Australian Energy Market Commission

RULE DETERMINATION

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

Rule Proponent(s)

South Australian Minister for Mineral Resources and Energy

19 September 2017

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Reference: ERC0211

Citation

AEMC 2017, Managing power system fault levels, Rule Determination, 19 September 2017, Sydney.

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.

Executive Summary

The Australian Energy Market Commission (AEMC or Commission) has made a final rule, which is a more preferable rule, and final determination to establish a transparent and efficient framework for the management of power system fault levels, also known as system strength, in the National Electricity Market (NEM). This framework also sets out clear allocation of roles and responsibilities for the Australian Energy Market Operator (AEMO) and network service providers (NSPs) in the management of system strength.

The final 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.

The final rule:

- requires AEMO to develop a system strength requirements methodology from which it can determine the minimum required fault level at locations in each transmission network (referred to in the final rule as "fault level nodes") necessary for the power system to be maintained in a secure operating state. AEMO will then be required to assess whether a fault level shortfall exists or is likely to exist in the future.

- provides a clear and transparent framework that requires transmission network service providers (TNSPs) to procure system strength services needed to provide the levels determined by AEMO if AEMO has declared a shortfall. AEMO will be able to enable the system strength services provided by TNSPs and third-party providers under specific circumstances in order to maintain the power system in a secure operating state. This framework is different to what was considered in the draft rule and is similar to that being implemented in the *Managing the rate of change of power system frequency* rule change request.

- requires AEMO to develop system strength impact assessment guidelines that set out a methodology to be used by NSPs and generators when assessing the impact of a new generator connection on system strength. The rule also introduces the ability for a new connecting generator to dispute the application of those guidelines, the model used in the assessment of the adverse system strength impact, or the results of a system strength impact assessment made using those guidelines.

- introduces a requirement on new connecting generators to 'do no harm' to the security of the power system, in relation to any adverse impact on the ability of the power system to maintain system stability or on a nearby generating system to maintain stable operation, in accordance with AEMO's system strength impact assessment guidelines.

- includes interim system strength impact assessment guidelines, made and published by AEMO that apply from 17 November 2017 until 1 July 2018.
- includes transitional arrangements that can provide for the current network support and control ancillary service (NSCAS) gap declared by AEMO[1] to transition into the framework above.

The rule change request

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

The rule change request proposed to amend the NER to address issues associated with low fault levels arising from reduced levels of synchronous generation in the NEM, and to allocate responsibility for setting fault levels at different parts of the network that take account of costs, incentives and allocation of risk.[2] The proponent claimed that a reduction in fault levels in certain areas on the network may result in generators being unable to remain connected to the system at certain times.[3]

What is system strength?

System strength is a characteristic of an electrical power system that relates to the size of the change in voltage following a fault or disturbance on the power system. System strength can be measured by the availability of fault current at a given location. High fault levels are generally found in a strong power system while low fault levels are representative of a weak power system. When the system strength is high at a connection point the voltage changes very little for a change in the loading (i.e. a change in load or generation). However, when the system strength is lower the voltage would vary more with the same change in loading.

Reducing system strength in the NEM

Historically, the main concern has been that fault levels have been too high which can cause the failure of some network protection elements.

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. This can mean that the system strength is not sufficiently high to keep the remaining generating systems stable and remaining connected to the power system following a major contingency in the power system, which introduces the risk of a cascading outage and a major supply disruption (or widespread blackouts). Similarly, the stability of the power system can reduce when additional non-synchronous generators connect to the network.

1 AEMO, Update to the 2016 National Transmission Network Development Plan, 13 September 2017.

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

3 Ibid.

Managing reduced system strength

The Commission considers that TNSPs are the best party to allocate the responsibility to maintain system strength such that the power system can be kept in a secure operating state. TNSPs have a holistic perspective of their networks and are best placed to manage the risks associated with this obligation. In addition the existing incentive based economic regulatory framework will provide an incentive for the TNSP to assess the least-cost approach to meeting the obligation with oversight by the Australian Energy Regulator (AER). Having system strength maintained by TNSPs is likely to result in more efficient investment decisions that reduce long-term costs for consumers.

The Commission considers that TNSPs 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 rules make NSPs responsible for the functioning of protection systems and the management of network voltages; both of which become more difficult as system strength reduces, as TNSPs will be able to co-optimise the sources of system strength services with the provision of other necessary system security services such as inertia.

Obligation on AEMO to determine system strength requirements

The final rule places an obligation on AEMO to develop a methodology ("system strength requirements methodology") that sets out the process for how it will determine the system strength needed in each region ("system strength requirements"). When AEMO specifies the system strength requirements for a region, it will need to define this in terms of:

- the "fault level nodes" in the region, being the location on the transmission network for which fault level must be maintained at or above a level determined by AEMO
- for each fault level node, the minimum three phase fault level.

Following the determination of system strength requirements for each region, AEMO must undertake an assessment of any fault level shortfall. If AEMO assesses that there is, or is likely to be, a shortfall, it is required to publish a notice and give it to the relevant TNSP. This notice must specify the extent of the fault level shortfall and the date by which the TNSP must provide services to address the shortfall (the services to address the fault level shortfall are "system strength services"). This date must not be earlier than 12 months after the notice is published (unless otherwise agreed), to allow the TNSP sufficient time to much the services available).

Obligation on TNSPs to maintain system strength

Following the receipt of a notice from AEMO declaring a shortfall, the TNSP must make system strength services available to AEMO in accordance with the specification in the notice. These services must cover the system strength requirements for the region and must be provided by the date specified by AEMO.

When procuring these services, the TNSP is required to identify and implement the least cost option or combination of options. If AEMO requires the services less than 18 months after the publication of the notice, and prior to the notice being given, the TNSP had not been under an obligation to provide system strength services for that fault level node, the TNSP isn't required to undertake a regulatory investment test for the relevant transmission investment. This will allow the TNSP to equally assess the best combination of operational expenditure (e.g. contracting with synchronous generators) and network expenditure (e.g. building a fault level source on the network).

Following the provision of system strength services, AEMO is able to enable these services to maintain the secure operation of the region.

Obligation on new connecting generators to 'do no harm'

The final rule places an obligation on new connecting generators to 'do no harm' to the level of system strength necessary to maintain the security of the power system.

The 'do no harm' obligation in the final rule applies to generators connecting to both the transmission network and distribution network under Chapter 5 (i.e. under rule 5.3 and rule 5.3A) of the NER. It does not apply to the connection of micro-embedded generation, such as residential photovoltaics (PV).

Under the final rule, when a new generator is negotiating its connection with the relevant NSP, a system strength impact assessment will be required to be undertaken by the NSP to assess the impact of the connection of the generating system on the ability of the power system to maintain stability in accordance with the NER, and for other generating systems to maintain stable operation including following any credible contingency event or protected event.

This assessment would be performed using a methodology and power system model set out in system strength impact assessment guidelines developed and published by AEMO. In developing these guidelines, AEMO must follow the Rules consultation procedure. These guidelines must specify the nature of what AEMO considers to be an "adverse system strength impact", i.e. "doing harm". The guidelines will also provide guidance about the different network conditions and dispatch patterns and other relevant matters that should be examined when undertaking an assessment. A dispute mechanism has been put in place for a new connecting generator which effectively will allow the generators to dispute the allocation of costs associated with remediating the assessed harm.

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 of its connection on system strength. This will incentivise new connecting generators to be able to operate at lower levels of system strength and to connect to the network where there is sufficient system strength. As a result, new connecting generators will be able to consider the costs of remediating adverse system strength impacts when making investment decisions. This will reduce overall costs to the system of new generator connections as these connections start to adversely affect power system stability.

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 will be incorporated into the connection agreement between the generator and the NSP. TNSPs will then be responsible for maintaining system strength on an ongoing basis.

Transitional arrangements

The final rule places a requirement on AEMO to develop interim system strength impact assessment guidelines. These guidelines will apply from 17 November 2017 until AEMO publishes revised guidelines, which AEMO is required to do by 1 July 2018.

The Commission is of the view that this will mean the impact of generators connecting between these dates can be effectively managed.

Reasons for making the final rule

Having regard to the issues raised in the rule change request and during consultation, the Commission is satisfied that the more preferable final rule will, or is likely to, better contribute to the achievement of the NEO than the rule proposed by the proponent for the following reasons:

- The framework in the final 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 TNSP. The framework enables TNSPs to identify efficient solutions that support long run efficient operation, use and investment in electricity services.

- The existing economic regulatory framework will provide an incentive for the TNSP to assess the least-cost approach to meeting the obligation with oversight by the AER. The final rule will allow the TNSP to meet the obligation in the short-term by contracting with existing third-party providers of fault level or investing in network assets, while concurrently assessing the most efficient means of meeting the obligation over the long term

- The final rule places an obligation on AEMO to assess the system strength requirements of the power system on a regular basis, including nominating fault level nodes where minimum fault levels are specified, and to identify any fault level shortfalls. The results of AEMO's assessment will be published in the national transmission network development plan (NTNDP). This obligation is consistent with AEMO's general obligation to maintain the power system in a secure operating state. Also, requiring AEMO to develop a system strength requirements methodology for it to apply when assessing the system strength requirements, including how it nominates the fault level nodes and whether a fault level shortfall exists, provides transparency and certainty to stakeholders.

- The periodic review of the minimum required fault level, and so possible fault level shortfalls which a TNSP is required to provide services to meet, and an obligation on the TNSP to identify and procure the least cost option or combination of options to meet its fault level obligation, will assist in making sure that investments are efficient and reflective of changing market conditions.

- The final rule provides for a holistic, flexible and technologically neutral solution to issues arising from reduced system strength by requiring TNSPs to maintain system strength at the levels determined by AEMO, under the range of operating conditions specified by AEMO. 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. TNSPs 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, as well as co-optimise these services with other services necessary for system security. This should result in a more efficient outcome for consumers in the long term by minimising the potential duplication of investment.

- New connecting generators would be required to 'do no harm' to the stability of the existing power system. This imposes the associated costs of maintaining system strength at the relevant connection point and neighbouring network upon the connection of the new 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. Also, requiring AEMO to develop system strength impact assessment guidelines, to be applied by generators and NSPs when assessing the impact of a connecting generating system, provides transparency and consistency between NSPs in assessing harm arising from the connection of new generators.

Differences between the draft and final rule

The draft rule required NSPs (both TNSPs and DNSPs) to maintain system strength by providing each generator with a short circuit ratio at its connection point.[4] However, short circuit ratios are an overly simplistic measure of system strength that may not always be a good indication of system security risks, including the potential impacts of connecting generators.

The final rule better maintains system security at an efficient cost by considering system strength in a region as opposed to at each generator connection point. It is not necessary to maintain system strength at every connection point to maintain system security. The risk to system security of generators not operating stably is not consistent for all generators. That is, for a small, remotely connected generator, the risk of the generator not being able to withstand a fault does not pose the same risk to system

4 Short circuit ratios are an alternative measure for system strength where the short circuit ratio is the system strength in MVA to the capacity of the associated generating systems in MW.

security when compared to the risk of a large generator connected in a highly meshed part of the network being unable to ride-through a fault. Maintaining a short circuit ratio for all connected generators would inefficiently over-emphasise the risk to system security of certain generators not operating in a stable manner.

The transitional arrangements set out in the draft rule involved agreeing a short circuit ratio at generator connection points to be maintained by NSP. There is the potential for this to create an onerous burden on generators, NSPs and AEMO. For many existing generators, determining a minimum short circuit ratio could be expensive, particularly if it required the involvement of the original equipment manufacturer.

The draft rule therefore created a risk of over investment in services to manage the system strength. Both the generators and NSPs would be incentivised to specify inefficiently high minimum short circuit ratios. This could have led to perverse outcomes, where new generation faced a significant barrier to entry and NSPs maintained an inefficiently high short circuit ratio for existing generators.

Therefore, the Commission is of the view that assessing system strength issues using the system strength requirements methodology and system strength impact assessment guidelines would be likely to better maintain system security and would be less likely to lead to inefficient investments in system strength services. The revised framework in the final rule, as it relates to address fault level shortfalls in a region, is similar to that being implemented in the *Managing the rate of change of power systems frequency* rule change request, and share many of the same features.

The final rule also excludes from the definition of a "NSCAS need" any requirement for system strength services to address a fault level shortfall. The Commission considers that it is undesirable to have two frameworks in the NER for the provision of equivalent services, that is, both system strength services provided under the existing network support and control ancillary service (NSCAS) framework and under the new framework, for providing the required level of system strength.

Commencement of the final rule

The obligations under the final rule for new connecting generators to 'do no harm' when connecting to the network will commence on 17 November 2017. By this date, AEMO is required to publish interim system strength impact assessment guidelines. By 1 July 2018, AEMO is required to have published a version of the guidelines that have followed the Rules consultation procedure.

New obligations stemming from the final rule in relation to the ongoing obligation for TNSPs to maintain required levels of system strength will commence on 1 July 2018. By this date AEMO must have developed and published the methodology it will use to determine system strength requirements for each region in the NEM, determine minimum three phase fault levels for each region and whether there will be a fault level shortfall. If a shortfall is declared the relevant TNSP will have been given notice by AEMO of this shortfall by this time and will then need to have system strength services available to address the shortfall by 1 July 2019.

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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 proposed 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.[5]

The rule change request did not include a proposed rule.

1.2 Approach to the final determination

The rule change request has been considered concurrently with, and informed by the broader system security work programme of the AEMC, and technical work undertaken by AEMO as part of its Future Power System Security Program (FPSS).

This final determination effectively implements a key recommendation made in the Commission's final report on the *System security market frameworks review*.[6]

The report made a number of recommendations, both for immediate measures to address priority issues and a further program of work to develop robust market frameworks for the longer term.

The Commission has been assessing a number of rule change requests relating to a number of the priority issues that were considered as part of the *System security market frameworks review*. It is also undertaking further reviews into other critical aspects of system security including the *Frequency control frameworks review*, and working collaboratively with AEMO and other key stakeholders.

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

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

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

6 AEMC, *System security market frameworks review - final report*, 27 June 2017.

1.3 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 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.

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.[7]

1.4 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.[8]

1.5 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. For more background information relating to system strength refer to Appendix A.

1.5.1 Reducing system strength

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 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 being 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.

When new non-synchronous 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, effective system strength at the connection point of existing generators would decrease as additional new units are connected, even if the fault level does not change.

In the 2016 *National transmission network development plan* (NTNDP), AEMO performed a high-level assessment to locate areas of low system strength.[9] 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 1.1.

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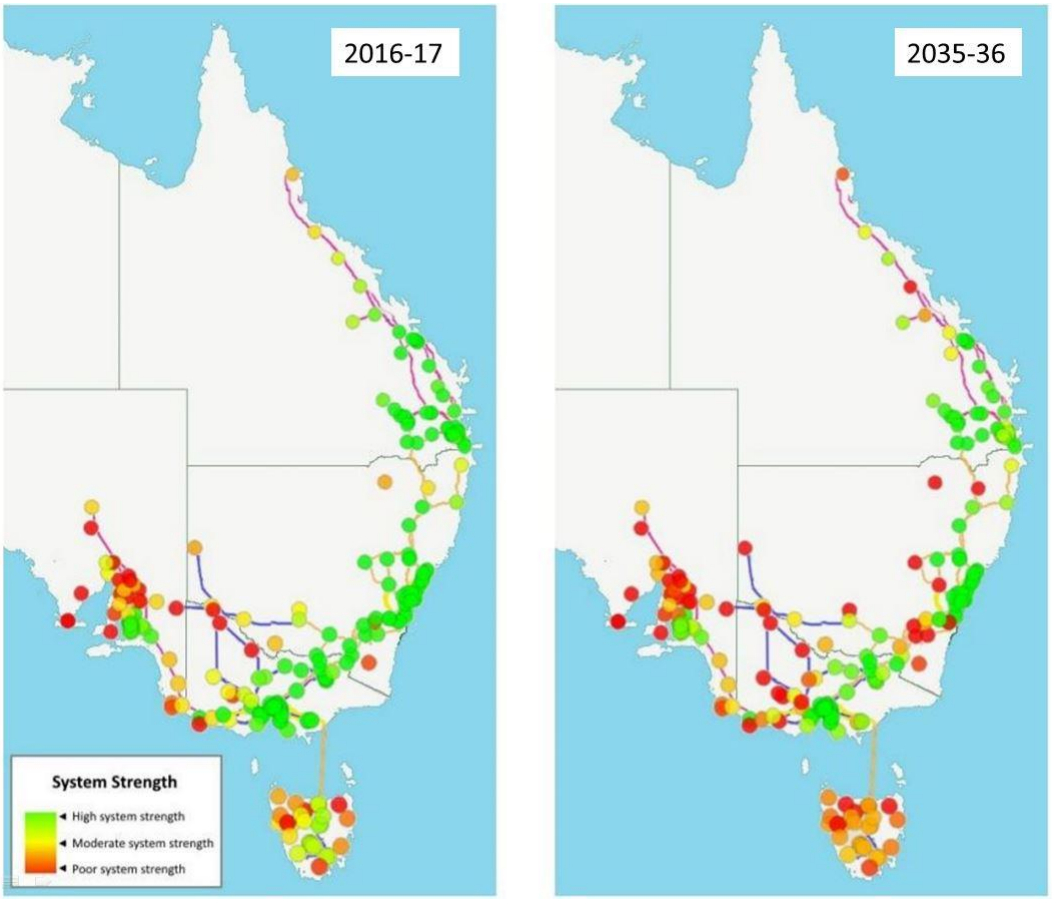
7 More information on PSI-TAG is available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/FPSSP-Reports-and-Analysis

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

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

Figure 1.1 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.[10]

1.6 Maintaining sufficient system strength for power system security

1.6.1 Technical envelope

The security of the power system relies on AEMO operating the power system within a technical envelope. This envelope accounts for a number of technical parameters including power system voltage, frequency and the operation of equipment within its rated limits. For AEMO to be able to operate the power system securely, it is reliant on being able to anticipate the performance of equipment in the power system, particularly large generators and large loads.

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

The NER requires that generator connection applicants must provide the NSP and AEMO with sufficient information to assess its expected impact on the operation of the power system.[11] This includes the type and size of the generating system being considered, detailed models of the generating system and the associated control and protection systems. Typically, this assessment has been undertaken with a presumption that there will be a minimum level of system strength at each generator's connection point. Historically, this level of system strength has been freely available due to the large numbers of synchronous generators present in the network.

However, as noted above, the level of system strength typically available throughout the network has been reducing as synchronous generators retire and non-synchronous generators connect to the network.

Of particular concern in a power system with reduced system strength is the operation inverters used by modern wind farms, high voltage direct current (HVDC) interconnectors, solar PV and battery storage. This is because inverters require sufficient system strength to be 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.

While synchronous generators have traditionally provided system strength, reduced system strength can also compromise the ability of these synchronous generators to connect to, and generate into the network. With low levels of system strength, synchronous machines become unstable and may be incapable of normal operation or may not be able to stay connected following a fault.

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 with 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 able to operate stably during periods of low system strength, this could lead to a cascading outage or major supply disruption, or even potentially a black system condition.

1.6.2 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. Potential solutions 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.

11 Clause S5.2.1 of the NER.

- Reinforcing the network with additional lines and/or transformers.
- Installing static VAr compensators (SVCs),[12] static synchronous compensators (STATCOMs)[13] 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 increases fault levels in the network.

1.7 Existing arrangements under the NER

1.7.1 Responsibility for network system strength

The NER do not place an 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.

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.

1.7.2 Responsibility for protection systems and network voltages

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.

12 A SVC is a fast acting power electronic device that provides reactive power generation or absorption in a 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.

13 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.

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[14]
- step changes in the level of voltage, which must be smaller than the limits set in the Australian Standards[15]
- voltage unbalance,[16] which must be smaller than the limits required by the Australian Standards.[17]

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,[18] AEMO is responsible for the dispatch of reactive power[19] from scheduled generating units.[20] AEMO's responsibilities with regard to power system security[21] include:[22]

- 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.

14 Schedule 5.1a.4 of the NER.

15 Schedule 5.1a.5 of the NER.

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

17 Schedule 5.1a.7 of the NER.

18 Schedule 5.1.4 of the NER.

19 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.

