relevant standards.

any need to change the obligation on NSPs in regards to protection settings and network voltage management.

However, what will be important is that both TNSPs and the DNSPs are aware that:

- they face risks with their protection systems not operating correctly and should be reviewing the need for mitigation measures
- voltage control issues are more likely to occur under unusual outage conditions that are generally not considered in planning studies
- the issues faced in the distribution networks may require actions within the transmission networks, which may be in addition to any measures that the TNSP needs to take to address the low fault level issues within its network.

A further issue for attention is the fact that the traditional models used to assess the behaviour of the power system are becoming less accurate at low system strengths and low inertia, and are generally optimistic about the security of the power system. Therefore, to accurately model the security of the power system, data for more detailed models is likely to be required. This is the subject of a rule change proposal recently received from AEMO.[146]

A.5 Conclusions

The draft rule does not make changes to the NER in relation to the management of network protection systems during periods of lower system strength. The Commission considered that the existing NER is sufficiently clear in allocating the responsibility of managing network protection settings to NSPs. The draft rule also does not make changes to the NER in relation to the management of network voltages.

The Commission noted that NSPs need to be aware of issues relating to reduced system strength and how this may interact with network protection settings and the ability to manage network voltages.

The Commission considers that not changing the existing NER will contribute to the achievement of the NEO. TNSPs and DNSPs are best placed to manage the operation of their protection systems and manage network voltages, including in parts of the network where the system strength is reducing, and this is given effect in the current arrangements in the NER.

146 AEMO, Generating systems model guidelines, *Rule change request*, 28 October 2016.

B Legal requirements under the NEL

This appendix sets out the relevant legal requirements under the NEL for the AEMC to make this draft rule determination.

B.1 Draft rule determination

In accordance with s. 99 of the NEL the Commission has made this draft rule determination in relation to the rule proposed by the South Australian Minister for Mineral Resources and Energy.

The Commission's reasons for making this draft rule determination are set out in sections 2.2 to 2.4.

A copy of the draft rule is attached to and published with this draft rule determination. Its key features are described in section 2.1.

B.2 Power to make the rule

The Commission is satisfied that the draft rule falls within the subject matter about which the Commission may make rules. The draft rule falls within s. 34 of the NEL as it relates to:

- the operation of the national electricity system for the purposes of the safety, security and reliability of that system
- the activities of persons (including Registered participants) participating in the national electricity market or involved in the operation of the national electricity system.

Further, the draft rule falls within the matters set out in schedule 1 to the NEL as it relates to:

- the operation of generating systems, transmission systems, distribution systems or other facilities
- the augmentation of transmission systems and distribution systems
- the application of a rule applicable to NSPs, to regulated transmission system operators, or to AEMO in its capacity as a provider of transmission services.

B.3 Commission's considerations

In assessing the rule change request the Commission considered:

- its powers under the NEL to make the rule
- the rule change request

- submissions received during consultation
- the Commission's analysis as to the ways in which the proposed rule will or is likely to, contribute to the NEO
- the ongoing package of work being undertaken by the Commission in conjunction with AEMO related to system security.

There is no relevant Ministerial Council on Energy (MCE) statement of policy principles for this rule change request.[147]

The Commission has not considered the revenue and pricing principles because the Commission considers that these are not relevant to this rule change request.

The Commission may only make a rule that has effect with respect to an adoptive jurisdiction if satisfied that the proposed rule is compatible with the proper performance of Australian Energy Market Operator (AEMO)'s declared network functions.[148] The draft rule is compatible with AEMO's declared network functions because as it leaves those functions unchanged.

B.4 Northern Territory considerations

The National Electricity (Northern Territory) (National Uniform Legislation) Act 2015 allows for an expanded definitions of the national electricity system in the context of the application of the NEO to rules made in respect of the Northern Territory, as well as providing the Commission with the ability to make a differential rule that varies in its terms between the national electricity system and the Northern Territory's local electricity system.[149] The Commission has considered whether a differential rule is required for the Northern Territory electricity service providers and concluded that it is not required in this instance. This is because the provisions of the draft rule either do not currently apply in the Northern Territory or, for the new Chapter 10 definitions, apply to parts of the NER that have not yet been adopted in the Northern Territory.

B.5 Civil penalties

The Commission's draft rule introduces new rules which the Commission will be recommending to the COAG Energy Council be classified as civil penalty provisions under Schedule 1 of the National Electricity (South Australia) Regulations. The

147 Under s. 33 of the NEL the AEMC must have regard to any relevant MCE statement of policy principles in making a rule. The MCE is referenced in the AEMC's governing legislation and is a legally enduring body comprising the Federal, State and Territory Ministers responsible for Energy. On 1 July 2011 the MCE was amalgamated with the Ministerial Council on Mineral and Petroleum Resources. The amalgamated council is now called the COAG Energy Council.

