CHAPTER 7

Strategic planning

7 Strategic planning

Key highlights

- Long-term planning takes into account:
  - the role network is to play in enabling the transition to a lower carbon future while continuing to balance the economic and efficient development of the network
  - uncertainties in load growth and sources of generation, and the condition and performance of existing assets to optimise the network that is best configured to meet current and a range of plausible future capacity needs.
- Plausible new loads within the resource rich areas of Queensland or at the associated coastal port facilities may cause network limitations to emerge within the 10-year outlook period. Possible network options are provided for Bowen Basin coal mining area, Bowen Industrial Estate, Galilee Basin coal mining area, Central Queensland to North Queensland (CQ-NQ) grid section, Central West to Gladstone and the Surat Basin north west area.

7.1 Introduction

Australia is in the midst of an energy transformation driven by advances in renewable energy technologies, displacement/retirement of existing fossil fuelled generation, community expectations and Government emission policies.

The future customer and consumer load will be supplied by a mix of large-scale generation and distributed energy resources (DER). Queensland is experiencing a high-level of growth in variable renewable energy (VRE) generation, in particular solar photovoltaic (PV) and wind farm generation. Section 6.2 outlines that approximately 2,700MW of large-scale VRE generation is, or committed, to connect to the Queensland transmission and distribution networks by 2020.

Consumer behaviour is central to the energy transformation. Consumers are demanding choice and the ability to exercise greater control over their energy needs, while still demanding reliability and greater affordability. The future load is also uncertain due to different economic outlooks, emergence of new technology and orchestration of significant DER, and the commitment and/or retirement of large industrial and mining loads.

These changes are creating opportunities and challenges for the power system. The changing generation mix and uncertain load levels will impact the utilisation of existing transmission infrastructure. Optimising the utilisation of existing assets and any new development requirements will be vital to achieving lower-cost solutions that meet energy security and reliability, affordability and reduced emissions.

To achieve these objectives the network must support the integration of large-scale VRE generation. The network must also enable the transition to a lower carbon future by supporting the sharing of generation between areas and National Electricity Market (NEM) regions and the connection of diverse sources of VRE generation. However, all developments must continue to be economic and efficient to support sustainable affordability.

Powerlink is investigating the future network needs by assessing the impact of uncertain load growth and the connection of VRE generation to meet Government emissions reduction targets on the utilisation of grid sections and interconnectors.

Chapter 2 provides details of several proposals for large mining, metal processing and other industrial loads whose development status is not yet at the stage that they can be included (either wholly or in part) in the medium economic forecast. These load developments are listed in Table 2.1. Section 7.2 discusses the possible impact these uncertain loads may have on the performance and adequacy of the transmission system.

Increasing the capacity of interconnection between NEM regions could be pivotal to meeting Australia's long-term energy targets, providing the advantage of the geographic diversity of renewable resources so regions could export power when there is local generation surplus, and import power when needed to meet demand. Investigations underway to inform the efficient development of the network include joint planning with:

- Australian Energy Market Operator (AEMO) and other Transmission Network Service Providers (TNSPs) to develop the Integrated System Plan (ISP)[1].
- ElectraNet for the South Australian Energy Transformation (SAET) Regulatory Investment Test for Transmission (RIT-T). The options being considered include a high voltage direct current (HVDC) interconnector between South West Queensland and South Australia.
- TransGrid to investigate the economic benefits of increasing the capacity between Queensland and New South Wales (NSW) (refer to Section 5.7.12). Powerlink and TransGrid propose to commence the formal RIT-T consultation process and publish the Project Specification Consultation Report (PSCR) in the third quarter of 2018.

The changing generation mix will also impact the stability and security of the power system. System security deals with the technical parameters of the power system such as voltage, frequency, the rate at which these might change and the ability of the system to withstand faults.

New investment in VRE generation will put pressure on the NEM's fossil fuelled power stations as the competition to supply load erodes the production base of these power stations. These synchronous generators, by nature or their technology and design, provide security and stability services to the NEM not inherent in the VRE generators. These generators, through their electro-mechanical interface to the system provide frequency stability and significant voltage support or system strength. However, VRE generators, such as wind and solar, use measurement, communications and control techniques to synchronise to the network which cannot provide instantaneous response and are reliant on system strength.