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

21 Section 49A of the National Electricity Law (NEL) gives AEMO the power to do all things necessary or convenient for, or in connection with, its statutory functions that include, under s.49, to maintain and improve power system security.

22 Clause 4.3.1 of the NER.

1.8 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 requests.[23]

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.[24]

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.

On 27 June 2017, the Commission published a draft rule and a draft determination on the *Managing power system fault levels* rule change request. Submissions closed on 8 August 2017. 17 submissions were received.

All of these documents, and submissions to them, are available on the AEMC website.[25]

The Commission has considered the issues raised by stakeholders in submissions relating to the *System security market frameworks review* and the draft determination. Issues raised in submissions relating to system strength are discussed and responded to throughout this final rule determination. The issues raised in stakeholder submissions that are not addressed in the body of the determination are contained in appendix C alongside the Commission's response.

23 This notice was published under s. 95 of the NEL.

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

25 Available at: http://www.aemc.gov.au/Markets-Reviews-Advice/System-Security-Market-Frameworks-Review and http://www.aemc.gov.au/Rule-Changes/Managing-power-system-fault-levels

1.9 Structure of final rule determination

This final rule determination is set out as follows:

- Chapter 2 sets out a summary of the Commission's final rule determination, including its assessment framework and summary of reasons for making the final rule.
- Chapter 3 sets out how the final rule places an obligation on AEMO to develop a methodology for determining the level of system strength needed in each region.
- Chapter 4 sets out the obligation on TNSPs to procure system strength services to meet the required level of system strength following AEMO's declaration of a shortfall.
- Chapter 5 describes the 'do no harm' arrangements for new connecting generators.
- Chapter 6 sets out the process of transitioning to the commencement of the final 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 final rule determination.
- Appendix C provides the Commission's response to stakeholder comments that are not addressed elsewhere in the final rule determination.

2 Final rule determination

The Commission's final rule determination is to make a more preferable final rule. The more preferable final rule places an obligation on AEMO to determine the system strength requirements in each region (the three phase fault level at specified nodes that could reasonably be considered to be sufficient for the power system to be in a secure operating state).

Further, the final rule places an obligation on TNSPs that are System Strength Service Providers to provide, and make continuously available, system strength services such that the region has sufficient system strength to allow AEMO to maintain the system in a secure operating state. The final rule also requires new connecting generators whose connection would have adverse system strength impact on the ability of the power system to maintain power system stability to provide a system strength remediation scheme or fund system strength connection works provided by the relevant NSP to mitigate that adverse impact.

This chapter outlines:

- the key features of the final rule
- the rule making test for changes to the NER
- the more preferable rule making test
- the assessment framework for considering the rule change request
- the Commission's consideration of the final rule against the national electricity objective.

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

2.1 The Commission's final rule determination

The more preferable final rule made by the Commission is attached to and published with this final rule determination. The key features of the final rule are as follows:

AEMO determines system strength requirements

An obligation on AEMO to:

- develop and publish as part of the national transmission network development plan (NTNDP) consultation process, a system strength requirements methodology setting out the process it will use to determine the system strength requirements for each region[26]

26 Final rule clause 5.20.2(c)(13).

- take into account the following in determining the fault level nodes and minimum three phase fault level in the system strength requirements methodology:
  - the combination of three phase fault levels at each fault level node in the region that could reasonably be considered to be sufficient for the power system to be in a secure operating state[27]
  - the maximum load shedding or generation shedding expected to occur on the occurrence of any credible contingency event or protected event affecting the region[28]
  - the stability of the region following any credible contingency event or protected event[29]
  - the risk of cascading outages as a result of any load shedding or generating system or market network service provider tripping as a result of a credible contingency event or protected event in the region[30]
  - additional contribution to the three phase fault level needed to account for the possibility of a reduction in the three phase fault level at a fault level node if the contingency event that occurs is the loss or unavailability of a synchronous generating unit or any other facility or service that is material in determining the three phase fault level at the fault level node[31]
  - the stability of any equipment that is materially contributing to the three fault level or inertia within the region[32]
  - any other matters that AEMO considers appropriate.[33]
- determine, generally no more than once in any 12-month period, the "system strength requirements" for each region, being:
  - the fault level nodes in the region (being the location on the transmission network for which the three phase fault level must be maintained at or above a minimum three phase fault level)[34]
  - for each fault level node, the minimum three phase fault level.[35]
- publish the system strength requirements determined for each region in the NTNDP.[36]

27 Final rule clause 5.20.7(b)(1).

28 Final rule clause 5.20.7(b)(2).

29 Final rule clause 5.20.7(b)(3).

30 Final rule clause 5.20.7(b)(4).

31 Final rule clause 5.20.7(b)(5).

32 Final rule clause 5.20.7(b)(6).

33 Final rule clause 5.20.7(b)(7).

34 Final rule clause 5.20C.1(b)(1).

35 Final rule clause 5.20C.1(b)(2).

AEMO determines and provides notice of any fault level shortfall

- An obligation on AEMO to:
  - assess whether, in its reasonable opinion, there is, or is likely to be, a fault level shortfall in a region, taking into account matters specified in the final rule. A fault level shortfall is when the fault level at fault level nodes typically provided in a region falls below the system strength requirements most recently determined by AEMO for the region[37]
  - where there is, or is likely to be, a fault level shortfall in a region, publish and give to the System Strength Service Provider for the region a notice of the assessment.[38] The System Strength Service Provider is the TNSP for the region that is the jurisdictional planning body for the relevant jurisdiction[39]
  - give notice of the extent of the fault level shortfall at the relevant fault level node[40]
  - give notice of the date that the System Strength Service Provider must provide for the availability of system strength network services, which must not be earlier than 12 months after the date that the notice of the assessment is published, unless an earlier date is agreed with the System Strength Service Provider[41]
  - provide five-year projections of fault level shortfalls in the NTNDP.[42]
- The final rule excludes from the definition of a "NSCAS need" any requirement for system strength services to address a fault level shortfall.[43]

System Strength Service Provider makes system strength services available

An obligation on the TNSP that is the System Strength Services Provider to:

- make system strength services available to AEMO[44]
- give AEMO information about system strength services made available by the System Strength Service Provider[45]

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36 Final rule clause 5.20C.1(c).

37 Final rule clause 5.20C.2(a).

38 Final rule clause 5.20C.2(c).

39 Final rule clause 5.20C.3(a).

40 Final rule clause 5.20C.2(c)(1).

41 Final rule clause 5.20C.2(c)(2).

42 Final rule clause 5.20C.2(c)(14).

43 Final rule, new Chapter 10 definition of "NSCAS need".

44 Final rule clause 4.3.4(l).

45 Final rule clause 4.3.4(m).

- comply with an instruction from AEMO to provide system strength services[46], including ensuring that appropriate personnel or electronic facilities are available at all times to receive and immediately act upon instructions issued by AEMO[47]
- when making system strength services available to AEMO:
  - use reasonable endeavours to make the system strength services available by the date specified by AEMO[48]
  - make a range and level of system strength services available such that it is reasonably likely that system strength services that address the fault level shortfall when enabled are continuously available, taking into account planned outages, the risk of unplanned outages and the potential for the system strength services to impact typical patterns of dispatched generation in central dispatch[49]
  - maintain the availability of those system strength services until the date the System Strength Service Provider's obligation ceases[50]
  - make available the least cost option or combination of options that will satisfy its obligation in the time required.[51]

System Strength Service Provider provides information on system strength services

An obligation on the System Strength Services Provider to:

- provide information in its transmission annual planning report (TAPR) about the activities undertaken to meet its obligations to provide system strength services[52]
- where it proposes network investment to provide system strength services, must publish in its next TAPR:[53]
  - a description of the requirement for system strength services including timing[54]
  - the technical characteristics that a non-network option would be required to deliver, such as the contribution to the three phase fault level, location, availability, response time and operating profile[55]

46 Final rule clause 4.4.5(f).

47 Final rule clause 4.4.5(g).

48 Final rule clause 5.20C.3(c)(1).

49 Final rule clause 5.20C.3(c)(2).

50 Final rule clause 5.20C.3(c)(3).

51 Final rule clause 5.20C.3(d).

52 Final rule clause 5.20C.3(f).

53 Final rule clause 5.20C.3(f).

54 Final rule clause 5.20C.3(e)(1).

  - a summary of potential options to make the system strength services available identified by the System Strength Service Provider, including network options and non-network options[56]

  - information to assist providers of non-network options wishing to present proposals to the System Strength Service Provider including details of how to submit a proposal for consideration.[57]

- give AEMO a schedule setting out the system strength services it has available and the System Strength Service Provider's proposed order of priority for those services to be enabled by AEMO[58]

- notify AEMO of any event which has changed or is likely to change the availability of any system strength services made available by the System Strength Service Provider to AEMO[59]

- register any synchronous generating unit from which it is procuring system strength services as a system strength generating unit with AEMO and specify that the generating unit must be constrained on when it is providing system strength under clause 3.9.7(e) of the final rule[60]

- provide specified details of the system strength services it is making available to AEMO and seek AEMO's approval for the technical specifications and performance standards for those services and for the information necessary for AEMO to enable or cease the provision of those services. AEMO must approve this information or advise the System Strength Service Provider of the reasons for withholding its approval, and the changes it requires to be made.[61]

Recovery of System Strength Service Provider's costs of making system strength services available

- The obligation to make system strength services available is a regulatory obligation imposed on the relevant TNSP. The provision of system strength services will be a prescribed transmission service. The System Strength Service Provider will be entitled to seek a revenue allowance that includes forecast operating expenditure or capital expenditure for its efficient costs of meeting these requirements.

- The final rule amends the definition of "network support payment" to include payments made by a TNSP under a system strength services agreement (system

55 Final rule clause 5.20C.3(e)(2).

56 Final rule clause 5.20C.3(e)(3).

57 Final rule clause 5.20C.3(e)(4).

58 Final rule clause 5.20C.4(a).

59 Final rule clause 4.9.9D.

60 Final rule clause 5.20C.4(b).

61 Final rule clause 5.20C.4(d).

strength service payments). This means that the TNSP can use a network support pass through under clause 6A.7.2 of the existing NER to recover the difference between system strength service payments included in its operating expenditure allowance for a regulatory year and its actual system strength service payments provided that the relevant system strength service payment was not included in the calculation of a pass through amount approved by the AER under clause 6A.7.3 of the NER.[62]

- The final rule amends the definition of "pass through event" in cl 6A7.3 a "fault level shortfall event". A fault level shortfall event occurs where a TNSP is required to provide, or cease providing, system strength services, and meeting this requirement materially increases or materially decreases the TNSP's costs of providing prescribed transmission services.[63]

TNSP planning investments to meet requirement to provide system strength services

- Under the final rule the regulatory investment test for transmission (RIT-T) does not apply to proposed expenditure on "system strength service payments"[64] or to network investment undertaken by the TNSP where a fault level shortfall is declared in a region. This exemption will apply, where system strength services are not already being made available at that time, and where the time for making the system strength services available is less than 18 months after the notice is given by AEMO.[65]

- In planning to meet the requirement to provide system strength services, the TNSP must prepare and publish information to enable potential providers of system strength network services to develop non-network options. This information should include a description of the requirement for system strength services, the technical characteristics that a non-network option would be required to deliver, a summary of potential options to make the system strength services available, and information to assist non-network providers wishing to present proposals to the TNSP.[66]

Obligations on AEMO to enable system strength services

- AEMO may enable a range and quantity of system strength services to:
  - maintain the minimum three phase fault level at a fault level node at any time while the three phase fault level at the fault level node would

62 Final rule, Chapter 10, amended definition of "network support payment".

63 Final rule clause 6A.7.3(6).

64 Final rule clause 5.16.3(a)(9).

65 Final rule clause 5.16.3(a)(10).

66 Final rule clause 5.20C.3(e).

otherwise be below the minimum three phase fault level or to maintain the power system in a secure operating state.[67]

- AEMO may at any time give an instruction stating that AEMO requires the provision of a system strength service to cease.[68]

AEMO produces system strength impact assessment guidelines:

- An obligation on AEMO to:
  - publish, and amend if required, system strength impact assessment guidelines that set out the methodology to be used by Network Service Providers (NSPs) when undertaking system strength impact assessments in relation to a proposed new connection of a generating system or market network service facility or an alteration to a generating system[69]
  - include in the system strength impact assessment guidelines guidance on the different network conditions and dispatch patterns and other relevant matters that should be examined when undertaking a full assessment[70]
  - specify the nature of the impacts that AEMO considers to be adverse system strength impacts, and options for system strength remediation schemes and system strength connection works[71]
  - exclude from the assessment of an adverse system strength impact (i.e. the 'harm' caused by the connection of the new generator) the impact on any protection system for a transmission network or distribution network[72]
  - comply with the Rules consultation procedures when making or amending the system strength impact assessment guidelines, other than minor or administrative amendments[73]
  - provide the applicable power system model to a Local Network Service Provider, Generator or Connection Applicant who requests the model used to assess harm needed to undertake a system strength impact assessment.[74]

67 Final rule clause 4.4.5(a).

68 Final rule clause 4.4.5(d).

69 Final rule clause 4.6.6(a).

70 Final rule clause 4.6.6(b)(4).

71 Final rule clause 4.6.6(b)(5).

72 Final rule clause 4.6.6(b)(3).

73 Final rule clause 4.6.6(c) and 4.6.6(d).

74 Final rule clause 4.6.6(e).

NSPs to determine any adverse system strength impact:

- Following the receipt of a connection enquiry, an NSP must provide the connecting party with details of fault levels at the proposed connection point.[75]
- A NSP must undertake a system strength impact assessment in line with AEMO's guidelines.[76]
- The results of any system strength impact assessment must be given to the connection applicant following consultation with AEMO.[77]
- If the assessment demonstrates that the connection of the generator would have an adverse system strength impact, either:
  - the NSP must remediate the adverse system strength impact at the cost of the connecting generator[78] or
  - the connecting generator may propose a remediation scheme (behind its connection point) to mitigate the adverse system strength impact[79] pending the approval of AEMO and the NSP.[80]
- A dispute can be referred to dispute resolution under clause 8.2 of the NER if there is a dispute between AEMO, the NSP or the connecting generator relating to the assessment of the harm assessed as arising from the new connection and so the nature and costs of its remediation.[81]

Further detail on the final rule can be found in the remaining chapters of the final determination.

The final 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 final rule determination.

Where this final 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.

75 Final rule clause 5.3.3(b5).

76 Final rule clause 5.3.4B(a).

77 Final rule clause 5.3.4B(b).

78 Final rule clause 5.3.4B(e).

79 Final rule clause 5.3.4B(g).

80 Final rule clause 5.3.4B(j)-(m).

81 Final rule clause 5.3.4B(d).

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

Box 2.1 Definitions introduced in the final rule

This box provides a summary of the definitions introduced, split into the definitions relating to the obligation for TNSPs to maintain system strength in its region (chapter 3 and 4 of this determination) and the obligation on new connecting generators to 'do no harm' (chapter 5 of this determination).

TNSP obligation to maintain required system strength

Three phase fault level: Measured in MVA at a location on a transmission network or a distribution network, the product of the pre-fault nominal voltage (measured in kV between a pair of phases), the fault current in each phase for a three phase fault at the location on a transmission network or a distribution network (measured in kA), and the square root of 3.

Fault level node: A location on a transmission network at which AEMO determines a fault level should be maintained in its determination of system strength requirements

Fault level shortfall: A shortfall in the three phase fault level typically provided at a fault level node in a region (having regard to typical patterns of dispatched generation in central dispatch) compared to the minimum three phase fault level most recently determined by AEMO for the fault level node.

Fault level shortfall event: An assessment by AEMO that there is a fault level shortfall at a fault level node in a region

System strength requirements: The minimum three phase fault level for each fault level node.

System strength requirements methodology: Methodology published by AEMO in the NTNDP setting out the process AEMO will use to determine the system strength requirements for each region.

System strength service: A service for the provision of a contribution to the three phase fault level at a fault level node.

System Strength Service Provider: the Transmission Network Service Provider for the region or if there is more than one Transmission Network Service Provider for a region, the jurisdictional planning body for the participating jurisdiction in which the region is located.

System strength services agreement: An agreement under which a person agrees to provide one or more system strength services to a System Strength Service Provider.

System strength services payment: A payment by a Transmission Network Service Provider made under a system strength services agreement.

Do no harm obligation

Adverse system strength impact: An adverse impact on the ability of the power system to maintain system stability or on a generating system or market network service facility to maintain stable operation including following any credible contingency event or protected event so as to maintain the power system in a secure operating state.

System strength impact assessment: Power system studies to assess whether the connection of a new generator has an adverse system strength impact.

System strength impact assessment guidelines: The guidelines for conducting system strength impact assessments developed by AEMO.

System strength connection works: Investment in a transmission or distribution system in order to remedy or avoid an adverse system strength impact arising from the connection of a generator.

System strength remediation scheme: a scheme proposed by a connecting party, required to be implemented as a condition of a connection agreement, to remedy or avoid an adverse system strength impact.

2.2 Rule making test

Under the NEL 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 national electricity objective (NEO).[82] This is the decision making framework that the Commission must apply.

The NEO is:[83]

> "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"

2.2.1 Making a more preferable rule

Under s. 91A of the NEL, the Commission may make a rule that is different (including materially different) to a proposed rule (a more preferable rule) if it is satisfied that, having regard to the issue or issues raised in the rule change request, the more preferable rule will or is likely to better contribute to the achievement of the NEO.

82 Section 88 of the NEL.

83 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. In making this final 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 lead to more efficient operational and investment decisions than prescriptive rules and central planning as well as being more flexible to changing market conditions and provide consumers with the services in the most efficient manner possible. For competition to be effective, market signals must be delivered to parties best able to respond in a manner that benefits consumers. 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. The Commission has considered how 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

The Commission considers the relevant aspects of the NEO to this rule change to be the security of the national electricity system and to promote efficient investment in electricity services for the long term interests of consumers of electricity.

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

Having regard to the issues raised in the rule change request and during consultation, the Commission is satisfied that the more preferable final rule will, or is likely to, better contribute to the achievement of the NEO than the draft rule, which was the rule as proposed by the proponent, for the following reasons:

- The framework in the final 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 TNSP. The framework enables TNSPs to identify efficient solutions that support long run efficient operation, use and investment in electricity services. In addition, an incentive based regulatory scheme requires TNSPs to share cost savings with consumers.

- The existing economic regulatory framework will provide an incentive for the TNSP to assess the least-cost approach to meeting the obligation with oversight by the AER. The final rule will allow the TNSP to meet the obligation in the short-term by contracting with existing third-party providers of fault level or investing in network assets, while concurrently assessing the most efficient means of meeting the obligation over the long term.

- The final rule places an obligation on AEMO to assess the system strength requirements of the power system on a regular basis, including nominating fault level nodes where minimum fault levels are specified, and to identify any fault level shortfalls. The results of AEMO's assessment will be published in the NTNDP. This obligation is consistent with AEMO's general obligations to maintain the power system in a secure operating state. Also, requiring AEMO to develop a system strength requirements methodology for it to apply when assessing the system strength requirements, including how it nominates the fault level nodes and whether a system strength shortfall exists, provides transparency and certainty to stakeholders.

- The periodic review of the minimum required fault level, and so possible fault level shortfalls which a TNSP is required to provide services to address, and an obligation on the TNSP to identify and procure the least cost option or combination of options to meet its fault level obligation, will assist in making sure that investments are efficient and reflective of changing market conditions.

- The obligation on TNSPs to provide system strength services will only apply when AEMO has identified that a fault level shortfall exists. This will promote efficient investment and use of services by:

  - maintaining system security where it is needed while not imposing undue market or compliance costs on other areas

  - providing for future shortfalls in fault level to be identified in a timely manner.

- The final rule provides for a holistic, flexible and technologically neutral solution to issues arising from reduced system strength by requiring TNSPs to maintain system strength at the levels determined by AEMO. 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. TNSPs have a holistic perspective of their network and are able to address system strength in a manner that considers the best options for their entire network, as well as co-optimise these services with other services necessary for system security. This should result in a more efficient outcome for consumers in the long term by minimising the potential duplication of investment.

- New connecting generators would be required to 'do no harm' to the stability of the existing power system. This 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. Also, requiring AEMO to develop system strength impact assessment guidelines to be applied by generators and NSPs when assessing the impact of a connecting generator provides transparency and consistency.