148 Section 91(8) of the NEL.

149 For the version of the NER that applies in the Northern Territory, refer to : http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/National-Electricity-Rules-(Northern-Territory).

Commission cannot create new civil penalty provisions. However, it may recommend to the COAG Energy Council that new or existing provisions of the NER be classified as civil penalty provisions.

The Commission considers that the following new provisions ought to be classified as civil penalty provisions:

- Clause 4.3.4(e1) - NSPs to plan and operate their networks so as to ensure that the short circuit ratios at relevant connection points is at least equal to the registered short circuit ratio at that connection point in certain power system conditions (i.e. in a secure operating state, following a credible contingency or following a protected event).

- Clause 4.6.1(e) – a Registered Participant must comply with a direction given by AEMO to manage a threat to power system security arising from a short circuit ratio being less than the applicable registered short circuit ratio.

- Clause 5.2.5(c) – a generator must comply with any terms of its connection agreement that provide for a system strength remediation scheme.

- Clause 5.3.4B(h), 5.3.4B(k), 5.3.4B(l), 5.3.4B(n) – these clauses set out strict timelines within which an NSP must respond to a proposed short circuit ratio, including by rejecting or accepting the proposal and the reasons for rejecting the proposal.

- Clauses 5.7.3A(a)-(c) – each Registered Participant that is required to have a system strength remediation scheme must provide evidence when requested by AEMO or the NSP that its facilities meet the requirements of that scheme. If they do not, the Registered Participant must inform AEMO and the NSP. If AEMO believes that the requirements of a system strength remediation scheme are not being complied with, it may instruct the Registered Participant to conduct tests.

- Clause 11.100.2 (a) – this clause oblige existing Registered Participants to register minimum short circuit ratios with AEMO no later than 1 July 2018 (unless there is a dispute).

- Clauses 11.100.3(d), 11.100.3(f), 11.100.3(h), and 11.100.3(i) – these clauses address the timing requirements for the process for negotiating and registering a short circuit ratio for existing generators and market network service providers.

The reasons that these clauses ought to be civil penalty provisions are:

- Clause 4.3.4(c1) is consistent with other similar obligations on NSPs in relation to their role in maintaining power system security, which are already classified as civil penalty provisions.

- It will encourage compliance by the relevant parties. A breach of clause 4.3.4(c1), clause 5.2.5(c), clauses 5.7.3A(a)-(c), or clause 4.6.1(e) could have a material

impact on power system security and reliability, and classification of these provisions as a civil penalty will encourage compliance with them.

- Clauses 5.3.4B(h), 5.3.4B(k), 5.3.4B(l), 5.3.4B(n), 11.100.3(d), 11.100.3(f), 11.100.3(h), and 11.100.3(i) will enable short circuit ratios to be negotiated and registered in a timely manner. This in turn will allow the NSP to be able to begin to perform its obligations to manage registered short circuit ratios.

These clauses will not operate as civil penalties until changes have been made to the Regulations.

C Summary of issues raised in submissions

This appendix sets out the issues raised in the first round of consultation on this rule change request and the AEMC's response to each issue. If an issue raised in a submission has been discussed in the main body of this document, it has not been included in this table.

Stakeholder	Issue	AEMC Response
Clean Energy Council	It will be critical that the National Electricity Rules provide ample opportunity for the connecting party to manage this risk and cost, rather than expecting the local TNSP to contract for the provision of these services in all cases (p. 6)	The draft rule allows for the connecting party to propose a system strength remediation scheme. This provides the connecting party with flexibility in addressing the impacts on its connection to the network.
S & C Electric	S & C Electric would strongly support an approach that allowed generators to meet their obligation by placing equipment on their site (p. 3)	
S & C Electric	The ability to “free-ride” is also a concern, with the last connecting generator potentially bearing more of the cost, than is merited by its single impact. All parties connected to that part of the system have contributed to the issue and have a role in the costs and the benefits. (pp. 3-4)	Under the draft rule, connecting parties would only be required to remediate the impacts associated with their connection.
S & C Electric	A fairer approach to the distribution of costs associated with maintaining system strength, rather than “causer pays” should be developed. “Causer pays” is likely to ensure that the deemed “causer” that triggers reinforcement (or the requirement to fund network support) is unlikely to connect and seek an alternative connection location that doesn’t have the additional cost.	Generators would be able to either connect and fund the associated costs of remediating system strength impacts or relocate to an alternate location. The system strength in that part of the network would be addressed either as a future generator connects, or when an NSP is maintaining system strength for the purposes of network protection systems or managing network voltages.