Therefore, displacing synchronous generation will reduce these services giving rise to increasing challenges for:

- AEMO to maintain the power system in a secure operating state
- Network Service Providers (NSP) to maintain power system standards for power quality, voltage control and protection system operation.

The power system must therefore facilitate mechanisms that provide the necessary stability, security and ancillary services at the lowest possible cost.

These technical challenges have been recognised and are being addressed through various reviews and working groups, including:

- AEMO's Future Power Systems Security taskforce and Power System Issues Technology Advisory Group (PSITAG)
- Independent Review into the Future Security of the National Electricity Market (Chief Scientist)
- Australian Energy Market Commission's (AEMC's) System Security Market Frameworks Review.

Section 7.3 provides a high-level summary of the technical challenges and the role TNSP's will play in providing directly or facilitating the connection and/or sharing of these services.

1 During 2018 AEMO will deliver the first ISP, a strategic infrastructure development plan that will present a framework to facilitate the connection of renewable energy in the NEM.

7.2 Possible network options to meet reliability obligations for potential new loads

Chapter 2 provides details of several proposals for large mining, metal processing and other industrial loads whose development status is not yet at the stage that they can be included (either wholly or in part) in the medium economic forecast. These load developments are listed in Table 2.1.

The new large loads in Table 2.1 are within the resource rich areas of Queensland or at the associated coastal port facilities. The relevant resource rich areas include the Bowen Basin, Galilee Basin and Surat Basin. These loads have the potential to significantly impact the performance of the transmission network supplying, and within, these areas. The degree of impact is also dependent on the location and capacity of new or withdrawn generation in the Queensland region.

The commitment of some or all of these loads may cause limitations to emerge on the transmission network. These limitations could be due to plant ratings, voltage stability and/or transient stability. Options to address these limitations include network solutions, demand side management (DSM) and generation non-network solutions. Feasible network projects can range from incremental developments to large-scale projects capable of delivering significant increases in power transfer capability.

As the strategic outlook for non-network options is not able to be clearly determined, this section focuses on strategic network developments only. This should not be interpreted as predicting the preferred outcome of the RIT-T process. The recommended option for development is the credible option that maximises the present value of the net economic benefit to all those who produce, consume and transport electricity in the market.

The emergence and magnitude of network limitations resulting from the commitment of these loads will also depend on the location, type and capacity of new or withdrawn generation. For the purpose of this assessment the existing and committed generation in tables 6.1 and 6.2 have been taken into account when discussing the possible network limitations and options. However, where current interest in connecting further VRE generation has occurred, that has the potential to materially impact the magnitude of the emerging limitation, this is also discussed in the following sections.

For the transmission grid sections potentially impacted by the possible new large loads in Table 2.1, details of feasible network options are provided in sections 7.2.1 to 7.2.6. Formal consultation via the RIT-T process on the network and non-network options associated with emerging limitations will be subject to commitment of additional demand.

7.2.1 Bowen Basin coal mining area

Based on the medium economic forecast defined in Chapter 2, the committed network described in Chapter 9, and the committed generation described in tables 6.1 and 6.2 network limitations exceeding the limits established under Powerlink's planning standard may occur following the possible retirement of assets described in Section 5.7.2. A possible solution to the voltage limitation could be the installation of a transformer at Strathmore Substation, network reconfiguration works, or a non-network solution.

In addition, there has been a proposal for the development of coal seam gas (CSG) processing load of up to 80MW (refer to Table 2.1) in the Bowen Basin. These loads have not reached the required development status to be included in the medium economic forecast for this Transmission Annual Planning Report (TAPR).

The new loads within the Bowen Basin area would result in voltage and thermal limitations on the 132kV transmission system upstream of their connection points. Critical contingencies include an outage of the Strathmore 275/132kV transformer, a 132kV transmission line between Nebo and Moranbah substations, the 132kV transmission line between Strathmore and Collinsville North substations, or the 132kV transmission line between Lilyvale and Dysart substations (refer to Figure 5.6).