2.5 Strategic priority

This rule change request relates to the Commission's strategic priority relating to markets and networks.[84]

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.

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

3 Determining the minimum level of system strength and fault level shortfalls

This chapter outlines the issues relating to the reduction of system strength in the network, and explains how the final rule introduces an enhanced framework to determine the minimum level of system strength required for the stable operation of the power system in a region.

This chapter:

- sets out the proponent and stakeholder views on the rule change request
- describes the components of the framework for maintaining a minimum system strength at all connection points as described in the draft rule determination
- provides a summary of stakeholder views expressed in response to the draft rule determination
- discusses some of the key issues the Commission considered in developing the enhanced framework in the final rule.

The Commission considers that the existing provisions in the NER do not set out a clear delineation of responsibility for the maintenance of sufficient system strength in the NEM. In addition to the efficient allocation of these responsibilities, the Commission considers that the NER should set out a transparent process through which the required level of system strength in each region can be determined. This chapter sets out how the Commission's final rule institutes this process by placing an obligation on AEMO to:

- publish as part of the NTNDP consultation process a 'system strength requirements methodology' setting out the process it will use to determine the required fault level for each region
- identify a number of points on the transmission network in each region ('fault level nodes') where a required fault level must be provided for the region to be in a secure operating state
- determine, not more than once every 12 months, the fault level that must be provided at each fault level node in a region to maintain the network in a secure operating state, taking into account the most severe credible contingency and protected event in each region
- where there is, or is likely to be, a fault level shortfall in a region, publish and give to the System Strength Service Provider for the region a notice of the assessment[85]

85 The System Strength Service Provider is the TNSP for the region or, if there is more than one TNSP for the region, the jurisdictional planning body for the relevant jurisdiction.

- give notice of the date that the System Strength Service Provider must provide for the availability of system strength services, which must not be earlier than 12 months after the date that the notice of the assessment is published unless an earlier date is agreed with the System Strength Service Provider

- publish the system strength requirements for each region in the NTNDP and include forecasts of any fault level shortfall arising at any time within a planning horizon of at least five years.

The final rule is different from the draft rule. These differences are:

- the system strength requirements in the final rule are specified in terms of the fault level at fault level nodes, rather than as the minimum short-circuit ratio that would be maintained at generator connection points

- the required system strength is determined by AEMO in accordance with the methodology that it develops in consultation with market participants, rather than through negotiation between the generator, the relevant NSP and AEMO

- AEMO is obligated to prepare a system strength requirements methodology which sets out the process AEMO will use to determine the fault level nodes and the minimum fault level requirements, as opposed to specifying how the short circuit ratios should be calculated.

3.1 Responsibility for determining system strength requirements

AEMO is primarily responsible for maintaining power system security. 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,[86] AEMO is responsible for the dispatch of reactive power[87] from scheduled generating units.[88] AEMO's responsibilities with regard to power system security include:[89]

- 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.

86 Schedule 5.1.4 of the NER.

87 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.

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

89 Clause 4.3.1 of the NER.

Box 3.1 demonstrates how AEMO has addressed insufficient system strength in the South Australian power system.

Box 3.1 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.[90] Following a 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 generators in Victoria provided via 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.[91]

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.[92]

AEMO has undertaken further analysis of the system strength requirements for South Australia and introduced additional constraints on 2 July 2017 to manage periods of low system strength in that region. In particular, AEMO introduced a requirement for minimum numbers of large synchronous generating units to be operating at all times, with increased numbers of synchronous units when the wind generation exceeds 1200MW. Details of the technical analysis that supports these South Australian system strength requirements was published by AEMO on 6 September 2017.[93]

90 AEMO, *Power system not in a secure operating state in South Australia on 13 November 2016 - reviewable operating incident report*, p. 4. Available at http://www.aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2016/Power-System-Operations-Incident-Report_SA13Nov16.pdf

91 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.

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

93 AEMO, *South Australia System Strength Assessment*, September 2017, p. 1.

3.2 South Australian Government's view

The South Australian Government said in its rule change request 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.[94]

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 considered that this highlights a gap in roles and responsibilities.[95]

The rule change request proposes that the NER should be amended to allocate responsibility for fault levels in the network.[96]

3.3 System security market frameworks review

On 23 March 2017, the Commission published a directions paper on the *System security market frameworks review*. In the directions paper, the Commission proposed amending the NER to clarify that NSPs should be responsible for maintaining an agreed minimum short circuit ratio to connected generators. Generators would continue to be required to meet their registered performance standards above this agreed level.

In the directions paper proposal, where the entry of a new generator would cause minimum short circuit ratios to be breached for one or more existing generators, the NSP would be entitled to recover the costs of the remedial actions from the connecting generator on a "causer-pays" basis. Any works resulting from the retirement of a synchronous generator was proposed to be undertaken by the NSP as a prescribed service.

The Commission's proposal put forward in the directions paper received varied support from stakeholders. Their views are summarised in the draft rule determination.[97]

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

95 Ibid.

96 Ibid.

97 AEMC, *Managing power system fault levels - draft determination*, June 2017.

3.4 The draft rule

The Commission published its draft determination and accompanying draft rule on 27 June 2017.[98] In relation to specifying the level of system strength that needs to be maintained, the draft rule:

- expressed the minimum system strength requirements in terms of a minimum short circuit ratio at the connection point for each generating system
- provided that the minimum short circuit ratios requirements be determined through negotiation between the Generator, the relevant NSP and AEMO
- set out a transitional process in which existing generators would agree a short circuit ratio with the relevant NSP and AEMO, and register this short circuit ratio with AEMO.
- required AEMO to publish short circuit ratio calculation guidelines to assist stakeholders, with interim guidelines to commence when the final rule is made.

3.4.1 Stakeholder views on the draft rule

Generally submissions to the draft determination did not support the use of short circuit ratios as an appropriate measure of system strength. ElectraNet considered that the management of system strength through specification of a minimum short circuit ratio should not be continued.[99]

AGL, ENGIE, AEMO and Energy Networks Australia (ENA)[100] said that using a short circuit ratio threshold as a proxy for system security is too simplistic a solution to a complex and evolving situation. In addition, the ENA also said that the requirement for short circuit ratios to be assessed and agreed for every generation connection point is likely to be onerous and problematic. AEMO noted specific concerns with the use of short circuit ratio as a proxy for system strength, namely that:[101]

- it does not adequately allow the determination of synchronous machine stability
- is not appropriate for evaluating any susceptibility the protection systems may exhibit as the system strength declines.

Stakeholders were also concerned that specifying system strength requirements in terms of a short circuit ratio may lead to over investment in services to manage system strength. The ENA and TransGrid[102] claimed that the use of a short circuit ratio

98 Ibid.

99 ElectraNet, submission on draft determination, p. 4.

100 Submissions on draft determination: AGL, p. 1; ENGIE, p. 5; AEMO, p. 3; Energy Networks Australia, p. 4.

101 AEMO, submission on draft determination, p. 4.

102 Submissions on draft determination: Energy Networks Australia, p. 5, TransGrid, p. 6.

provides an incentive on generators to attempt to negotiate a higher minimum short circuit ratio to discourage other generators from connecting in a particular area. In addition, the Clean Energy Council (CEC) said that TNSPs would also have an incentive to register high short circuit ratios as they would benefit from future investments to maintain these higher levels.[103]

The ENA also highlighted that the process of estimating and negotiating a short circuit ratio with existing generators would likely risk of over-investment in network and connection assets and equipment to address unproven system strength issues.[104]

TasNetworks said that system strength should be treated in a holistic manner, rather than focusing on fault level or its derivative metrics (such as short circuit ratio), as a definitive measure of system security.[105]

The ENA and AEMO submitted that an alternative metric would be to express the minimum system strength requirements as maintaining a workable minimum fault level at major system nodes.[106] This would provide a more predictable and simple baseline. Further, AEMO recommended broadening the scope of the 'Short Circuit Ratio Calculation Guidelines' to allow consideration of related matters such as inertia, and renaming the guidelines as the System Services Guidelines. The Guidelines would provide transparency on these new power system strength and inertia obligations and, specifically, how NSPs must meet the new requirements as part of the short term solution.[107]

3.5 The final rule

The final rule introduces an enhanced framework for how the level of system strength is to be determined. The framework provides a transparent process through which AEMO will be able to determine the system strength requirements for each region in the NEM.

Box 3.2 Difference between draft and final rule

The differences between the draft rule and the final rule are:

- The draft rule placed an obligation on AEMO to produce a short circuit ratio calculation guideline. The final rule replaces this obligation with an obligation for AEMO to prepare a methodology outlining how it will determine the system strength requirements in each region (being the three phase fault level that must be maintained at each fault level node in the region)for that region to be in a secure operating state.

103 Clean Energy Council, submission on draft determination, p. 5.

104 Energy Networks Australia, submission on draft determination, p. 4.

105 TasNetworks, submission on draft determination, p. 4.

106 Submissions on draft determination: Energy Networks Australia, p. 4; AEMO, p. 9.

107 AEMO, submission on draft determination, p. 9.

- The draft rule addressed the system security impacts of reducing system strength by requiring NSPs to maintain a short circuit ratio at the connection point of all generators connected in its network. The final rule places an obligation on TNSPs to maintain a specified fault level at fault level nodes where a shortfall has been declared by AEMO.

- The draft rule required NSPs to maintain a level of system strength at all times. The final rule requires a level of system strength to be provided by TNSPs following the declaration of a shortfall by AEMO. As a result, system strength services will only be provided in regions where AEMO has determined the level of system strength is insufficient for that region to operate in a secure operating state.

Detail on the final rule is provided below.

3.5.1 Expressing the minimum system strength requirement

Following its consideration of the arguments put forward in submissions to the draft rule and draft determination, the Commission agrees that there are a number of limitations with the use of short circuit ratios as a proxy for system strength:

- A minimum short circuit ratio threshold may not be a sufficiently accurate proxy for identifying system security issues. That is, a registered short circuit ratio does not capture the variable nature of system strength. There may be circumstances where a generator experiences stability issues with a short circuit ratio above its registered minimum, and there may also be circumstances where a generator can operate stably below its registered short circuit ratio. Consequently, short circuit ratios are not always a proper metric for maintaining system strength and stability.

- It would potentially create an onerous burden on generators, NSPs and AEMO to assess and agree minimum short circuit ratio requirements for every generation connection point. For many existing generators, determining a minimum short circuit ratio could be expensive, particularly if it required the involvement of the original equipment manufacturer.

- There is a risk of over investment in services to manage system strength, with both generators and NSPs potentially incentivised to specify inefficiently high minimum short circuit ratios. In the transitional process of registering short circuit ratios, generators would be incentivised to register a high short circuit ratio as this could pose a barrier to entry for new generation. The Commission considers that this would have led to perverse outcomes, where new generation faced a significant barrier to entry and NSPs maintained an inefficiently high short circuit ratio for existing generators.

- It is not necessary to maintain system strength at every connection point to maintain system security. The risk to system security from generators not operating stably is not consistent for all connection points. That is, for a small, remotely connected generator, the risk of the generator not being able to withstand a fault does not pose the same risk to system security when compared to the risk of a large generator connected in a highly meshed part of the network being unable to withstand a fault. Maintaining a short circuit ratio for all connected generators would inefficiently over-emphasise the risk to system security of certain generators not operating in a stable manner.

The Commission also agrees with the alternative approach for specifying system strength that was raised in submissions; that system strength requirements should be specified in terms of a required fault level at major system nodes in each region. Consequently, the final rule defines the minimum system strength requirements in a region as a combination of a required fault level to be maintained at specified fault level nodes.

This approach addresses the shortcomings identified for using a short circuit ratio. In particular, the risk of inefficient investment in system strength services for every individual generating system would be reduced if the fault level is maintained at the level required to maintain the power system in a secure operating state. That is, the risk of cascading outages and major supply disruptions would be managed if there was sufficient system strength for the majority of generating systems to operate stably and ride through credible contingencies or protected events.

By specifying the minimum level of system strength in terms of required fault level at specified fault level nodes, the Commission considers the final rule provides for a holistic solution for maintaining system security without imposing unnecessary costs on consumers or connecting generators.

3.5.2 A new framework to replace the use of the Network Support and Control Ancillary Service framework

Network support and control ancillary services (NSCAS) are network support services designed to promote power system security and the reliability of the transmission network or to maintain or increase the power transfer capability of the transmission network in order to maximise net economic benefits. The NSCAS framework is explained in Box 3.3.

The existing NSCAS framework provides for the acquisition of services to maintain power system security, and this may include the provision of services that increase system strength within the power system.

The Commission understands that in practice the NSCAS framework has not worked as effectively as possible for a variety of reasons, often resulting in AEMO being required to act a procurer of last resort (see Box 3.3).

The Commission considers that it is preferable to have a framework that is better suited and targeted to managing low fault levels than the NSCAS framework. The framework in the final rule achieves this for the following reasons:

- *Regular assessment of potential requirements* – The new framework requires AEMO to consider system strength level requirements each year. Under the NSCAS framework, issues tend to be identified in a more ad-hoc fashion as there is no obligation on AEMO to explicitly consider NSCAS related requirements.

- *Transparent framework to assess requirements* – The new framework requires the development of a system strength requirements methodology in consultation with industry participants. There is limited transparency as to the assumptions that AEMO uses when declaring a NSCAS need.

- *Anticipates future requirements* – The NSCAS framework tends to address issues as they arise, whereas the new framework requires AEMO to provide projections of system strength shortfalls into the future.

- *Clearly defined obligation on TNSPs with regulatory oversight* – The new framework places a clear and well defined obligation on the relevant TNSP to meet system strength requirements. Under the NSCAS framework, TNSPs may elect not to address the requirements.

The Commission considers that it is undesirable to have two frameworks in the NER for the provision of equivalent services, that is, both system strength services provided under the existing NSCAS framework and under the new framework for managing fault levels.

Therefore, the final rule amends the existing NSCAS framework so that from 1 July 2018, when the managing fault levels framework is effectively in place, a system security issue that could be addressed as a system strength shortfall cannot be declared as a NSCAS gap.

Any low system strength issue that is identified after 1 July 2018, when the framework in the final rule takes effect, will need to be declared as a fault level shortfall under the new framework and the TNSP will need to meet the associated system strength requirement in accordance with the new framework.

This provision of the final rule does not prevent AEMO taking other action in the interim, such as imposing network constraints or issuing system security directions.

The final rule also includes transitional arrangements to apply for any NSCAS gaps declared prior to 1 July 2018. These transitional arrangements are set out in chapter 6 of this final determination.

Box 3.3 Network support and control ancillary services

NSCAS are network support services designed to promote power system security and the reliability of the transmission network or to maintain or increase the power transfer capability of the transmission network in order to maximise net economic benefits.[108]

NSCAS requirements are identified by AEMO as part of its NTNDP after taking into account all activities which have been identified by the TNSP. As such, NSCAS requirements represent a gap between the level of services that have been identified by AEMO and those that have been identified by the TNSP. This is referred to as the NSCAS Gap.

AEMO is required in the NER to determine the different types of NSCAS.[109] AEMO has determined three types of NSCAS to be:[110]

- Network loading ancillary service (NLAS): The purpose of NLAS is to allow an increase in the power transfer of a transmission network whilst ensuring that the network will still be in a secure operating state.
- Voltage control ancillary service (VCAS): The purpose of VCAS is to control the power flows of a transmission network for the control of voltage to be within defined operating limits and maintaining voltage stability.
- Transient and oscillatory stability ancillary service (TOSAS): The purpose of TOSAS is to increase power flows on a transmission network by increasing the transient or oscillatory stability limit of the network.

In summary, the NSCAS process involves the following steps:

- AEMO, in the NTNDP, may identify a NSCAS gap. If a gap is identified, AEMO may request the relevant TNSP to advise when the TNSP will have arrangements in place to meet that NSCAS gap, or provide reasons why the NSCAS gap will not be met.
- The TNSP's response to the identification of a NSCAS Gap can take the form of physically building assets or contracting a service to a third party. The TNSP determines the most economically efficient option for addressing the NSCAS Gap by comparing expressions of interest from third party providers.
- Following the TNSP's response, AEMO must consider whether it a NSCAS gap still exists (i.e. whether the TNSP proposal is sufficient to meet the gap).

108 Clauses 3.11.3 to 3.11.6 of the NER.

109 Clause 3.11.4(a1) of the NER.

110 AEMO, *Network Support and Control Ancillary Services (NSCAS) Description*, December 2011.

- If AEMO determines the gap still exists, AEMO must use reasonable endeavours to meet the gap.
- As the procurer of last resort, AEMO can only acquire services to address system security or reliability NSCAS gaps, not market benefits.[111]

3.5.3 AEMO to determine the minimum system strength requirements

In the final rule, AEMO will be required to:

- consult on and produce a 'system strength requirements methodology' which outlines the methodology that AEMO will use to determine the minimum system strength required in each region
- follow the system strength requirements methodology to determine the minimum system strength required in each region, specified in terms of the minimum three phase fault level to be maintained at certain fault level nodes.

The Commission considers that AEMO is best placed to produce the system strength requirements methodology and determine the minimum fault level requirements. AEMO has an existing obligation to manage power system security and has the detailed power system models necessary to make this determination. Consequently, the Commission considers the development of a methodology and the determination of required levels of system strength throughout the NEM to be consistent with AEMO's existing role.

System strength requirements methodology

The system strength requirements will be determined periodically in accordance with a system strength requirements methodology published by AEMO. This methodology will be published as part of the NTNDP consultation process, which is explained in Box 3.4. Regular revision of this methodology will provide a greater level of flexibility and adaptability to the evolution of the system strength requirements methodology.

When producing the system strength requirements methodology, AEMO is required to consider:[112]

- the combination of three phase fault levels at each fault level node in the region that could reasonably be considered to be sufficient for the power system to be in a secure operating state

111 That is, AEMO cannot procure NSCAS services to maximize or increase the power transfer capability of the network to increase the economic benefits of those using the network.

112 Final rule clause 5.20.7(b).

- the maximum load shedding or generation shedding expected to occur on the occurrence of any credible contingency event or protected event affecting the region

- the stability of the region following any credible contingency event or protected event

- the risk of cascading outages as a result of any load shedding, generating system or market network service provider tripping as a result of a credible contingency event or protected event in the region

- additional contribution to the three phase fault level needed to account for the possibility of a reduction in the three phase fault level at a fault level node if the contingency event that occurs is the loss or unavailability of a synchronous generating unit or any other facility or service that is material in determining the three phase fault level at the fault level node

- the stability of any equipment that is materially contributing to the three phase fault level or inertia within the region

- any other matters AEMO considers appropriate.

System strength requirements determination

Following the publication of the system strength requirements methodology, AEMO will be required to determine the system strength requirements for each region.

The requirements would consist of:

- the fault level nodes in the region, being the location on the transmission network for which the three phase fault level must be maintained at or above a minimum three phase fault level determined by AEMO

- for each fault level node, the minimum three phase fault level.

AEMO is required to make this determination no more than once in every 12 month period. However, following a material change to the power system, where the timing, occurrence or impact of the change was unforeseen, AEMO must also undertake this determination. For example, following the announcement of the retirement of a large synchronous generator, the system strength requirements in a region may be significantly altered. However, when the retirement of a large synchronous generator is not unforeseen, AEMO would be expected to have already included this in its most recent assessment of the system strength requirements.

Box 3.4 NTNDP consultation process[113]

In its role as National Transmission Planner, AEMO is required to prepare, maintain and publish a plan for the development of the national transmission grid, the NTNDP.

The development and publication of the NTNDP is a two-staged process which constitutes a preliminary consultation and the publication of the NTNDP.

By 30 January each year, AEMO is required to publish a document setting out the NTNDP inputs and a statement of the material issues to be considered in the NTNDP.

Following the publication of these documents, AEMO is required to invite submissions for at least 30 business days on:

- proposed inputs into the NTNDP (e.g. assumptions about generation costs and electricity demand forecasts)
- the material issues raised by AEMO to be considered in the NTNDP
- the system strength requirements methodology
- the contents of the most recent NTNDP.

By 30 December, AEMO is required to publish the NTNDP. The NTNDP provides an overview of the development of the transmission network in the NEM over a 20 year planning horizon.