Stakeholder	Issue	AEMC Response
	This will mean that the reduced strength on that part of the network will not be addressed by a future connected generation nor the NSP (p. 4)	
Energy Queensland	Energy Queensland would recommend that as soon as a generator makes its pending retirement known to the market, the resultant short circuit ratio should be used for managing new connection applications (p. 5)	The NSP would need to consider this when meeting its obligation.
Energy Queensland	One of these changes is real-time management of system strength by AEMO (section 5.5.3) which could involve constraining the output of an affected generating system. Such a constraint may be possible for semi-scheduled and scheduled generators but this approach may not be effective where the generator is non-scheduled or exempt and AEMO lacks visibility and control (p. 6)	The Commission notes this issue. However, AEMO would be responsible for maintaining system strength on an ongoing basis and would need to undertake action necessary to maintain system security.
Hydro Tasmania	Care needs to be taken so that investments made now do not subsequently lock out investment in emerging technologies or market solutions in the future that provide a more cost effective solution for customers (p. 1)	NSPs will be obliged to undertake actions necessary to maintain system strength. Under network regulatory arrangements, NSPs have incentives to minimise costs by either undertaking investments or contracting for operational actions.
RES Australia	By introducing short circuit ratio requirements, synchronous condensers are favoured over less costly alternative technology. (p. 7)	
RES Australia	RES Australia opposes the proposal to place an obligation on NSPs to maintain the short circuit ratio at each generating system's connection point. RES Australia is concerned that the	The Commission considers it is crucial that system security is maintained. In order for this to be achieved, the Commission considers that system strength for existing generators should be maintained by NSPs to a level that allows them to meet their performance standards.

Stakeholder	Issue	AEMC Response
	proposal will result in unnecessary costs for new generators and ultimately consumers. (p. 1)	The Commission is not convinced that without this obligation on NSPs, the security of the system would be maintained. While the Commission notes that AEMO will have to maintain system security on an ongoing basis, this is likely to be inefficient and would likely be given effect through operational actions instead of investment in equipment where that may be the most efficient solution.
RES Australia	Any new rule that requires the explicit maintenance or increase of fault levels is likely to introduce unnecessary costs to consumers either through increased generation or network costs. (p. 4)	
RES Australia	The normalisation of system strength through the use of the short circuit ratio metric can introduce some significant issues. For example, if a number of generators with separate connection points are connected in the same part of the transmission network, a complicated short circuit ratio rationing approach may be required. RES Australia does not support the explicit use of the short circuit ratio metric within the NER. (p. 4)	The draft rule outlines a requirement for AEMO to determine a guideline for calculating short circuit ratios, including for circumstances where there is the need to ration system strength between multiple generators.
RES Australia	RES Australia suggested that the Commission explore the potential for NSPs to re-negotiate lower performance standards with existing generators with the objective of maintaining system security whilst minimising total costs. (p. 4)	The draft rule provides for the option of the NSP providing system strength works including negotiating with an existing generator to lower its registered short circuit ratio.
RES Australia	RES Australia does not support the view that there is a need to allocate responsibility to one or more parties to maintain short circuit ratio for existing generator connections. Introducing the requirement to maintain short circuit ratio for generator connections will result in unnecessary expenditure. The key issue is the ability of generators to continue to meet their performance	As discussed in chapter 3, there are issues that arise if existing generators were made responsible for maintaining system strength to a level that would allow them to meet their performance standards.

Stakeholder	Issue	AEMC Response
	standards. The rules should recognise this issue and not use short circuit ratio as a simplified proxy. (p. 5)	
RES Australia	RES Australia also notes that there may be a significant level of uncertainty and ambiguity if a large synchronous generator commits to retirement when a proposed asynchronous generator is undergoing the connection application process (p. 7)	The NSP is responsible for maintaining the short circuit ratio to existing generators when a large synchronous generator retires. New generators only need to do no harm in respect of the equipment they are connecting.
RES Australia	It will be essential that the NER provide sufficient opportunities for connecting generators to manage their own risks and costs, rather than allowing NSPs to select the preferred solution and pass through the associated costs (p. 7)	The NSPs need to coordinate activities related to system strength with their other activities. The draft rule provides connecting parties with the option of being able to propose a system strength remediation scheme to the relevant NSP. A system strength remediation scheme would allow connecting generators to manage their own risks and costs if accepted by the NSP and AEMO. System strength remediation schemes are discussed in more detail in chapter 4.
RES Australia	The registered short circuit ratio should be based on the technical ability of the generator to meet its performance standard, rather than the assumed short circuit ratio at the time of connection. (p. 7)	The Commission agrees. Under the draft rule, the registered short circuit ratio for existing generators would be based on technical capability.
RES Australia	There is typically a mismatch in design life between generating assets and network assets. For example, a connecting generator with a design life of 25 years should not be required to fund a network asset with a design life of 45 years. (p. 7)	This would need to be negotiated between the NSP and the generator. As discussed above, generators would have the option of proposing a system strength remediation scheme as an alternative to being provided system strength connection works by the NSP.
RES Australia	The directions paper has not outlined a cost sharing methodology for short circuit ratio	Chapters 3 and 4 of this draft determination discuss cost recovery for