In preparing the NTNDP, AEMO must take into account the submissions made in response in the NTNDP consultation process.

The minimum fault level requirements are specified as the minimum three phase fault level. In a three phase power system, such as that in the NEM, there are various fault levels corresponding with different types of power system faults.[114] These fault levels are inter-related. That is, increasing one fault level will lead to an increase in other forms of fault level. Consequently, the Commission considers that the obligation to maintain system strength can be specified in terms of three phase fault level as this accounts for other required fault levels needed to maintain power system security. While the required fault level is specified as a three phase fault level, AEMO will need to consider the impact of all relevant fault types when determining the required three phase fault level in a region.

113 Clause 5.20.1 of the NER.

114 The types of faults depend on the nature of the contingency. They include three-phase faults, phase to phase faults, single-phase to ground faults, and double phase to ground faults.

3.5.4 Identifying fault level shortfalls

The final rule requires AEMO to assess fault levels at fault level nodes in each region and assess whether, in its reasonable opinion, there is, or is likely to be, a fault level shortfall, taking into account matters specified in the final rule relative to the system strength requirements determined by AEMO.

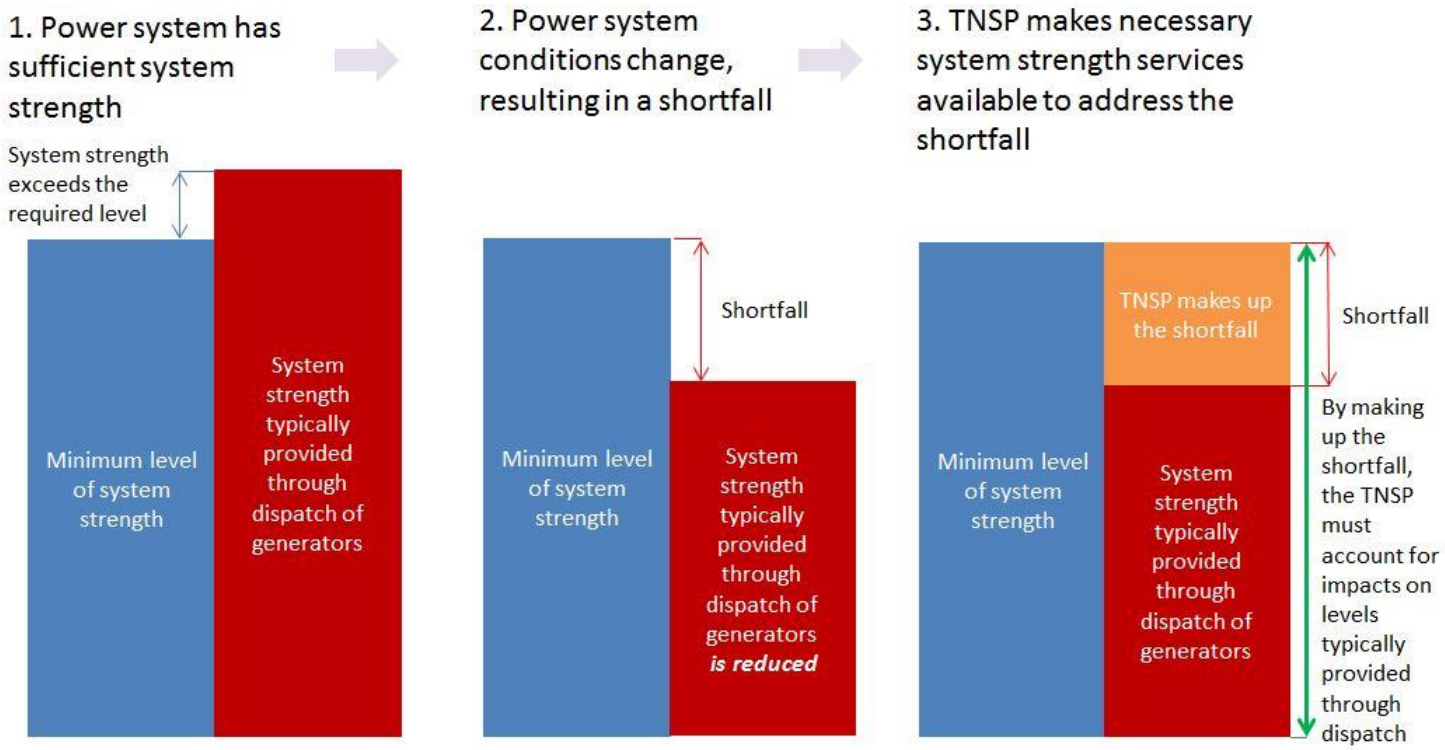
Following the determination of the system strength requirements for a region, AEMO must assess:

- whether in AEMO's reasonable opinion, there is or is likely to be a fault level shortfall in the region and AEMO's forecast of the period over which that shortfall will exist

- where AEMO has previously assessed that there was or was likely to be a fault level shortfall, whether in AEMO's reasonable opinion that a fault level shortfall has been or will be remedied.

Figure 3.1 demonstrates the process through which a fault level shortfall may arise, and how it can be subsequently addressed by the TNSP.

Figure 3.1 Fault level shortfall



1. **Power system has sufficient system strength** - if the typical dispatch of generation in central dispatch provides the minimum fault levels needed for the secure operation of the power system, there will be no shortfall. AEMO is required to determine the amount of system strength that is needed in each region for the power system to be in a secure operating state.

2. **Power system conditions change, resulting in a shortfall** - a shortfall in fault level may arise following a change in the generation typically dispatched. The shortfall is the difference between the minimum level needed and the amount provided through dispatch. A shortfall may also arise if the required minimum level of system strength increases. AEMO is required to declare whether it considers there to be a fault level shortfall and the period over which is forecasts that shortfall will exist.

3. **TNSP makes necessary services available to address the shortfall** - following the declaration of a shortfall, the TNSP make a range and level of system strength services available such that it is reasonably likely that system strength services that provide the minimum three phase fault level address the fault level shortfall when enabled are continuously available to meet the shortfall, including for the period in which that shortfall is projected by AEMO to exist. This must take into account planned outages, and the risk of unplanned outages and the potential for the system strength services to impact typical patterns of dispatched generation in central dispatch.

AEMO will be required to publish its projections of the fault level shortfalls as part of the NTNDP.[115]

If AEMO assesses that there is, or is likely to be, a fault level shortfall[116] in any region, it must publish and give to the relevant System Strength Service Provider (the relevant TNSP in that region) a notice of that assessment that includes AEMO's specification of the extent of the shortfall at the relevant fault level node, and the date by which the system strength network services must be available.[117] This date must not be any earlier than 12 months after the notice is published unless an earlier date is agreed with the System Strength Service Provider.

This framework gives AEMO sufficient flexibility in being able to declare a fault level shortfall following material changes to the power system, while also providing the System Strength Service Provider with sufficient time to address any alteration to its obligation to provide system strength services. The Commission considers this flexibility is necessary to address material events that were not foreseen and which may significantly change the required system strength in a region.

115 Final rule clause 5.20.2(c)(14).

116 A shortfall in the three phase fault level typically provided at a fault level node in a region when compared to the required level most recently determined by AEMO for the fault level node.

117 Final rule clause 5.20B.3(c).

3.5.5 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, the Commission considers 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 co-ordination.[118]

118 Rule 5.14 of the NER.

4 Providing a workable level of system strength

The final rule places an obligation on the TNSP that is the System Strength Provider in a region to:

- make "system strength services" available to AEMO that, when enabled, will increase three phase fault level at fault level nodes
- use reasonable endeavours to make the system strength services available by the date specified by AEMO in the notice provided to the System Strength Service Provider
- identify and procure the least cost option or combination of options that will satisfy its obligation in the time required
- provide information in its transmission annual planning report about the activities undertaken to meets its obligations to provide system strength services
- give AEMO a schedule setting out the system strength services available and the System Strength Service Provider's proposed order of priority for those services to be enabled by AEMO
- register any generating unit from which it is procuring system strength services as a system strength generating unit with AEMO and specify that the generating unit must be constrained on when it is providing system strength services under clause 3.9.7(c) of the final rule
- provide specified details of the system strength services it is making available to AEMO and seek AEMO's approval for the technical specifications and performance standards for those services and for the arrangements necessary for AEMO to enable or cease the provision of those services. AEMO must approve this information or advise the System Strength Service Provider of the reasons for withholding its approval and the changes it requires to be made. The System Strength Service Provider must then make these amendments and resubmit this information to AEMO.

The final rule also requires:

- AEMO to enable system strength services to the levels, and in the circumstances, specified in the final rule.
- AEMO to enable or cease system strength services by giving instructions to a TNSP providing system strength services or a Registered Participant who has contracted with the TNSP to provide system strength services.
- A Registered Participant providing a system strength service to comply with an instruction given by AEMO to enable system strength services.

The Commission has considered stakeholder submissions on the draft rule and has made the changes set out in Box 4.1, which are reflected in this final rule determination.

4.1 Existing allocation of roles and responsibilities in regard to system strength

4.1.1 Existing allocation of roles and responsibilities

As discussed in chapter 3, 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 throughout the network.

This means that there is a potential risk that some generators would not meet their performance standards if a major contingency event were to occur.

The final rule places this obligation on TNSPs.

4.1.2 TNSP as the provider

Placing an obligation on the relevant TNSP to provide the required system strength services is supported by:

- the existence of an incentive based economic regulatory framework that can provide some discipline on the level of expenditure by TNSPs on system strength services by enabling the AER to assess the efficiency of that expenditure and enable cost savings obtained by the TNSPs to be shared with consumers
- the ability to coordinate the system strength services with existing obligations relating to network protection systems and voltage management, as well as any inertia requirements.

An existing economic regulatory framework

The purpose of an obligation to provide system strength services is to provide a high degree of confidence that system security can be maintained as fault levels in a region fall.

One of the key reasons the Commission considers that the obligations should be placed on TNSPs is that the existing economic regulatory framework provides an incentive for TNSPs to undertake efficient expenditure on services, such as system strength services, by enabling the AER to assess the efficiency of that expenditure, including a consideration of how the services can also be used to meet inertia shortfall requirements.

Under the RIT-T, a detailed cost benefit analysis is undertaken to identify the investment option to meet an identified need (such as the need for system strength

services) which has the highest net benefits. TNSPs are required to consider all feasible network and non-network options and are required to seek submissions from registered participants, AEMO and interested parties on all credible options.

An investment undertaken to meet network obligations may still go ahead even if an economic assessment determines that there is an associated negative net economic benefit. Investments with negative net economic benefits are permitted if the investment is undertaken to meet a reliability, system security or technical standards requirement. However, it must still be demonstrated that the investment is the least cost approach.

In Victoria, the obligation to make system strength services available will be placed on AEMO as the jurisdictional planning body. AEMO is responsible for planning, authorizing and directing augmentation of the declared shared network in Victoria. Different arrangements for the provision of shared transmission services, including system strength services, will apply to AEMO in its role as the System Strength Service Provider for Victoria.

Coordinating the location of services in the network

The location of sources of fault level in the system has implications for the management of system security. The location of the services can dictate who these services interact with each other. Equally important, other aspects of system security including inertia network services are likely to be impacted by the location of system strength services.

Procurement mechanisms for frequency control, which might lead to investments in new synchronous devices, should therefore also be considered when locating system strength services in order to co-optimise this investment if possible.

Consequently, the Commission considers that TNSPs are best placed to provide the required fault levels within each region network and to coordinate the location of systems strength services with other network support services, including obligations related to providing inertia.

4.1.3 Determining the system strength to be provided

The final rule establishes an obligation on the TNSP to make sure that the required fault levels are continuously available. However, it is likely that in some regions of the NEM, sufficient system strength is already provided by synchronous generators. As a result, the maintenance of system security is unlikely to necessitate additional contributions to the fault level of the system. The variability in system conditions will mean that decisions will need to be made around the appropriate fault levels to be provided to the system at any given time.

The required fault levels will also need to be sufficient to maintain the islanded system in a satisfactory operating state should it be separated from the rest of the NEM. The power system is defined as being in a satisfactory operating state when a series of

technical parameters, such as frequency and voltage, are within normal operating limits. However, a credible fault, in a system with insufficient system strength, could result in a cascading loss of generation and a system black event.

Because system strength is localised (i.e., the system strength will decrease moving away from a system strength source) it may be necessary to specify multiple locations on the transmission network where minimum fault levels must be provided. The combination of sufficient fault level at these locations will be able to maintain the power system in a secure operating state.

Issues resulting from reduced system strength are complex. For this reason, it is difficult to specify an obligation for TNSPs to maintain prescribed level of system strength directly in the NER. The final rule therefore requires AEMO to undertake studies of the power system to consider the interactions of fault level sources to determine the level of system strength needed for the secure operation of the power system.

In addition, it is expected that AEMO will consider both system strength requirements and the inertia requirements, under the *Managing the rate of change of power system frequency* final rule, at the same time.

4.2 South Australian Government's view

The South Australian Government noted that low fault levels can reduce the ability for inverter connected plant to operate effectively, and claimed that falling system strength can impact on the ability of inverter-connected generation to ride through faults or operate properly during normal system operation.[119]

The South Australian Government also acknowledged the issues arising from generator withdrawals. In particular, there are circumstances where a wind farm, for example, may be meeting its performance standards until 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.[120]

The rule change request proposed that the NER should be amended to allocate responsibility for fault levels in the network.[121]

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

120 Ibid.

121 Ibid.

4.3 System security market frameworks review

In the directions paper published on 23 March 2017,[122] 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.

The Commission's proposal put forward in the directions paper received varied support from stakeholders. Their views are summarised in the draft rule determination.[123]

4.4 The draft rule

The Commission's draft rule:[124]

- required the NSPs to maintain registered short circuit ratios at generator connection points
- provided for a set of transitional arrangements through which existing generators would register a short circuit ratio that would be maintained by the NSP on an ongoing basis
- set out a process through which new connecting generators would register a short circuit ratio with the NSP which would also be maintained by the NSP on an ongoing basis.

4.4.1 Stakeholders' views on the draft rule

The South Australian Government agreed that NSPs are suitably placed to maintain minimum system strength.[125] Energy Queensland also supported the proposal for NSPs to maintain system strength.[126]

ENGIE submitted that it considers AEMO to be the appropriate entity for maintaining system strength as it considers AEMO's existing role closely aligns with the maintenance of system strength.[127] The majority of stakeholders did not explicitly refer to the party who should be responsible for maintaining system strength.

ENGIE also believes that it is more desirable that the procurement of system strength services be carried out within a competitive framework, as this is more likely to deliver

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

123 AEMC, *Managing power system fault levels - draft determination*, 27 June 2017.

124 AEMC, *Managing power system fault levels - draft rule*, 27 June 2017.

125 South Australian Government, submission on draft determination, p. 8.

126 Energy Queensland, submission on draft determination, p. 5.

127 ENGIE, submission on draft determination, p. 2.

efficient outcomes. Further, ENGIE believes that by assigning responsibilities for system strength procurement to NSPs, the AEMC would be moving outside of the policy and regulatory framework established by the NEL and NER.

AEMO supported the proposal for NSPs to be responsible for maintaining system strength in their network as an interim policy. AEMO also suggested that in the longer term, it may be more efficient to address system security as part of a holistic process that takes into account the full range of power system needs.[128] AEMO suggested an alternative proposal which would specify the necessary security obligation in terms of maintaining a specified minimum fault current at major power system nodes.[129]

4.5 The final rule

This section sets out further detail on the Commission's final rule to:

- place an obligation on TNSPs to make available a required fault level at specified fault level nodes as determined by AEMO
- provide system strength services on instruction by AEMO.

The final rule places similar obligations on TNSPs in relation to procuring and providing system strength services to those placed on TNSPs in relation to inertia network services under the *Managing the rate of change of power system frequency* final rule. There are significant similarities in the process through which TNSPs must procure these services, as well as their treatment under the economic regulatory framework.

The Commission considers that this will result in better outcomes in terms of providing both system strength and inertia at least cost. By making TNSPs responsible for the provision of both services, the TNSPs will be able to optimise between sources of both. For example, if a TNSP determined that the installation of a synchronous condenser would be the least-cost solution to providing inertia, this final rule will facilitate co-optimising of sizing and location such that system strength benefits are also provided for.

The similarities between the two final rules will also reduce the administrative burden on AEMO, TNSPs and providers of system strength services/inertia. The Commission acknowledges that in many circumstances, providers of inertia may also be able to provide fault levels. As a result, the TNSP may be able to provide address both obligations through contracting or through network investments or through a combination of both.

128 AEMO, submission on draft determination, p. 3.

129 Ibid, p. 5.

Box 4.1 Changes between the draft rule and the final rule

There are changes between the draft rule and the final rule in relation to the provision of fault levels by TNSPs.

These changes are summarised below:

- The obligation to maintain system strength applies to TNSPs in the final rule, as opposed to applying to DNSPs and TNSPs in the draft rule. The Commission considers that the obligation on TNSPs to maintain system strength at specified fault level nodes on the transmission network will also increase system strength in neighbouring distribution networks. Requiring DNSPs and TNSPs to both maintain system strength would likely lead to over-investment or inefficient investment in system strength services.

- The level of system strength that a TNSP would be required to maintain is specified in terms of fault level at fault level nodes, rather than short circuit ratios at generator connection points. Maintaining system strength at each generator connection point would also lead to an excessive procurement of system strength services, above what would be necessary to provide power system security. This would also be overly onerous on AEMO to monitor and on TNSPs to maintain.

- System strength services need to be provided by a TNSP following a fault level shortfall declaration by AEMO, instead of being provided at all times as was the case in the draft rule. For regions of the NEM with sufficient system strength being provided in generator dispatch, this will preclude the unnecessary procurement of system strength services, reducing overall costs.

- The final rule introduces a process through which AEMO can enable the necessary system strength services procured by the TNSP. As AEMO is the entity responsible for maintaining system security, this gives it the discretion to enable the system strength services needed to maintain the secure operation of the power system.

- The final rule introduces a clearer cost recovery framework that applies to the provision of system strength services by a TNSP. The draft rule gave limited consideration to issues related to the ability for TNSPs to provide system strength services and recover associated costs. The final rule amends the NER so that TNSPs are able to procure these services in a timely manner needed to maintain system security. This includes the introduction of provisions that allow TNSPs to recover costs during a regulatory period and an exemption from undertaking a RIT-T in the first instance of providing system strength services.

Detail on the final rule is provided below.

4.5.1 TNSP to procure system strength services to meet fault level shortfall

As outlined in chapter 3, the final rule introduces a requirement for AEMO to develop a methodology for determining the system strength requirements for each region (a "system strength requirements methodology"). AEMO is also required to monitor system strength in each region and make a declaration of a fault level shortfall. The final rule obliges TNSPs to, following the receipt of a notice from AEMO declaring a fault level shortfall, procure system strength services to address that shortfall.

Under the final rule, the obligation to provide system strength services is placed on the TNSP responsible for transmission planning in each region.[130] In Victoria, the obligation will be placed on AEMO through its role as the jurisdictional planning body.

The Commission considers that an absolute obligation on TNSPs to guarantee the availability of the required fault levels at fault level nodes at all times is not practical. It may lead to excessive costs being imposed depending on the extent to which the TNSP needs to contract with a large number of providers of fault level in order to confidently meet the obligation at all times. The Commission also agrees with the views expressed by stakeholders in response to the draft determination that, in some circumstances, there may be a limited number of parties with whom to contract for the provision of services, and that arrangements should be included to limit potential cost impacts on consumers.[131]

Therefore the final rule requires the TNSP:

- to use reasonable endeavours to make system strength services available by the date specified by AEMO[132]
- make a range and level of system strength services available such that it is reasonably likely that system strength services that provide the minimum three phase fault level when enabled are continuously available, taking into account planned outages and the risk of unplanned outages.[133]

Meeting the obligation

Under the final rule, the TNSP will be required to seek and identify the least-cost option or combination of options to meet the obligation to provide system strength services to meet the shortfall, including for the time in which it is projected to exist.[134]

130 If there is more than one TNSP for the sub-network, this would be TNSP that has the transmission planning responsibility in each region. Final rule clause 5.20C.3(a).

131 The majority of these concerns were raised in submissions to the draft determination for *Managing the rate of change of power system frequency*. However, the Commission considers that these concerns are also relevant to this final rule.