Stakeholder	Issue	AEMC Response
	augmentations (p. 8)	existing and new generating systems.
Clean Energy Council	It will be critical that the NER provide ample opportunity for the connecting party to manage this risk and cost, rather than expecting the local TNSP to contract for the provision of these services in all cases (p. 6)	The draft rule allows for the connecting party to propose a system strength remediation scheme. This provides the connecting party with flexibility in addressing the impacts on its connection to the network.
Clean Energy Council	The NER already carry an obligation in cl. 5.3.5(d) that prevents a connecting generator from doing harm to the performance standards of an existing generator. It is unclear why an additional system strength obligation is required to be considered. (p. 6)	The Commission considers that the draft rule clearly allocates responsibility for maintaining system strength. Additionally, the draft rule makes clear that connecting parties would be required to pay the costs associated with the impact of their connection on existing generators' registered short circuit ratios.
Clean Energy Council	System strength obligations should be limited to the transmission network. They can already be managed locally within the distribution network generator connections arrangements and procedures (cl. 5.3.5(d)). Given there is thousands of kilometres of weak distribution network in the NEM, blanket minimum standards, if applied to distribution networks, would have major investment ramifications for DNSPs (and consumers) that have not been justified by this review. (p. 7)	The Commission considers that the same system security risks of large generator failures present in the transmission network extend into the distribution network. DNSPs would be required to maintain system strength at a sufficient level for connected generator in addition to current obligations to maintain effective network protection systems and manage network voltages. The Commission notes that the most efficient solution to low system strength in distribution networks may be implemented in the transmission network. This option is provided for under the joint planning obligations in the NER.
Clean Energy Council	The power quality (harmonics and flicker) allocation processes already set a precedent that should be replicated for system strength (p. 7)	The process for allocating power quality is contingent on a determined level of power quality that can be allocated to connected parties. The Commission acknowledges that while this approach may be applicable when a new generator connects to a part of the network with sufficient system strength, it does not provide for circumstances such as the retirement of a synchronous generator reducing the

Stakeholder	Issue	AEMC Response
		available system strength.
Clean Energy Council	As the TNSP may be the provider of the system strength through meeting its inertia requirements, the NER should be clear that this would be a negotiated service provided under the negotiating guidelines and with scope for the use of the independent engineer, as set out by the *Transmission connections and planning arrangements* rule change. (p. 7)	Under the draft rule, if a TNSP is providing system strength connection works to a connecting generator, this would be provided as a negotiated transmission service. As such, the connecting party and the TNSP would be able to call for independent technical advice from an independent engineer.
Clean Energy Council	The Commission's proposal to consider applying minimum short circuit ratio standards to inverter-based generation omits the stability limits of synchronous plant. If a standard is to be applied, it should be technology neutral and apply to all generating equipment (p. 7)	The draft rule does not impose minimum short circuit ratio standards on inverter based generation, although this is being considered in the *System security market frameworks review*.
AEMO	There may be merit in considering what would drive acceptable minimum levels of short circuit ratio, and whether the NER should provide guidance or standards in relation to that. (p. 27)	The draft rule will introduce a requirement for AEMO to develop short circuit ratio calculation guidelines. These guidelines would provide guidance to connecting parties and NSPs on how to determine short circuit ratios.
AEMO	It would be important to consider a broad range of factors when considering whether inverter based generation should be able to operate at a certain short circuit ratio. This should cover the possibility of: • Some generating systems might have many generating units that are geographically and electrically remote from the connection point while other generating systems might have few generating units close to the connection	The draft rule does not require generators to be able to operate at a certain short circuit ratio. The draft rule will include a requirement for AEMO to develop short circuit ratio calculation guidelines to maintain an effective level of system strength. These guidelines should: • include the method for calculating the short circuit ratio from a given set of fault levels within the network • provide guidance to the NSP as to the different network conditions

Stakeholder	Issue	AEMC Response
	point. • Some central network solutions might have lower overall cost than multiple solutions at multiple individual generating units. • Some network locations might have high system strength so the improved generating unit performance might not be necessary (p. 27)	and dispatch patterns that should be examined by the NSP when determining the fault levels within the network.
Application to the distribution network		
Energy Queensland	The review should be broadened to include system security at the DNSP level. (p. 2)	The draft rule allocates responsibility for system strength in distribution networks.
ENA	A more specific role may need to be identified for the distribution network to address system security (p. 10)	