132 Final rule clause 5.20C.3(c)

133 Final rule clause 5.20C.3(c).

134 Final rule clause 5.20C.3(c).

Options available to the NSP when meeting the obligation to provide fault levels and fault level nodes could include:

- installing synchronous condensers, or other equipment that can provide a fault current contribution
- contracting with synchronous generators, or other parties that can provide a fault current contribution
- re-enforcing or upgrading existing network elements.

A system strength services agreement is a contractual arrangement between the TNSP and a third party under which a person agrees to provide system strength services. The entry into a system strength services agreement may be a more cost-effective means of providing system strength services than the construction of new assets by the TNSP. Similarly, it may be cost effective to initially address a fault level shortfall with a system strength services agreement while longer term options are considered by the TNSP to address the shortfall on an ongoing basis. A system strength services agreement could involve the TNSP contracting with a synchronous generator to be able to request them to be online at certain times, or to run in synchronous condenser mode.

The Commission considers that, in order for the TNSP to meet the required fault level, through a contracting option, it may need to contract with multiple potential third party providers to make sure that the required level can be met at any given time under the range of system conditions identified by AEMO in the system strength requirements methodology.

Where AEMO identifies a fault level shortfall in a region, the obligation on the TNSP is to make fault level continuously available to address the shortfall. This may mean that the TNSP would need to make the entire minimum fault level continuously available in the region, even in circumstances where AEMO has identified only a small shortfall in fault level. This is because any contracts that the TNSP has with synchronous generators to come online to provide fault level are likely to cause other synchronous generators, which are also providing fault level, to be pushed out of the dispatch merit order, potentially resulting in only a small, or no, overall increase in fault level.

The TNSP's proposal to make the required fault level available must be developed and set out as part of its TAPR. This will provide transparency to the market, and particularly potential providers of system strength services, in regards to how the TNSP is meeting its obligation.

Service classification and cost recovery

The obligation to make system strength services available is a regulatory obligation or requirement imposed on the relevant TNSP in connection with the provision of prescribed transmission services.

The TNSP will be entitled to seek a revenue allowance that includes forecast operating expenditure or capital expenditure for its efficient costs of meeting the requirement.

This may include an amount forecast to be spent as system strength service payments for system strength services to be provided by third parties to the TNSP. The AER will assess the efficiency of that expenditure as part of the regulatory determination process for a regulatory control period.

The commencement of the obligation on TNSPs will occur during a regulatory control period.

For any increase in the costs of providing system strength services that are incurred during the regulatory control period that is underway when the rule commences in order to meet the system strength requirements in a region, the TNSP may be able to use the network support pass through under clause 6A.7.2 of the NER (for system strength service payments) or the cost pass-through provisions under clause 6A.7.3 of the NER or a combination of the two. Pass-through applications under clause 6A.7.3 are subject to a materiality threshold equal to one per cent of maximum allowed revenue for the regulatory year.[135]

In order to make clear that the determination of a fault level shortfall during the course of a regulatory control period constitutes a pass through event under chapter 6A of the NER, the final rule adds a new category of pass-through event - a 'fault level shortfall event'. A fault level shortfall event occurs where a TNSP is required to provide, or cease providing, system strength services and meeting this requirement materially increases or decreases the TNSP's costs of providing prescribed transmission services.

The addition in the final rule of a new category of pass through event should provide greater certainty to the System Strength Service Provider that the costs of meeting the obligation can be efficiently recovered during the regulatory control period in which the costs are incurred.

Under the final rule, payments made to third parties under system strength services agreements (system strength services payments) are a type of network support payment and differences in the forecast amount of network support payments for a regulatory year and the actual network support payments in that regulatory year can be passed through to transmission network users under the network support pass through in clause 6A.7.2 of the NER.[136]

Where AEMO reviews and updates the required fault levels for a given region during a regulatory control period, the relevant TNSP will either enter into new system strength services agreements, or update the conditions of existing agreements. The TNSP may also compare this against the cost of physically constructing the required assets in order to meet the obligation.

In the case of system strength services agreements, any adjustment to the required fault level will likely require the TNSP to apply to the AER for cost recovery under the existing network support pass-through provisions in the NER (if the TNSP is

135 Clause 6A.7.3 of the NER.

136 Final rule amendment to chapter definition of "network support payment"; Final rule clause 5.20C.3(h).

addressing any shortfall through contractual arrangements). Network support pass-through is not subject to a materiality test and allows for increases and decreases in the amount of payments forecast in revenue determinations to be adjusted annually on an "overs and unders" basis, but after the period in which the costs are incurred. In making a determination on the TNSP's application for cost pass-through, the AER takes into consideration the efficiency of the TNSP's activities in meeting the obligation.

If the TNSP determines that the construction of network assets would be the most efficient way to meet the obligation to provide system strength services in the next regulatory control period then this should form part of the TNSP's capital expenditure allowance for the period. In this case, the value of the network assets would be rolled into the TNSP's regulatory asset base at the beginning of the following regulatory control period.

Timing and location

As set out in chapter 3, AEMO will determine the system strength requirements for each region.

In the event that a fault level shortfall is declared for a given region, the TNSP will be required to meet the obligation to address the fault level shortfall. The TNSP must meet the obligation by the date specified by AEMO in the notice of assessment given to the TNSP (which must be no earlier than 12 months after the notice of assessment is published unless an earlier date is agreed with the TNSP).

The TNSP will also be required to address any adjustments made by AEMO to the region's system strength requirements for as long as a fault level shortfall remains. As is the case following the declaration of the ongoing shortfall itself, the TNSP will be required to make the fault level at fault levels nodes available to address the adjustment by the date specified by AEMO in the notice of assessment given to the TNSP. This must be no earlier than 12 months after the notice of assessment is published unless an earlier date is agreed with the TNSP.

If AEMO determines that there will no longer be a fault level shortfall in a region,[137] AEMO must specify in a notice to be given to the TNSP the date from which the system strength requirements no longer apply to the TNSP. This date cannot be earlier than 12 months after the publication of the notice, unless an earlier date is agreed with the TNSP. This should provide certainty to the TNSP and third-party providers when evaluating the benefits of investing in the construction of physical assets compared to expenditure under system strength services agreements.

137 This is only likely to occur if there is a change in the generation mix in that region or the underlying system strength requirement for a region to be secure has reduced.

As part of the transitional amendments with the final rule, the Commission proposes that TNSPs will not be required to meet any obligation to make sure that the system strength services are continuously available until 1 July 2019.[138]

Under the draft rule, a timeframe to meet the obligation by 1 July 2019 was likely to restrict the options available to TNSPs in the initial stage of meeting the obligation. This was because it would likely not permit the TNSP to undertake a Regulatory Investment Test for Transmission (RIT-T) to assess capital expenditure to address a fault level shortfall.[139] It was expected that TNSPs would need to contract with existing generators, or owners of existing synchronous condensers, to make sure that the obligation can be met.

However, the Commission considers that limiting the options available to TNSPs to third-party contracting could preclude potentially efficient investment options. Further, the Commission recognises that, under some circumstances, there may be a lack of competitive provision of the required services, and that it would not be in the interests of consumers for contracts to be entered into at any cost.

Therefore, under the final rule, TNSPs are not required to apply the RIT-T to proposed expenditure on "system strength service payments" or to network investment undertaken by the TNSP where a fault level shortfall is declared in a region, where prior to the declaration the TNSP is not under an obligation to provide system strength services and where the time for making the system strength services available is less than 18 months after the notice is given by AEMO.[140]

The objective of the RIT-T exemption for network investments is to provide the TNSP with a practical ability to meet the obligation in a reasonable time, and in an efficient manner, in the first instance that a shortfall is declared within the region. It will still be necessary for the TNSP to undertake a RIT-T for any subsequent ongoing adjustments to the required fault levels as the Commission expects that there will be a reasonable level of foresight in the projection of fault level shortfalls into the future, given AEMO will be required to publish such projections in the NTNDP. The Commission considers that the exemption should apply if the TNSP has 18 months or more as this would be sufficient time to undertake a RIT-T to assess the most cost-effective solution to address the fault level shortfall.

The Commission recognises the view held by some stakeholders that the TNSP may be more predisposed to building physical network assets than contracting with third parties for the provision of fault level and that this may result in a higher cost outcome or foreclose subsequent market sourcing options. However, the Commission considers that the potential costs associated with this risk are relatively low given that the TNSPs are only required to make the fault level shortfall available. Further, limiting the

138 Final rule clause 11.100.5(b).

139 Generally, a RIT-T is applied for all augmentation investments greater than six million dollars. For investments under the six million dollar threshold, the TNSP has discretion to determine the most appropriate assessment.

140 Final rule clause 5.16.3(a)(9)-(10).

TNSP's options to contracting with third-party providers in the first instance may lead to inefficient outcomes if there is limited competition for the provision of system strength services and potentially more efficient network investments are unable to be undertaken in time to meet the obligation.

Nevertheless, the final rule will impose a requirement on TNSPs to undertake a process of screening of potential third-party providers of system strength services to improve the efficiency of the contracting solution and to make sure that the TNSP considers all options available to meeting the obligation beyond network investments. The TNSP will be required to prepare and publish information to enable potential providers of system strength services to develop non-network options. This information will include a description of the requirement for system strength services, the technical characteristics that a non-network option would be required to deliver, a summary of potential options to make the system strength services available, and information to assist non-network providers wishing to present proposals to the TNSP.[141]

The exemption to conducting a RIT-T for network investments will increase the competitive pressure on third-party providers of services to maximise the probability of a more efficient outcome through contracting for the provision of system strength services.

If the TNSP proposes network investment to meet the requirement to provide system strength services then it must provide information in its TAPR setting out the date when the proposed relevant network investment became or will become operational, the purpose and total cost of the proposed network investment, and the indicative total cost of any non-network options considered.

When investing for the provision of fault levels (where the source of fault levels also provides inertia, such as a synchronous generator) the TNSP will necessarily need to consider the interaction with any obligation to provide inertia arising from the final rule for *Managing the rate of change of power system frequency*.[142] Meeting the required levels of inertia and minimum required levels of system strength in a coordinated manner should be an inherent part of the TNSP's planning process.

Further, the Commission considers that allocating the responsibility to the TNSP for the provision of fault levels would be more likely to avoid the possibility of higher costs that would be incurred through the duplication of network assets. For example, the TNSP would be in a better position to identify that the need for a synchronous condenser that could provide required fault level and inertia. There is a greater likelihood that separate assets would be constructed to address frequency and system strength individually if separate entities were given responsibility or separate mechanisms were used.

141 Final rule clause 5.20.C(e).

142 AEMC, *Managing the rate of change of power system frequency - final rule*, 19 September 2017.

4.5.2 Providing fault levels to the system

This section sets out further detail on the provision of fault level to the system based on the system strength services made available by the TNSP.

The obligation to provide system strength services to the system when instructed by AEMO

Under the final rule:

- AEMO may enable system strength services to maintain the minimum three phase fault level at a fault level node at any time[143]
- AEMO may enable or cease system strength services by giving instructions to a TNSP who is providing system strength services or to a Registered Participant who has contracted with the TNSP to provide system strength services
- The System Strength Service Provider and Registered Participants that provide a system strength service must comply with instructions from AEMO to enable the system strength services.

The Commission considers that a role for AEMO to enable system strength services is consistent with AEMO's role in managing the secure operation of the power system. Any generators that receive dispatch instructions will be required to meet the dispatch target provided by AEMO.[144] The Commission proposes to recommend to the COAG Energy Council that the obligation on Registered Participants to comply with the instructions provided by AEMO be classified as a civil penalty provision.

AEMO will not be obliged to provide the full system strength requirements if AEMO does not consider this necessary to maintain the region in a secure operating state. The Commission considers that AEMO is best placed to be able to determine the optimal amount of fault level at fault level nodes to be provided based on changing system conditions. AEMO will also be able to take into account any additional fault level being incidentally provided at the time by other providers of fault level that are not contracted with the TNSP.

The TNSP will be required to provide AEMO with a schedule of the system strength services which it has made available to meet the obligation.[145] The schedule will rank the system strength services and will act as a guide to the most efficient means of providing the required fault levels at fault level nodes to the system from the various sources.

AEMO's oversight of the power system suggests that it will be best placed to coordinate the provision of system strength services from different sources. AEMO will

143 Final rule clause 4.4.5(a) or (b). A system strength service is enabled when AEMO has selected the relevant system strength service and it is providing fault levels at fault level nodes in a region.

144 Clause 3.8.23 of the NER.

145 Final rule clause 5.20C.4(a).

instruct the System Strength Service Provider or Registered Participants to provide fault levels to the system in accordance with the schedule of system strength services provided by the TNSP. AEMO will be required to use reasonable endeavours to select services in the order of priority specified in the schedule.[146]

Conditions of contracting with generators

The operation of system strength services agreements with generators for the provision of fault levels will be similar to existing provisions under clause 5.4AA of the NER in respect of network support payments. If a TNSP contracts with a generator under a system strength services agreement for the provision of system strength, the TNSP must register the relevant generating unit with AEMO as a system strength generating unit that may periodically be used to provide system strength services.[147]

When AEMO elects to use the generator to provide fault levels, it will notify the TNSP of its intention. At these times, AEMO will be required to constrain on the generator providing fault levels and the generator will not be eligible to set the spot price in relation to its minimum loading level.[148] Any generation capacity that the generator offers over and above its minimum loading level will be dispatched and settled as normal through the NEM dispatch process.

AEMO will be required to review and approve the technical conditions of any system strength services agreements to be entered into between the TNSP and third parties. The Commission considers it necessary that any technical limitations associated with TNSP contracts for system strength services are consistent with AEMO's ability to maintain the power system in a secure operating state.

The majority of existing sources of fault level in the NEM are thermal generators that were built ten or more years ago. In many cases, changes to technical performance standards were not applied to these generating units at the time the standards were introduced. Contracts with these generators for the provision of system strength services should consider the ability to meet certain technical standards, in particular the stability of these units.

Under the final rule, the TNSP will be required to provide AEMO with specified details of system strength services agreements. This information will include but is not necessarily limited to:[149]

- details of the contracted generator so it can be registered with AEMO, including the nature of the service, the purpose for which the service is being provided, and the location of the service

146 Final rule clause 4.4.5(b).

147 Final rule clause 5.20C.4(b).

148 Final rule clause 3.9.7(c).

149 Final rule clause 5.20C.4(c).

- details of the availability of the service, including its minimum loading level and any other restrictions
- fault level at relevant fault level nodes provided by the contracted generator.

A System Strength Service Provider will be required, without delay, to notify AEMO of any event which has changed or is likely to change the availability of any system strength services made available by the System Strength Service Provider to AEMO as soon as the System Strength Service Provider becomes aware of the event.

While technical specifications and performance standards for system strength services will be required to be approved by AEMO, AEMO will not have a role in assessing or approving the commercial terms of system strength services agreements.

The Commission recognises that the ability for AEMO to determine the timing and magnitude of the provision of system strength may create some challenges for the TNSP when negotiating contract terms with third parties. The conditions and payment structures for the provision of system strength services will likely be influenced by the regularity with which system strength services are enabled by AEMO, which the TNSP may find difficult to forecast. However, AEMO will be expected to consider, in its decisions with respect to the enablement of system strength services, the schedule of system strength services provided by the TNSP. The TNSP will be able to use the schedule as a basis for forecasting the expected costs of system strength services agreements that it enters into.

5 Do no harm obligation

This chapter outlines the aspects of the final rule that address the impact of a new connection to the network. The final rule sets out a framework that provides a transparent assessment of whether a new connecting generator adversely impacts on the power system in terms of system strength.

The Commission considers that the introduction of a broader obligation on TNSPs to maintain sufficient system strength in a region (as outlined in chapter 3 and 4), combined with an obligation on new connecting generator to 'do no harm', results in an effective and transparent framework for maintenance of system strength following reductions in fault levels and the connection of new generators.

The final rule introduces a 'do no harm' obligation by:

- placing an obligation on AEMO to develop, in consultation with stakeholders, guidelines that provide a methodology to be used by NSPs when undertaking system strength assessments. These assessments are power system studies to assess the impact of the connection of a new generating system or the proposed alteration to a generating system on the ability of the power system to maintain stability in accordance with the NER and for generating systems to maintain stable operation, including following any credible contingency or protected event so as to maintain the power system in a secure operating state ("system strength impact assessment guidelines")

- requiring the relevant NSP (both TNSPs and DNSPs) to provide a connecting party with information regarding the local system strength in its response to the connection enquiry

- requiring the NSP to undertake a preliminary assessment to screen for the need to undertake a detailed assessment of the connection of a new generator

- requiring the NSP to remediate any adverse impact on system strength of the connection of the generator as a negotiated network service (unless the generator implements a system strength remediation scheme) following approval by the NSP

- requiring the generator to fund the cost of remediating any works to address an adverse impact on system strength

- allowing generators to propose a solution that can be implemented behind its connection point (a "system strength remediation scheme")

The draft rule included a framework to implement the 'do no harm' obligation on new connecting generators. The final rule retains this framework; however, the "harm" is defined in a different way and identified through a different mechanism.

The differences between the final and draft rule are:

- The final rule requires AEMO to publish system strength impact assessment guidelines setting out the methodology to be used by NSPs when undertaking system strength impact assessments, rather than considering the impact of a new connecting generator on registered short circuit ratios.
- A requirement for new connecting generators to not cause adverse system strength impacts when connecting such that the power system is able to maintain stability in accordance with the NER, rather than requiring new connecting generators to not have any adverse impact on an existing generator.
- The final rule introduces the ability for a connecting generator to dispute the assessment of an adverse system strength impact. The disputes are to be addressed through the dispute resolution process set out in rule 8.2 of the NER. The disputes raised must be in relation to:
  - whether the model specified by AEMO for the purpose of the system strength impact assessment was appropriate
  - the application of the system strength impact assessment guidelines by the NSP when undertaking a system strength impact assessment.

The 'do no harm' obligation described in this chapter is imposed on generators connecting under Chapter 5 (i.e. under rule 5.3 and rule 5.3A) of the NER. It does not apply to the connection of micro-embedded generation, such as residential photovoltaic panels.

5.1 Impact of new connecting generators on the power system

Nature of the issue

The need to consider the impact on system security of a new connecting generator is becoming increasingly necessary as the formerly intrinsic levels of system strength are being diminished through the retirement of synchronous generators, and the entry of inverter connected generation.

Historically, the presence of a large number of synchronous generators strengthened the power system and negated the need for thorough considerations of system strength impacts. However, the changing generation mix means that this is no longer the case. When new non-synchronous generators connect to the network, they will potentially impact on the stable operation of the power system. If the impact is large enough, a number of issues can manifest including reducing the ability of existing generators to ride through disturbances in the power system.

Consequently, leaving the connection of new generators to the network untreated may pose increasing risks to system security.

Potential solutions to address system strength impacts of connecting generators

There are a number of potential solutions to reduced system strength when a new 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 new connecting 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 level of system strength
- upgrading control systems to improve the ability of affected generators to operate at lower levels of system strength.

5.2 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.[150]

The rule change request proposes that the NER should be amended to allocate responsibility for maintaining fault levels in the network.[151] When allocating responsibility for system strength, the South Australian Government requested that the Commission consider the incentives, cost and allocation of risk.

5.3 System security market frameworks review

On 23 March 2017, the Commission published a directions paper on the *System security market frameworks review*.

In the directions paper, the Commission's proposed approach was that where the entry of a new generator would cause minimum short circuit ratios to be breached for one or more existing generators, the NSP would be entitled to recover the costs of the remedial actions from the connecting generator on a "causer-pays" basis. Stakeholder responses to the directions paper are contained in the draft determination.[152]

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

151 Ibid.

152 AEMC, *Managing power system fault levels - draft determination*, June 2017.

5.4 The draft rule

The draft rule prescribed that new connecting generators should agree to a minimum short circuit ratio when connecting to the network. NSPs would be required to guarantee this short circuit ratio.

In the draft determination, the Commission outlined a process through which the NSP would assess the impact of the connection of a new generator on the registered short circuit ratios of existing generators. The Commission determined that where a new connecting generator was going to reduce the short circuit ratio of an existing generator below the registered level, the new connecting generator would be required to fund any required remediation.

The draft rule also contained amendments to the connection process in Chapter 5 of the NER. The amended connection process would require information to be exchanged between connecting parties and the relevant NSP. This would allow the parties to determine the extent of the harm imposed by the connecting generator as well as providing connecting parties with high-level information regarding system strength to assist with decisions regarding generator site location.

5.4.1 Stakeholders' views on the draft rule

In submissions to the draft determination, a range of stakeholders supported the introduction of a 'do no harm' obligation.[153]AEMO noted that requiring new connecting generators to manage their impact on the network provides a locational incentive to connect in parts of the network with sufficient system strength.[154]

TasNetworks was of the view that the costs of implementing the draft proposal did not consider the benefits and risks resulting in an inefficient outcome.[155] However, some stakeholders felt that the introduction of a 'do no harm' obligation was unnecessary.[156] The Clean Energy Council argued that the existing arrangements provide for a 'do no harm' obligation that is enforced by TNSPs. The Clean Energy Council considered that clause 5.3.5(d) of the NER provides TNSPs with the ability to ensure that new connections do not prevent the TNSP from meeting commitments made in existing connection agreements.[157]

A range of stakeholders raised concerns that the draft rule would introduce a barrier to entry for new generation.[158] PIAC submitted that it is essential that efficient and

153 Submissions on draft determination: Hydro Tasmania, p. 1; Energy Queensland, p. 10; AEMO, p. 7; Meridian Energy Australia, p. 1.

154 AEMO, submission on draft determination, p. 7.

155 TasNetworks, submission on draft determination, p. 11.

156 Submissions on draft determination: Energy Developments Limited, p. 1; Clean Energy Council, pp. 1-2.

157 Clean Energy Council, submission on draft determination, pp. 1-2.

158 Submissions on draft determination: TransGrid, p. 7; Energy Networks Australia; p. 11; PIAC, p. 1.

cost-effective generation is not discouraged from entering the market.[159] TransGrid reiterated this point, noting that is it important any system strength 'do no harm' obligation is balanced with the open access design of the NEM.

PIAC supported the provision of information to proponents regarding system strength impacts on the connection process. It argued that providing this information early would provide an effective cost signal to proponents.[160]

Energy Queensland suggested that generators, in the process of connecting to the network, should be obligated to provide the detailed generator models during the application to connect stage. Energy Queensland argued that this is necessary for proper assessment of the impact of that generator connection.[161] PIAC supported placing the obligation on the NSP to assess whether a generator might adversely impact on the power system, as opposed to placing this obligation on the connecting party.[162]

5.5 The final rule

Box 5.1 Changes between the draft rule and the final rule

The differences between the draft rule and the final rule are:

- the final rule considers the impact of a new connecting generator in terms of its impact on the power system to maintain stability in accordance with the NER and for generating systems to maintain stable operation, including following any credible contingency or protected event so as to maintain the power system in a secure operating state. The draft rule had considered the impact of a connection on the short circuit ratio of any specific existing generator.
- the final rule requires AEMO to develop the system strength impact assessment guidelines, rather than guidelines to be used for the calculation of short circuit ratios

The approach in the final rule is as a result of short circuit ratio no longer being considered to be an appropriate proxy for system strength. The do no harm obligation needs to align with the approach in the final rule where the system strength requirements are assessed in terms of the required fault level to maintain power system security

The approach for assessing the do no harm obligation in the final rule also considers the impact of the new connecting generator on the ability of the power system to maintain stability in accordance with the NER, and for generating

159 PIAC, submission on draft determination, p. 1.

160 Ibid.

161 Energy Queensland, submission on draft determination, p. 10.

162 PIAC, submission on draft determination, p. 1.

systems to maintain stable operation, including following any credible contingency or protected event, rather than the impact on the short circuit ratio at individual generating units.

The Commission considers that it is not necessary to maintain system strength at every connection point to maintain system security. The risk to system security of generators not operating stably is not consistent for all generators. That is, for a small, remotely connected generator, the risk of the generator not being able to withstand a fault does not pose the same risk to system security when compared to the risk of a large generator connected in a highly meshed part of the network being unable to withstand a fault. Maintaining a short circuit ratio for all connected generators would inefficiently over-emphasise the risk to system security of certain generators not operating in a stable manner.

Further details the final rule are provided below.

5.5.1 Treatment of connecting generators

The final rule introduces:

- an obligation on AEMO to develop 'system strength impact guidelines' which will set out a methodology and model to be used by NSPs when undertaking a system strength impact assessment in relation to a new generator connection, and a dispute mechanism in relation to the power system model supplied by AEMO, and the application of the guidelines
- a transparent process in which NSPs can determine whether a new connecting generator will cause an adverse system strength impact
- a requirement for a new connecting generator to fund remedial works necessary to accommodate its connection if it would cause an adverse system strength impact – these remedial works can either be undertaken by the TNSP as negotiated transmission services,[163] or by the generator as part of its connection

New connecting generators should 'do no harm' to power system security

The connection of new generators has the potential to reduce the system strength in the area of the network where the generator is connecting. If this impact is substantial, it may result in:

- the power system being unstable under normal operating conditions
- equipment connected to the power system being incapable of withstanding disturbances[164]
- power quality issues.

163 For distribution networks, the classification of services would be determined by the AER.

164 These disturbances refer to large changes in voltage or frequency following a fault or the trip of equipment connected to the power system.

Under extreme circumstances, the connection of a new generator may compromise system security as a result of this reduced system strength. To the extent this is demonstrated to occur with the connection of a new generator, the Commission considers it necessary to place an obligation on that generator to remediate this impact.

The Commission considers that the impact of a new connecting generator is best remediated during the connection process. This is because adverse impacts on system strength of a new connection may be felt by existing generators; however, these generators have limited opportunity and ability to plan for or address these impacts.

For example, an existing generator may be connected in the network with sufficient system strength to be able to operate stably and ride through credible disturbances. Following the connection of a new generator nearby, neither the new generator nor the existing generator are able to operate in a stable manner, potentially 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.

As highlighted by stakeholders, there are existing mechanisms in the NER that consider the impact of a new generator connection. These mechanisms include:

- Clause 5.3.5(d) – this clause requires NSPs to, in preparing an offer to connect, consult with AEMO and other registered participants with whom it has connection agreements, and which it believes may be affected by the new connection.
- Clause S5.2.5.13 – this clause is an access standard that requires that the operation of the generating unit does not cause instability that would adversely impact other registered participants.

The Commission acknowledges that these clauses already place a form of 'do no harm' obligation on connecting generators. However, the Commission does not consider these clauses provide connecting generators and NSPs with sufficient transparency regarding what should be considered when assessing the impact of a new connection on system strength, nor sufficient flexibility in relation to solutions to address that impact.

The final rule establishes a transparent framework in which 'harm' can be assessed, and the allocation of responsibilities is clear. The final rule also clarifies that the costs of remediating any adverse system strength impact must be funded by the connecting generator at the time of connection. Any ongoing impacts on system strength are addressed through the broader TNSP obligation explained in chapter 3 and 4.

The Commission therefore considers that there is the need for explicit consideration of the impact of a new generator connecting to the network prior to its connection. The final rule introduces this consideration into the process of negotiating a connection agreement, which is explained in more detail below.

Connecting generators should fund any system strength works necessary as a result of its connection

As discussed in chapters 3 and 4, the final rule introduces an obligation on TNSPs to maintain fault levels at fault level nodes in their region where AEMO has declared a fault level shortfall. These services are prescribed transmission services and therefore the costs of providing these services would be recovered from all consumers in the relevant region.[165]

In addressing the direct impact of a new connection, the Commission considers 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 remediate any adverse system strength impact.

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. The Commission considers the framework introduced in the final rule provides connecting parties with the appropriate incentives to connect in the most efficient location, resulting in lower costs being passed to consumers through network investments.

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.[166] 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 system strength requirements.

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

166 This would be in the circumstance where it has been demonstrated, in accordance with AEMO's system strength impact assessment guidelines, that the connection of that generator would have an adverse impact on power system security in terms of system strength. Clause 5.3.4B(c) of the final rule.

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.[167]

More detail on system strength connection works and system strength remediation schemes is provided in Box 5.2.

Generators' ability to address system strength individually

The impact of a new connecting generator on power system security in terms of system strength could be addressed by that generator. However, the ability for the generator to address this would be contingent on the NSP agreeing that the proposal made by the generator would not adversely affect power system security or the quality of supply to other network users.

The most efficient resolution to impacts on system strength may be addressed 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 prefer to be required to reduce its output under low system strength conditions.

The final rule outlines a process through which connecting parties would be able to propose a system strength remediation scheme behind their connection point as an alternative to the NSP providing system strength connection works.[168] A system strength remediation scheme would be instigated by a 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:

- in the reasonable opinion of the NSP, it would adversely affect quality of supply for other network users or
- on AEMO's reasonable advice, it would 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.

167 Final rule clause 5.3.4B(d).

168 Final rule clause 5.3.4B(d).

5.5.2 System strength impact assessment guidelines

At lower levels of system strength, the interaction of generators becomes increasingly complex. As such, the impact of a new generator connection requires thorough consideration to determine the extent of any adverse impacts on system strength. The Commission also acknowledges that these impacts may manifest themselves in various forms and these impacts may not currently be considered by NSPs and generators in the connection process.

In the draft rule, the "harm" caused by a new connecting generator was relatively straightforward to ascertain during the connection process – i.e. it was whether the connection would impact the short circuit ratio of at the connection point of other neighbouring generating systems. However, as discussed in chapter 3, the Commission no longer considers short circuit ratio to be an appropriate proxy for system strength.

Therefore the final rule introduces an obligation on AEMO to develop and publish system strength impact assessment guidelines that set out the methodology to be used by NSPs when undertaking system strength impact assessments in relation to a new connection. These guidelines will apply consistently between regions. This will assist both connecting generators and NSPs by providing a transparent process through which any adverse system strength impacts can be identified and quantified.

The Commission considers AEMO to be best placed to produce these guidelines. AEMO currently produces 'power system stability guidelines' and has also undertaken extensive work to understand the impacts of reducing system strength. The guidelines will need to be developed in accordance the Rules consultation process. This will allow generators, NSPs, equipment manufacturers and other interested stakeholders the opportunity to have input into the development of the guidelines.

The system strength impact assessment guidelines must:

- provide for a two stage assessment process comprising a preliminary and full assessment
- require the full assessment to be carried out using a power system model that is reasonably appropriate for conducting system strength impact assessments and which is applicable to the location on the network where the generator may be connected
- exclude from the assessment the impact on any protection system for a network
- provide guidance about the different network conditions and dispatch patterns and other relevant matters that should be examined when undertaking an assessment
- specify the nature of the impacts that AEMO considers to be adverse system strength impacts

- provide guidance about the matters that must be considered when determining whether a connection or alteration will result in an adverse system strength impact

- include if applicable any thresholds below which an impact may be disregarded when determining the need for remediating an adverse system strength impact

- provide general guidance about options for remediating an adverse system strength impact.

AEMO, in producing the guidelines, is also required to determine a methodology for performing a preliminary assessment. This will act as a screening for the need for a more detailed consideration of the impact of a new connection.

The incorporation of the system strength impact assessment guidelines into the connection process is explained in section 5.5.3.

The final rule also introduces interim guidelines to apply until the guidelines are developed in accordance with the NER. The need for these guidelines is discussed in more detail in chapter 6.

When considering the impact of a new connecting generator, the assessment guidelines are to exclude the impact on any protection system for a transmission network or distribution network from what can be considered as an adverse system strength impact. The Commission considers that the NER clearly allocates responsibility for the maintenance of network protection systems to NSPs. NSPs are required to operate protection systems under a range of conditions, including reduced system strength. Consequently, the Commission does not consider new connecting generators should be required to fund the costs of NSPs meeting this obligation when connecting to the network through the do no harm obligation introduced in the final rule. NSPs' obligations under the existing arrangements are explained in more detail in appendix A.

Under the final rule, the costs of maintaining levels of system strength needed for the secure operation of the power system are shared between:

- connecting parties where adverse system strength impacts can be attributed to its connection

- transmission network users when system strength is provided by the TNSP.

These costs should reduce the extent to which less efficient market outcomes arise as a consequence of the need for AEMO to impose other operational measures to manage system security, such as the application of constraints and directions.

The extent to which costs are either borne by connecting parties or the TNSP will have an impact on locational incentives. Where costs are attributable to a connecting party, this will place a strong incentive to locate in an area of the network where it is likely that there will be a lower impact to the stability of the system.

Where possible, costs should be allocated to parties who are best able to respond to these costs (i.e. system strength impacts that are attributed to a connection should be borne by that connecting party). However, it is also important to make sure that the costs allocated are efficient, otherwise it may result in perverse outcomes where connecting generators face inefficiently high incentives to relocate, or otherwise act as barriers to access, if adverse system strength impacts are incorrectly attributed to new connections.

If it is determined that a new connecting generator would have an adverse system strength impact, this may result in material costs being imposed on that generator which may impact on the ability of a generator to gain access to the network.

The Commission considers it important that the connection of a new generator does not adversely impact on system security. However, as is the currently the case when seeking access, connecting generators should have recourse to dispute resolution in relation to impacts attributed to their connection, particularly as this may impact on the viability of a new generator and the allocation of costs to maintain sufficient system strength. As such, the Commission considers it is appropriate for a dispute resolution process to apply to issues relating to a generator's ability to access the network and to make sure that the costs of gaining access accurately reflect its potential impact on the stability of the system.

Under the existing NER arrangements, connecting parties have the ability to address disputes arising in relation to any aspect of the connection process. These disputes can be addressed through commercial arbitration or through a dispute resolution panel (DRP) process.[169]

Consistent with existing dispute resolution provisions, the final rule introduces the ability for a connecting generator to seek to resolve any dispute in relation to the harm, (or adverse system strength impact) attributed to its connection under clause 8.2 of the NER. This applies to any dispute relating to the assessment of an adverse system strength impact as a result of conducting a system strength impact assessment including a dispute in relation to:[170]

- whether the model specified by AEMO in the guidelines was reasonably appropriate
- the application of the guidelines by the NSP when undertaking a system strength impact assessment.

This provides connecting parties with the ability to dispute any adverse system strength impacts that have been allocated to its connection and is consistent with a connection applicant's ability to seek dispute resolution regarding issues arising with

169 In the final rule for the *Transmission connections and planning arrangements* rule change, the Commission clarified that disputes arising in the process of connecting to the transmission network should be addressed through commercial arbitration. This process was also moved from Chapter 6A to Chapter 5 of the NER.

170 Final rule clause 5.3.4B.

its connection application under Chapter 5 of the NER. The Commission considers the DRP process set out in clause 8.2 of the NER is an appropriate mechanism for addressing such disputes.

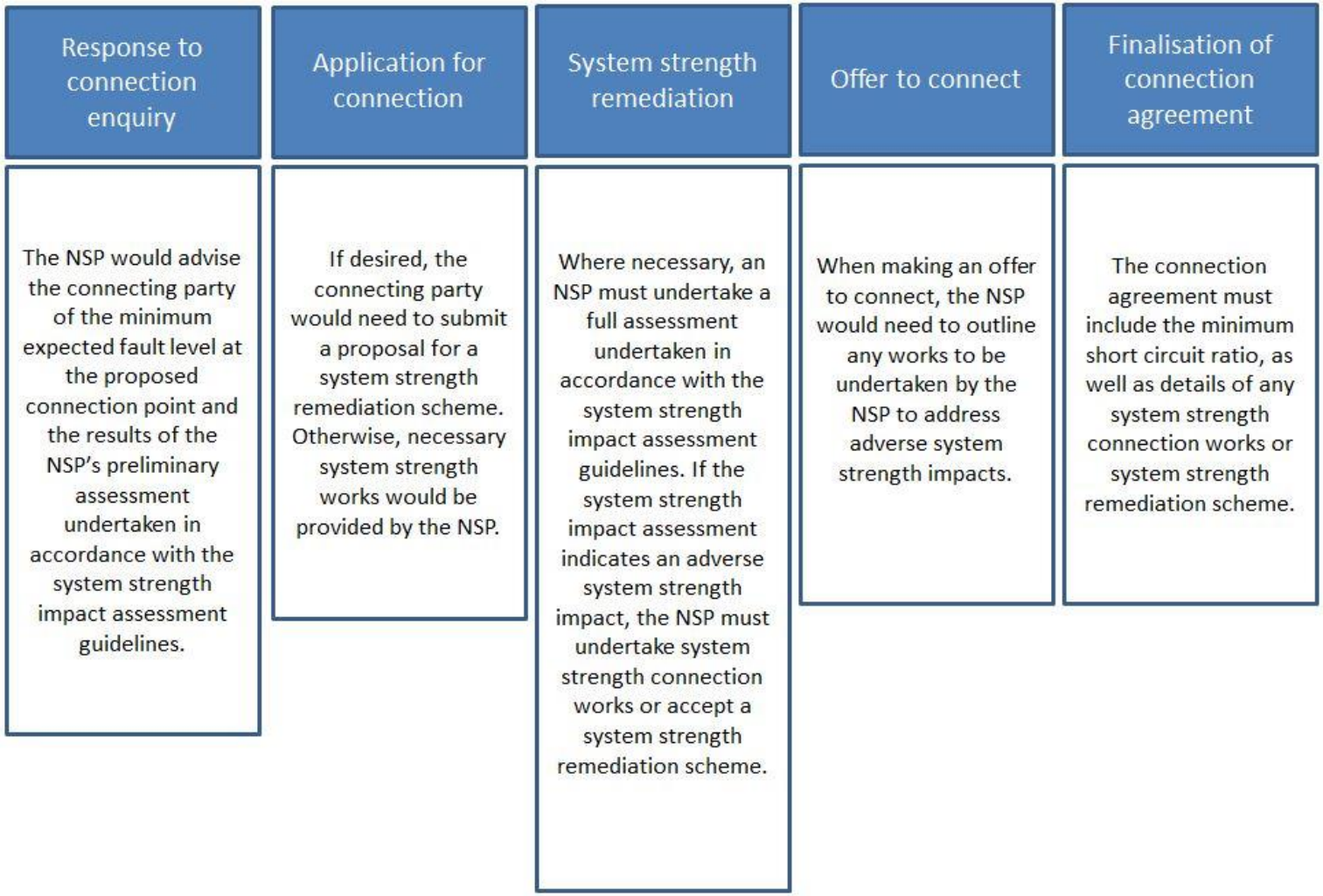
In addition, if the connection applicant and the NSP are not able to agree in respect of a proposal for a system strength remediation scheme (system strength remediation schemes are explained in Box 5.2), the matter can also be addressed through a dispute resolution process.[171]

5.5.3 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 compromise power system security. The process of determining how system strength would be considered for new connecting parties is outlined in Figure 5.1.

171 Where these disputes relate to transmission connections, they are addressed in commercial arbitration process that will be established in rule 5.5 of the NER following the commencement of the final rule for the *Transmission connection and planning arrangements* rule change. These transmission connections will also be able to access the independent engineer process to provide advice on technical matters. Disputes relating to distribution connections do not have a dedicated commercial arbitration process and will thus be addressed through the dispute resolution process set out in rule 8.2 of the NER.

Figure 5.1 Addressing system strength in the connection process



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

- the extent of any adverse system strength impacts
- how to remediate any adverse system strength impacts.

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

Response to the connection enquiry

Under the connection process, following the receipt of a connection enquiry, a NSP is required to respond within a specified timeframe.[172] Under the current arrangements, the response from the NSP includes a preliminary program and information on access standards.

The final 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:[173]

- the minimum three phase fault level at the proposed connection point
- the results of the NSP's preliminary assessment of the impact of the new connection undertaken in accordance with the system strength impact assessment guidelines.

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.[174] The content of a system strength remediation scheme is discussed below.

System strength remediation for new connections

Under the final rule, an NSP must, in accordance with the system strength impact assessment guidelines, undertake a system strength impact assessment for each proposed new generator connection. An NSP must also undertake this assessment for any proposed alteration to a generating system to which clause 5.3.9 of the NER applies. In order to undertake this assessment, the NSP may approach AEMO for access to models necessary to undertake the assessment. If AEMO is approached in regards to a model of an existing participant, AEMO may require that participant to

172 Clause 5.3.3 of the NER.

173 Final rule clause 5.3.3(b5).

174 Final rule clause 5.3.4(g).

provide the necessary models such that the system strength impact assessment can be undertaken.[175]

If the system strength impact assessment indicates an adverse system strength impact, the NSP must undertake system strength connection works. These works would be funded by the connecting generator.

System strength connection works are not required if:

- the assessment indicates that there will be no adverse system strength impact or
- a system strength remediation scheme has been proposed and accepted.

Box 5.2 provides more detail on system strength connection works and system strength remediation schemes.

Box 5.2 System strength works

An adverse system strength impact can either be addressed 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 remedy or avoid an adverse system strength impact arising from establishing a connection.

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.

System strength remediation scheme

Under the final 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 equipment by the generator behind its connection point that provides fault current and remedies or avoids an adverse system strength impact. It may be the case that the additional fault current provided by the generator would not be required at all times to remediate impact on system strength.

175 This obligation was introduced in the final rule for the *Generating system model guidelines* rule change. The Commission notes that this final rule does not commence until 1 July 2019. The final rule and final determination for this rule change are available at: http://www.aemc.gov.au/Rule-Changes/Generating-System-Model-Guidelines

- Opt to reduce output under low system strength conditions. In this case, the generator would need to reduce output or turn off under low system strength conditions. This process could be managed through the NEM dispatch process or by a process defined in the connection agreement.

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 in the NSP's reasonable opinion, it would not achieve its required outcome or would adversely affect quality of supply for other network users. AEMO would be able to withhold its approval if it thought that the system strength remediation scheme would adversely affect power system security.

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.[176]

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 final rule, the connection agreement would need to contain details of any system strength connection works and details of any agreed system strength remediation scheme.[177]

176 Final rule clause 5.3.6(a1).

177 Final rule clause 5.3.7.

6 Implementation and transitional arrangements

This chapter outlines the transitional arrangements introduced in the final rule, including:

- arrangements for AEMO to produce guidelines for the TNSP obligation to provide required levels of system strength
- interim arrangements for the 'do no harm' obligation
- the treatment of any NSCAS gaps declared prior to the commencement of the final rule on 1 July 2018.

Different provisions of the final rule will commence on different dates:

- the do no harm obligations in the final rule will commence on, and apply from, 17 November 2017
- the other obligations in the final rule will commence on 1 July 2018.

6.1 Initial determination of system strength requirements and TNSP provision of system strength services

AEMO to determine system strength requirements methodology

The transitional arrangements in the final rule set out how AEMO must establish a methodology setting out the process AEMO will use to determine the system strength requirements for each region.

The final rule includes an on-going obligation on AEMO to follow the NTNDP consultation process when updating the system strength requirements methodology. However, the publication of the final rule is not concurrent with AEMO's NTNDP process. Therefore, the transitional arrangements in the final rule require AEMO by 1 July 2018 to publish a methodology setting out the process AEMO will use to determine the system strength requirements for each region.

In producing this methodology, AEMO is not required to comply with the NTNDP consultation process. However, AEMO must comply with the NTNDP consultation process for any subsequent proposal to change this methodology. By 1 July 2018, AEMO must also make a determination of the system strength requirements for each region applying this methodology.

TNSP provision of system strength services

If AEMO determines that there is a fault level shortfall in a region by 1 July 2018, AEMO must notify the relevant TNSP. In declaring a shortfall AEMO must specify the extent of the shortfall (including the period over which it is expected to exist) and the date by which the TNSP, as the System Strength Service Provider, must make the

necessary system strength services available. The effect of the transitional arrangements will be that this date cannot be before 1 July 2019.[178]

If the TNSP receives notice after 30 April 2018 then it will not be required to include information in its TAPR by 30 June 2018 about the activities undertaken to satisfy its obligation to make system strength services available to address the shortfall. This information would however need to be included in the TAPR for the following year.[179]

6.2 Transitional do no harm arrangements

Do no harm obligation

In order to address the potential system strength impacts of new connecting generators, the final rule requires AEMO to publish interim system strength impact assessment guidelines by 17 November 2017.[180] AEMO is then required to develop and publish the updated system strength impact assessment guidelines, applying the Rules consultation procedure, by 1 July 2018.[181]

The Commission considers that interim system strength impact assessment guidelines are necessary to manage the potential legacy impacts of the large numbers of generator connection applications currently being considered by the NSPs and AEMO. The large numbers of generators seeking to connect to the network, particularly non-synchronous generators seeking to locate in close proximity to each other, have the potential to adversely impact on system strength to the extent of possibly compromising system security. For example, in its submission to the draft determination, Energy Queensland noted that it has over 130 projects at various stages of the connection process and the cumulative impacts of these connections poses significant challenges in maintaining power system security.[182]

In the absence of interim system strength impact assessment guidelines, the impacts of these new generators that are currently seeking connection would not be managed and this could impose system security issues in the future.

Introducing interim guidelines would mean that the system strength impacts of new connecting generators could be addressed. New connecting generators would be required to follow the remediation process set out in chapter 5 of this determination. The introduction of an interim guideline would also provide new connecting generators with an incentive to consider system strength when considering a connection proposal.

178 Final rule clause 11.101.4(c).

179 Final rule clause 11.101.4(d).

180 Final rule clause 11.101.2(a).

181 Final rule clause 11.101.2(c).

182 Energy Queensland, submission to draft determination, pp. 3-4.

6.3 Transitional arrangements for NSCAS

As discussed in chapter 3, from 1 July 2019 a system security issue that could be addressed as a fault level shortfall cannot addressed through the NSCAS framework.[183] However, the Commission considers that transitional arrangements are necessary in order to accommodate the declaration of a NSCAS gap prior to 1 July 2018, when the new system strength requirements framework commences. These transitional arrangements apply to a NSCAS gap declared in the period:

- from 19 September 2017 (the date the final rule is made) to 1 July 2018
- prior to 19 September 2017.

The transitional arrangements in this rule also prevent a system security issue that could be addressed as a fault level shortfall being declared a NSCAS gap after 1 July 2018.

NSCAS gaps declared between 19 September 2017 and 1 July 2018 (NSCAS transition period)

NSCAS gaps are usually declared for 5 year planning horizons and actions can be taken by TNSPs or AEMO to address these gaps. However, if a system strength related NSCAS gap[184] is declared between 19 September 2017 and 1 July 2018, the final rule prevents:

- AEMO from acquiring NSCAS for any period after 1 July 2019[185]
- a TNSP from responding to the NSCAS gap for any period after 1 July 2019.[186]

If, in this period, AEMO declares a system strength related NSCAS gap and provides a TNSP 12 months or more notice to meet the gap, the relevant TNSP must treat the NSCAS gap as if it were a notice of a fault level shortfall under the new framework.[187] The Commission considers that if the TNSP is provided with at least 12 months to meet the gap, being the same minimum level of notice a TNSP would receive under the new framework, this would be sufficient time for the TNSP to be obliged to address the gap and be able to do so pursuant to the new system strength requirements framework.

However, if AEMO provides less than 12 months' notice, the TNSP may elect to treat the gap:[188]

- under the existing NSCAS framework or
- as if it were a notice of a fault level shortfall under the new framework.

183 Unless the declaration of the NSCAS gap was made prior to 19 September 2017.

184 A system strength-related NSCAS gap is a NSCAS gap that is equivalent to a fault level shortfall.

185 Final rule clause 11.101.5(b).

186 Final rule clause 11.101.5(c).

187 Final rule clause 11.101.6(b).

188 Final rule clause 11.101.6(a).

If the TNSP elects to treat the NSCAS gap under the existing NSCAS framework, the NSCAS framework will continue to apply to that gap. This includes allowing AEMO to act as procurer of last resort for the balance of the planning horizon of the gap. AEMO has the ability to act as procurer of last resort if the relevant TNSP advises AEMO, in response to the gap, that it will be taking no, or insufficient, action to address the gap, as reassessed by AEMO after receiving such advice.

In order for the TNSP to be able to treat the NSCAS gap under the new framework, the NSCAS gap must be represented as a shortfall in the three phase fault level typically provided at a specified node having regard to typical patterns of dispatched generation, compared to the level required to maintain the power system in a secure operating state.[189]

If the TNSP elects to address the declaration of the NSCAS gap as if it were a notice of a fault level shortfall under the new framework then any associated services procured would be subject to the provision of the new framework, including the ability for the TNSP to:

- not undertake a RIT-T, if it receives less than 18 months' notice of the fault level shortfall[190]

- apply to recover its associated costs as a fault level shortfall event under the NER cost pass-through provisions.[191]

The Commission considers that this transitional approach for NSCAS gaps declared between 19 September 2017 and 1 July 2018 facilitates a practical and efficient transition to the new more transparent and clearly defined framework, without limiting AEMO and TNSP's flexibility to continue with the existing NSCAS framework where necessary.

In addition, these transitional arrangements could expedite the management of system strength issues by:

- specifying the requirement for system strength services prior to 1 July 2018, which is when AEMO is required under the final rule to publish the initial system strength requirements methodology

- allowing a NSCAS gap that is equivalent to a fault level shortfall to be addressed under the new framework which would not require a RIT-T to be undertaken for expenditure to address the fault level shortfall, where permitted under the new framework.

189 Final rule clause 11.101.1(a), definition of "system strength related NSCAS gap".

190 Final rule clause 5.16.3(a)(11)(ii). If the TNSP receives more than 18 months' notice then it is not exempted from undertaking a RIT-T for network investments.

191 Final rule clause 6A.7.3(a1)(7).

NSCAS gaps declared prior to 19 September 2017

On 13 September 2017 AEMO declared a NSCAS gap in relation to system strength in South Australia through an update to its 2016 NTNDP.[192] Further technical information on the system strength requirements in South Australia is available in a complementary AEMO report.[193]

AEMO has requested that ElectraNet provide a response to the declaration of the NSCAS gap, setting out the technical capability it will have in place to meet the gap by 5 December 2017. If ElectraNet elects to not meet the NSCAS gap, or to meet it in part, under the existing NSCAS framework AEMO will be required to consider whether to acquire the relevant NSCAS, to meet any reassessed NSCAS gap by AEMO after receiving such advice.[194]

In relation to the NSCAS gap, AEMO specified:[195]

- the fault level at the Para 275kV connection point in South Australia is not always above the minimum 2600MVA to 4000MVA required to maintain power system security in South Australia
- that the minimum fault level requirement is an annual, ongoing requirement for the current five-year planning horizon of the 2016 NTNDP
- how the declared NSCAS gap could be addressed by contracting with one or more combinations of synchronous generating units or through other means such as with the installation of synchronous condensers.

The transitional arrangements give AEMO the option of withdrawing this (and any other) system strength related NSCAS gap declared prior to 19 September 2017.[196] Given the existing NSCAS gap cannot be addressed under the system strength framework, the Commission considered it important to allow AEMO the flexibility to withdraw this NSCAS gap, in light of the balance of the transitional provisions. This means that, under the transitional arrangements introduced in this rule, the existing NSCAS gap in South Australia could either:

- continue to be treated under the existing NSCAS framework, if it is not withdrawn by AEMO or
- be withdrawn and potentially reissued after the commencement of the final rule. If the gap was declared again, its declaration would be in accordance with the balance of the transitional arrangements, and can be addressed as a NSCAS gap up until to 1 July 2019. If the gap is re-declared, ElectraNet will have the option to treat the NSCAS gap as a fault level shortfall under the new framework (unless

192 AEMO, *Update to the 2016 National Transmission Network Development Plan*, 13 September 2017.

193 AEMO, *South Australian system strength assessment*, 6 September 2017.

194 Clause 3.11.3 of the NER.

195 AEMO, *Update to the 2016 National Transmission Network Development Plan*, 13 September 2017.

196 Final rule clause 11.101.7(b).

provided with 12 or more months' notice, in which case ElectraNet **must** address the gap as a fault level shortfall).

If the existing gap is not withdrawn, it will not be able to be addressed under the new system strength framework introduced in this rule. The gap has been declared for the balance of the five year period after the 2016 NTNDP. As the new framework will commence on 1 July 2019, any actions taken by either or both AEMO and ElectraNet in addressing the gap will be relevant to assessing any fault level shortfall under the final rule.

Abbreviations

AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
MW	megawatt
NEL	National Electricity Law
NER	National Electricity Rules
NSCAS	network support and control ancillary services
NTNDP	national transmission network development plan
PSI - TAG	Power System Implications Technical Advisory Group
RIT-T	regulatory investment test for transmission
STATCOM	static synchronous compensator
SVC	static VAr compensator
TAPR	transmission annual planning report
TNSP	transmission network service provider

A System strength in an electricity network

This appendix provides more detail on:

- how system strength is expressed and how system strength changes throughout the network
- issues relating to network protection systems and voltage management.

A.1 System strength in an electricity network

A.1.1 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 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, which is that ratio of the system strength in MVA, and the capacity of the generating unit or inverter in megawatts MW.[197]

Box A.1 Spider webs

The strength of a power system can be likened in a sense 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 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.

197 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.

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.

A.1.2 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[198] connected nearby
- that point in the network is connected to these generating units with more transmission and/or distribution lines.

Non-synchronous generators[199] 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.[200] It is possible that future inverter based generation will be able to make a greater contribution to the system strength. Additionally, more modern machines are able to operate at lower levels of system strength. To an extent, this has the effect of reducing the required system strength.

A.1.3 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

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

199 Generators that are not electro-mechanically synchronised to the system frequency, typically wind turbines and PV cells.

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

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.

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.[201] The NER specifies faster clearance times for high voltages as the consequences of prolonged faults are greater.

A.2 Network protection systems and voltage managements

A.2.1 Issues resulting from reduced system strength

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

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

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:[202]

- the absolute level of voltage must be in a defined range
- 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 reactive bank. Of particular concern is that automatic voltage control systems can become unstable at low fault levels.

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.

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

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 static VAr compensators (SVCs) and static synchronous compensators (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 reactive 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 reactive 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.[203]

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 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,[204] 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.

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203 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.

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

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.

Current allocation of roles and responsibilities

NSPs are currently are responsible for the provision and operation of the protection systems for their networks.[205]

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.

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.2 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

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

output or limiting flows within the transmission network

A.2.2 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.[206]

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 request proposes changes that would allocate responsibility for fault levels at different parts of the network, considering cost, incentives and allocation of risk.[207]

A.2.3 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[208]
- undertake joint planning to achieve efficient planning outcomes[209]
- management of the voltage within their network.[210]

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 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

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

207 Ibid, p. 2.

208 Schedule 5.1.9 of the NER.

209 Clause 5.14.1 of the NER.

210 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.

- 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.[211]

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.

211 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 final rule determination.

B.1 Final rule determination

In accordance with ss. 102 and 103 of the NEL the Commission has made this final rule determination and related final rule in relation to the rule proposed by the South Australian Minister for Mineral Resources and Energy.

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

A copy of the more preferable final rule is attached to and published with this final rule determination. Its key features are described in section 2.1, and in detail in chapters 3-6 of this determination.

B.2 Power to make the rule

The Commission is satisfied that the more preferable final rule falls within the subject matter about which the Commission may make rules. The final 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 final 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 the first and second round of consultation
- the Commission's analysis as to the ways in which the proposed rule will or is likely to, contribute to the NEO and how the more preferable final rule will, or is likely to better contribute to the achievement of the NEO.

There is no relevant Ministerial Council on Energy (MCE) statement of policy principles for this rule change request.[212]

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.[213] The final rule is compatible with AEMO's declared network functions because as it leaves those functions unchanged.

B.4 Northern Territory considerations

From 1 July 2016, the NER, as amended from time to time, apply in the Northern Territory, subject to derogations set out in Regulations made under Northern Territory legislation adopting the NEL.[214] Under those Regulations, only certain parts of the NER have been adopted in the Northern Territory.[215] As the proposed rule relates to parts of the NER that currently do not 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, the Commission has not assessed the proposed rule against additional elements required by Northern Territory legislation.

B.5 Civil penalties

The 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's final rule introduces new

212 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.

213 Section 91(8) of the NEL.

214 National Electricity (Northern Territory) (National Uniform Legislation) (Modifications) Regulations.

215 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).

rules which the Commission is proposing to recommend, subject to consultation with the AER, to the COAG Energy Council be classified as civil penalty provisions under Schedule 1 of the National Electricity (South Australia) Regulations:

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

- Clause 3.9.7(c) – a generating unit must comply with dispatch instructions from AEMO to enable its system strength services.
- Clause 4.3.4(k) – TNSPs that are System Strength Service Providers must make system strength services available to AEMO in accordance with the NER, and clause 4.3.4(m) – each TNSP that is a System Strength Service Provider must give AEMO information about the system strength services it makes available and update that information if there is a material change.
- Clause 4.4.5(f) and (g) – a System Strength Service Provider or Registered Participant providing system strength services must comply with an instruction given by AEMO to enable the service, and must ensure that appropriate personnel are available to ensure that the instruction can be complied with.
- Clause 4.9.9D – A System Strength Service Provider must notify AEMO of any event which is likely to change the availability of a system strength service.
- Clause 5.2.3(g1) – an NSP must comply with any terms of its connection agreement for its market network service facilities that provide for a system strength remediation scheme.
- 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(g), 5.3.4B(i) and 5.3.4B(j) – these clauses set out strict timelines within which an NSP must respond to a proposed system strength remediation scheme, 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 5.20C.4(f) – A System Strength Service Provider must obtain AEMO's approval as to the specification, performance standards and arrangements necessary for AEMO to give instructions for a system strength service before it becomes available.

The reasons that these clauses ought to be civil penalty provisions are that a breach of these clauses 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.

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

C Summary of other issues raised in submissions

This appendix sets out the issues raised in the second 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. Please refer to the draft rule determination for a detailed discussion of the issues raised in the first round of consultation and the AEMC's response to those issues.[216]

Stakeholder	Issue	AEMC response
Energy Queensland	Energy Queensland would appreciate if the AEMC extended its consideration of these issues to include DNSPs, particularly with respect to any protections, limitations or immunities from liability that may be appropriate as a result of the provision of system strength services. (p. 9).	The final rule only places an obligation on TNSPs to maintain fault levels at the fault level nodes. As such, the provisions relating to contracting that apply to TNSPs in procuring system strength services have not been extended to DNSPs. This is discussed in section 4.5.
PIAC	PIAC supported the arrangements for undertaking system strength works being subject to the dispute resolution processes for negotiated services under the current NER and the Independent Engineer's review in transmission connections. (p. 2).	Connecting parties and TNSPs will have access to the independent engineer[217] for technical advice regarding the provision of system strength connection works. The independent engineer process does not apply to connections to the distribution network. The existing dispute resolution framework will continue to apply to the connection process more generally.
PIAC	PIAC recommended that the Commission considers the allocation of cost and risk in any	It is beyond the scope of this rule to address issues associated with 'queuing' of connection

216 AEMC, *Managing power system fault levels - draft determination*, 27 June 2017.

217 The independent engineer process was introduced in the *Transmission connections and planning arrangements* final rule. This rule commences on 1 July 2018.

Stakeholder	Issue	AEMC response
	prospective system strength work which may be done to connect multiple proponents to ensure that consumers are not bearing the risks of inefficient investments. (p. 2).	applications. The Commission acknowledges that there may be circumstances where coordination of investments in system strength works between multiple connecting parties would lead to more efficient outcomes and that it is open to networks to develop and publish how it they intend to address such issues. The Commission otherwise notes that the system impact assessment guidelines will apply consistently between regions and would be expected to a transparent process through which any adverse system strength impacts can be identified and quantified.
South Australian Government	There is a need to consider the effect of clustering of new generators up until the network becomes weak and eventually the last connecting generator bears the brunt of remediation. (p. 9).	
Energy Networks Australia	While we understand that the Commission has attempted to progress its thinking based on existing processes, there may be a need to examine the issues of 'queuing' and 'open-season' processes that has been functioning in other jurisdictions and sectors for connecting parties. This could be addressed either in this rule change or in a subsequent process. A key step in examining this 'queuing' issue, would involve some potential guidance and understanding of a consistent set of criteria where a mechanism could be triggered to allow an NSP to cluster or undertake a combined analyses of connection applications. (p. 9).	
Energy Queensland	Energy Queensland believes further consideration is required in the final rule determination as to how the 'do no harm' requirement is to be managed where there are multiple proponents as well as the circumstances under which information can be shared to enable efficient decision-making, particularly with respect to identifying the most cost-effective	

Stakeholder	Issue	AEMC response
	solution to address system strength issues on the network. (p. 11).	
Energy Developments Limited	Energy Developments Limited notes that obligations to do no harm are already dealt with in the NER. It notes the requirements of clause 5.3.5(d) of the NER. Where an existing project or project under development has reached an offer to connect or connection agreement that there be no further requirement to undertake any works not already set out in the offer to connect or in the connection agreement. (p. 1).	The Commission acknowledges that some clauses in the NER already place a form of 'do no harm' obligation on connecting generators. However, the Commission does not consider these clauses provide connecting generators and NSPs with sufficient transparency regarding what should be considered when assessing the impact of a new connection on system strength, nor sufficient flexibility in relation to solutions to address that impact. The final rule establishes a transparent framework in which 'harm' can be assessed, and the allocation of responsibilities is clear. The final rule also clarifies that the costs of remediating any adverse system strength impact must be funded by the connecting generator at the time of connection. The 'do no harm' obligations are discussed in chapter 5 of this determination.
Energy Developments Limited	It is reasonable to expect that when the NSP provides the connection applicant with the minimum expected fault current, this supported by the assumptions which have led to the minimum fault current. Providing the assumptions will enable a generator to better understand the risks associated with the proposed connection point. (p. 1).	AEMO's reporting of the system strength requirements will outline the assumptions to be used by NSPs when assessing the minimum fault levels.
Energy Developments Limited	Broadening the final rule to permit a contract with a third party to provide fault current will, in	The final rule allows connecting parties to propose a system strength remediation scheme.

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	Energy Developments Limited's view, provide benefits to both the connection applicant as well as the network business. (p. 1).	This scheme may include third party contracts between the connecting party and any source of fault level on the network where this fault level would remediate an adverse system strength impact. System strength remediation schemes are discussed in more detail in chapter 5 of this determination.
Clean Energy Council	The Clean Energy Council considered that the draft rule around 'system strength remediation schemes' needed to be updated to permit a contract with a third party to facilitate minimum short circuit ratios levels being met where the connection applicant identifies this as the lowest cost preference. Explicitly omitting this is inconsistent with the NEO as only higher cost solutions would be permitted. (p. 6).	
AEMO	AEMO considered the language in the draft rule implied that the obligation on new generating systems to 'do no harm' inferred some form of capital expenditure to remediate the problem even where alternative, more efficient, solutions might be available. To be consistent with other current market initiatives promoting mechanisms to reduce capital expenditure, AEMO considered that rather than a network solution, any 'harm' may be more efficiently addressed using non-network solutions, especially if the 'harm' has a low probability of occurrence. The obligations on connecting generators should, therefore, be clear that the cost associated with remediating any harm is not limited to a network solution. (p. 8).	
Clean Energy Council	The assets anticipated for network solutions are not aligned to those required for generator solutions, in particular with regards to life span.	If a new connecting party were to cause an adverse system strength impact (i.e. harm) when connecting, this will need to be remediated. The

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	Adding this requirement would give a TNSP scope to oblige new entrants to invest in solutions that have life expectancies beyond the connection agreement which may only be provided by TNSP-owned assets. (p. 5).	connecting party would be able to propose a system strength remediation if it considers this to be a more efficient option than having the impact remediated by the relevant NSP. System strength remediation schemes are discussed in more detail in chapter 5 of this determination.
Clean Energy Council	In the draft rule, the Commission proposed that NSPs include the minimum 'expected fault current' at the proposed connection point in a connection inquiry response. Given the diverse influences on fault current (augmentation, generator retirements and new entrants for example) it is reasonable to expect that this information is supported by the assumptions which have led to the minimum fault current. (p. 6).	The Commission considers requiring the NSP to provide the connecting party with the fault levels at the proposed connection point will be sufficient during the connection enquiry stage of the connection process. The connecting party will receive additional necessary information regarding system strength later in the connection process when both the connecting party and the NSP will be better able to assess any likely system strength impacts. AEMO's system strength impact assessment guidelines will provide the NSPs with the assumptions to be used when assessing the minimum fault levels when undertaking a full assessment of any system strength impacts.
Clean Energy Council	A more progressive solution would require that the TNSPs and AEMO inform connection applicants with short circuit ratio information and minimum expect fault levels ahead of the rule applying to advanced proposed connections. Noting that there are no new 'do no harm' obligations created by this rule the Commission should consider a six month window from the rule commencing to it applying to connection applicants that had lodged a connection	The Commission considers that the final rule should commence as soon as possible to mitigate any legacy impacts of new connecting generators. The transitional arrangements introduced in the final rule are discussed in chapter 6 of this determination.

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	agreement by the commencing date. (p. 6).	
South Australian Government	A NSP cannot guarantee that system strength will remain sufficient for the life of the generating system. (p. 9).	Under the final rule the TNSPs will no longer be required to maintain the system strength at generator connection points.
Energy Networks Australia	Energy Networks Australia sought further clarity as to how the generator "do no harm" obligation would be interpreted under a range of different examples and scenarios. (p. 11).	The final rule requires AEMO to prepare and publish system strength impact assessment guidelines that will provide stakeholders guidance when assessing the do no harm obligation. This is discussed in more detail in chapter 5 of this determination.
Energy Networks Australia	Energy Networks Australia did not want to see an outcome where any new system strength 'do no harm' obligation may result in significant additional costs for new non-synchronous generators (both for non-scheduled and semi-scheduled), which could be avoided by larger, solutions that exhibit economies of scale. (p. 11).	The final rule requires AEMO to prepare and publish system strength impact assessment guidelines by following the Rules consultation procedure, which would be expected to consider the costs to new connecting generators. TNSPs will also now be required to maintain system strength throughout a region where AEMO declares a shortfall. This is likely to result in larger, holistic solutions where this is the most efficient outcome.
Energy Networks Australia	There are a number of generating plants that are marginally below the 30 MW threshold for scheduled generator registration. It will be crucial for the Commission to clearly recognise the growing number of semi-scheduled generators' significant impact on system strength at this level. There could be the scope for an expert technical assessment to determine an	These impacts would be considered by AEMO when it develops the system strength impact assessment guidelines. All generators that connect under rule 5.3 and rule 5.3A of the NER (as generators with a nameplate capacity between 5MW and 30MW are expected to) will be required to do no harm to the system in terms of impacts on system

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	appropriate solution. (p. 12).	strength.
TasNetworks	The final rule should be clear about the need for such schemes and differentiate between system security impacts (increasing minimum fault level requirements for instance) and market access impacts (increasing the required equivalent short circuit ratio and corresponding fault level). (p. 12).	The do no harm obligation requires connecting generators to remediate any adverse system strength impact in terms of the security of the power system. New connecting generators will not be required to provide system strength for market benefits.
Hydro Tasmania	Hydro Tasmania suggests that AEMO should accommodate the local TNSP setting requirements for fault level. (p. 2).	This issue can be resolved when AEMO consults on the development of the system strength requirements methodology. The Commission considers that market participants should make AEMO aware of any jurisdictionally specific requirements while AEMO is in the process of developing its requirements.
ElectraNet	Neither AEMO nor TNSPs will know if there is a need to call for the commitment of a generator under contract to provide services until pre-dispatch has been reviewed based on commitment intentions of market participants. If after reviewing the pre-dispatch it is determined there is a need for additional unit commitment this would be included in a subsequent pre-dispatch with the unit operating at minimum stable load which generally will result in a reduction in forecast market price. This reduction may then prompt another generator to reduce its commitment on valid commercial grounds, leading to a further round of rebidding. Although rebidding to settle unit commitment is a normal part of the NEM, AEMO or a TNSP will be active	The Commission considers AEMO, as the market operator, is in the best position to determine the system strength services it considers necessary to meet the system strength requirements in a region. The obligation on TNSPs to make available the required services and the obligation on AEMO to determine when these services are required will only apply when a shortfall in either of the minimum levels of inertia and system strength necessary to maintain the system in a secure operating state is assessed.

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	participants in this process under amended NER, in conflict with the underlying principle of neutrality. An important question for operation of the energy market is therefore whether AEMO or TNSPs are best equipped to make the decision about unit commitment. There may be no alternative to making this decision where additional unit commitment is needed to ensure security, but it is a recent development and not foreseen in development of the NER. (p. 7).	
ElectraNet	ElectraNet considered that for TNSPs to specify the order in which AEMO should dispatch system strength service providers as inappropriate as it requires TNSPs to make advance decisions about the order of commitment. The decision about priority of use is an economic choice that can only be made economically with knowledge of the circumstances of the day and should be made by AEMO. An arrangement of this form implies TNSPs are to have a stake in the commercial outcomes of the energy and ancillary service markets alongside active market participants. ElectraNet submitted that TNSPs should not be expected to play this role, which is a fundamental departure from the key design principles of the wholesale market. (p. 7).	The final rule includes an ability for the TNSPs to inform AEMO of a schedule of services so that AEMO can aim to minimise the costs to consumers, and the cash flow concerns of the TNSPs. AEMO will be required to give consideration to this list but it not required to follow it. This provides an opportunity for more cost effective system strength services to be dispatched, reducing overall costs. AEMO's primary consideration in dispatching system strength services will be to maintain system security. The Commission does not consider that AEMO should be making economic decisions around the relative merits of dispatching generators based on contracts that were negotiated by TNSPs, the costs of which form part of the TNSP's operating expenditure. The final rule includes an ability for the TNSPs to inform AEMO of a schedule of services so that AEMO can aim to minimise the costs to consumers, and the cash flow concerns of the TNSPs.

Stakeholder	Issue	AEMC response
		The Commission also acknowledges the recent work undertaken by AEMO that indicates specific combinations of fault level sources are required. This list of combinations will also affect the system strength services that AEMO decides to dispatch.
Spark Infrastructure	Energy storage should be introduced as its own asset class distinct from existing asset classes. All entities should be entitled to provide energy storage and utilise the competitive benefits of energy storage, including services related to system strength and frequency control. (p. 2).	The final rule provides for TNSPs to contract for services from storage where it can be demonstrated that the services contribute to the management of system strength or rate of change of frequency.
TransGrid, Energy Networks Australia	Recommends the AEMC seeks from the South Australian Government an amendment to clause 13 of the NEL Regulations. This should extend the existing section 119 NEL(2) statutory limitation on liability for NSPs undertaking system security related functions to cover new obligations placed on them under these draft rules. (p. 4, p. 7).	It is not the Commission's practice to make recommendations on the classification of provisions as systems power and functions under NEL Regulations. The Commission encourages TransGrid and Energy Networks Australia raise this matter with the COAG Energy Council Secretariat.
Energy Queensland	Separating guidelines from the NER would enable the considered development of fit-for-purpose arrangements and allow for more timely modification of the guidelines as required. (p. 12).	The final rule introduces a system strength requirements methodology and system strength impact assessment guidelines, both of which are published by AEMO. The methodology and the guidelines will need to meet principles specified in the final rule.
Energy Networks Australia	Energy Networks Australia is concerned that the AEMC envisages implementation of new arrangements under an untested framework	Noted. The Commission is of the view that it has considered all the relevant stakeholder views when determining the final rule. The Commission

Stakeholder	Issue	AEMC response
	within short timeframes with its final determinations proposed for 19 September 2017. Members consider further discussion amongst participants (including AEMO, the AEMC and NSPs) is necessary before any new arrangements are finalised. (p. 12).	has sought the stage the implementation of the obligations in a practical manner. While some provisions will commence on 19 September 2017, other aspects of the final rule will commence on 1 July 2018. This later timeframe allows for AEMO to appropriately develop a system strength requirements methodology. The obligation on the NSP to provide system strength services commences on 1 July 2019, in order to allow TNSPS sufficient time to procure relevant services once any shortfall is declared. The Commission's reasoning for starting the 'do no harm' obligation earlier is explained in chapter 6 of this determination.
TasNetworks	A delay to the implementation timeframe should be considered to allow further refinement to the proposed framework, with 1 July 2019 being considered more achievable. This could be facilitated by placing detailed operational parameters in guidelines rather than in the NER. (p. 4).	
TasNetworks	It is recommended that the final determination have sufficient flexibility to enable DNSPs to negotiate on similar terms to generators where it is impractical for them to manage system strength issues independently of the TNSP. (p. 14).	Section 3.4.5 addresses the joint planning between TNSPs and DNSPs. In addition, the final rule requires AEMO to develop a system strength requirements methodology and system strength impact assessment guidelines to provide guidance to stakeholders.
Clean Energy Council	NSPs already publish maximum fault levels in their Annual Planning Reports and the NER should be updated to ensure publication obligations are extended to include expected minimum fault levels at the same nodes. The reporting of these fault levels should also be accompanied by a clear outline of the assumptions and modelling conditions applied to	The final rule includes a requirement for NSPs to provide the minimum fault levels as part of the connection process. In the NTNDP, AEMO will be required to report on the system strength requirements for each region. The system strength requirements methodology will outline the assumptions it will

Stakeholder	Issue	AEMC response
	determine the minimum fault levels. (p. 5).	make in determining the system strength requirements for each region. Further details are provided in chapter 3 of this determination.
SACOME	The proposed streamlined framework to negotiate RIT-T processes (18 months) and the obligation to provide inertia (12 months) is welcomed, however more detail is needed to ensure that the process can be adequately streamlined to provide necessary levels of system strength when needed. (p. 2).	The final rule requires AEMO to publish a notice of a fault level shortfall that must be addressed by the relevant TNSP. The notice must specify the extent of the shortfall and the date by which the system strength services must be made available; however, this cannot be sooner than 12 months after the publication of the notice in order to provide sufficient time for the TNSP to organise and coordinate the availability of the required services. This is discussed further in section 4.5.1.
Hydro Tasmania	The transitional arrangements suggest interim guidelines for short circuit ratio determination, and in the case of Tasmania the proposed distances for grouping of generating systems may need to be reconsidered. (p. 1).	The final rule, considers system strength in terms of the overall stability of the power system, rather than using short circuit ratios. The reasons for why the Commission does not consider short circuit ratio to be an appropriate metric for system strength are explained in section 3.5.1 of this determination. The final rule specifies the system strength requirement of a region in terms of three phase fault level. The Commission's reasons for specifying the obligation in terms of three phase fault level are outlined in chapter 3 of this
Clean Energy Council	In order to manage the risk of registered short circuit ratios being set above efficient levels AEMO should be given powers to ensure reasonable short circuit ratios are registered by existing generators. A clear calculation methodology must be put in place in the short circuit ratio guideline with AEMO positioned in a strong oversight and advisory role. (p. 5).	

Stakeholder	Issue	AEMC response
TasNetworks	There is a need to consider system strength in a holistic manner and not focus on fault level or its derivative metrics (such as short circuit ratio) as a definitive measure of system security. (p. 4).	determination.
ElectraNet	ElectraNet anticipates system strength will need to be expressed and measured through a number of metrics which broadly will ensure satisfactory system operation, for example of network protection facilities and limits on propagation of voltage swings that threaten the performance of other generators; and satisfactory performance of individual generators and loads such that individual generators will remain stable in the presence of specified system conditions (e.g. voltage swings). (p. 4).	
Energy Queensland	Energy Queensland suggest that further consideration is given to how network service providers can effectively plan to maintain system strength where a generator unexpectedly retires during a regulatory control period and the appropriate means of cost recovery. (p. 8).	If there were to be a major change to the power system, such as the retirement of a large synchronous generator, AEMO will need to determine the system strength requirements for the affected region in light of such changes. If AEMO determines there is a shortfall, it must publish a notice and require the TNSP to provide system strength services by the date specified in the notice. This date cannot be less than 12 months after the publishing of the notice, unless there has been a material change to the power system, where the timing, occurrence or impact of the change was unforeseen.
Energy Queensland	Energy Queensland believes that where a retiring synchronous generator is either	The final rule obliges the TNSP to maintain the system strength in its network, in accordance

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	transmission-connected or distribution-connected and has a significant impact on the fault levels at the transmission connection point, the transmission network service provider should be responsible for maintaining system fault levels in both the transmission and distribution networks. We would therefore appreciate further clarification in the final rule determination to ensure that the obligation to maintain system strength in this situation is the responsibility of the relevant transmission network service provider. (pp. 8-9).	with the system strength requirements determined by AEMO. If an embedded generator is materially contributing to fault levels within a region, AEMO may consider this in determining the system strength requirements for a region. AEMO will also be required to consider the expected fault level at fault level nodes. This will account for reduced operation or retirement of synchronous generators.
Energy Queensland	Energy Queensland considers that further clarity is required as to what is meant by 'retirement' of a generator for the purposes of this rule change (i.e. whether it includes long-term shutdown events) as well as which party will be responsible for funding any necessary remediation. (p. 9).	
TasNetworks	TasNetworks would recommend that the NER formulation provide adequate flexibility for NSPs to apply solutions that best suit the circumstances that prevail in their respective networks. TasNetworks believes that the proposed NER change is overly prescriptive and may limit innovation. (p. 4).	The Commission considers the final rule provides NSPs will flexibility to provide system strength services in the manner they best see fit. NSPs will be able to have input into the development of system strength requirements methodology to assist AEMO in accounting for any specific regional differences.
TasNetworks	TasNetworks has a view that NSPs should be responsible for defining the technical limits of their respective networks rather than ensuring that individual generating systems are capable of meeting their performance standards. The development of constraints that restrict operation	The final rule does not define the obligations, in relation to the TNSPs maintaining system strength and in relation to doing harm, on the basis of allowing generators to meet their performance standards. Rather, the final rule defines the system strength requirements and

Stakeholder	Issue	AEMC response
	of the network within its real time capability is the existing domain of NSPs. Creating obligations directly linked to the performance of generating systems introduces new issues pertaining to risk and liability. (p. 12).	impacts in terms of the need to maintain power system security. In addition, at the time of connection, the generator can make efficient trade-offs as the negotiation of the generator performance standards and the system strength impacts would be assessed at the time.
TasNetworks	It is TasNetworks' intention to explore how a 'constraints based approach' can be expanded to incorporate the increasing complexity brought about by more independent asynchronous generation connections. (p. 12).	Noted.
TasNetworks	Depending on the final formulation of the NER, TasNetworks would encourage the Commission to consider application of 'reference nodes'. The intent is to remove the formal requirement to perform calculations at every generator connection point. (p. 13).	The final rule defines the system strength requirements in terms of a minimum three phase fault level at the fault level nodes.
TasNetworks	Satisfaction of this absolute fault level requirement would enable all generators (and HVDC interconnectors) to satisfy their respective performance standards, at least in theory. It is proposed that the difference between the minimum fault level and that required to satisfy the performance standards of each individual generating system when operating in parallel, be managed through the application of constraint equations. The constraints will allocate the network's overall 'hosting capacity' between those generating systems that have an inherent	The Commission agrees with this approach.

Stakeholder	Issue	AEMC response
	reliance on system strength to operate satisfactorily. (p. 15).	
ENGIE	System strength services are able to be provided by a range of service providers and therefore cannot be regarded as monopoly services. (p. 3).	The Commission does not consider that system strength services are monopoly services. Rather, the Commission considers that the TNSP is best placed to procure these services to maintain the operation of its network and meet the obligations determined by AEMO. The maintenance of system strength also aligns with the current NSP obligations to manage network voltages and operate network protection systems.
ENGIE	Developments by AEMO in designing and applying new forms of constraints to manage system strength is an example of the fact that the management of system strength is within AEMO's area of responsibility, and that it is capable currently of responding to this need. (p. 4).	The Commission agrees that the real time operation of the power system needs to be managed by AEMO, but that the planning of the network is still the responsibility of the NSP. The Commission considers that the provision of these services by TNSPs will better meet the NEO. The Commission's reasoning is described in chapter 4 of this determination.
ENGIE	NSCAS arrangements make it clear that AEMO bears the ultimate responsibility for the adequate procurements of network support and control ancillary services, and this can easily be applied to procurement of system strength services. (p. 4).	The Commission considers the framework introduced in the final rule provides for a transparent manner in which the level of system strength required in a region will be regularly determined using a consulted on methodology. The final rule requires TNSPs to meet any shortfall in system strength. In procuring these services, TNSPs will be incentivised to procure the least costs services.