The impact these loads may have on the CQ-NQ grid section and possible network solutions to address these is discussed in Section 7.2.4.

Possible network solutions

Feasible network solutions to address the limitations are dependent on the magnitude and location of load. The location, type and capacity of future VRE generation connections in North Queensland may also impact on the emergence and severity of network limitations. The type of VRE generation interest in this area is predominately large-scale solar PV. Given that the Bowen Basin coal mining area has a predominately flat load profile, it is unlikely that the daytime PV generation profile will be able to successfully address all emerging voltage limitations. However, voltage limitations may be ameliorated by these renewable plants, particularly if they are designed to provide voltage support 24 hours a day.

Possible network options may include one or more of the following:

- second 275/132kV transformer at Strathmore Substation
- turn-in to Strathmore Substation the second 132kV transmission line between Collinsville North and Clare South substations
- 132kV phase shifting transformers to improve the sharing of power flow in the Bowen Basin within the capability of the existing transmission assets.

7.2.2 Bowen Industrial Estate

Based on the medium economic forecast defined in Chapter 2, no additional capacity is forecast to be required as a result of network limitations within the 10-year outlook period of this TAPR.

However, electricity demand in the Abbot Point State Development Area (SDA) is associated with infrastructure for new and expanded mining export and value adding facilities. Located approximately 20km west of Bowen, Abbot Point forms a key part of the infrastructure that will be necessary to support the development of coal exports from the northern part of the Galilee Basin. The loads in the SDA could be up to 100MW (refer to Table 2.1) but have not reached the required development status to be included in the medium economic forecast for this TAPR.

The Abbot Point area is supplied at 66kV from Bowen North Substation. Bowen North Substation was established in 2010 with a single 132/66kV transformer and supplied from a double circuit 132kV transmission line from Strathmore Substation but with only a single transmission line connected. During outages of the single supply to Bowen North the load is supplied via the Ergon Energy 66kV network from Proserpine, some 60km to the south. An outage of this single connection will cause voltage and thermal limitations impacting network reliability.

Possible network solutions

A feasible network solution to address the limitations comprises:

- installation of a second 132/66kV transformer at Bowen North Substation
- connection of the second Strathmore to Bowen North 132kV transmission line
- second 275/132kV transformer at Strathmore Substation
- turn-in to Strathmore Substation the second 132kV transmission line between Collinsville North and Clare South substations.

7.2.3 Galilee Basin coal mining area

There have been proposals for new coal mining projects in the Galilee Basin. Although these loads could be up to 400MW (refer to Table 2.1) none have reached the required development status to be included in the medium economic forecast for this TAPR. If new coal mining projects eventuate, voltage and thermal limitations on the transmission system upstream of their connection points may occur.

Depending on the number, location and size of coal mines that develop in the Galilee Basin it may not be technically or economically feasible to supply this entire load from a single point of connection to the Powerlink network. New coal mines that develop in the southern part of the Galilee Basin may connect to Lilyvale Substation via an approximate 200km transmission line. Whereas coal mines that develop in the northern part of the Galilee Basin may connect via a similar length transmission line to the Strathmore Substation.

Whether these new coal mines connect at Lilyvale and/or Strathmore Substation, the new load will impact the performance and adequacy of the CQ-NQ grid section. Possible network solutions to the resultant CQ-NQ limitations are discussed in Section 7.2.4.

In addition to these limitations on the CQ-NQ transmission system, new coal mine loads that connect to the Lilyvale Substation may cause thermal and voltage limitations to emerge during an outage of a 275kV transmission line between Broadsound and Lilyvale substations.

Possible network solutions

For supply to the Galilee Basin from Lilyvale Substation, feasible network solutions to address the limitations are dependent on the magnitude of load and may include one or both of the following options:

- installation of capacitor bank/s at Lilyvale Substation
- third 275kV transmission line between Broadsound and Lilyvale substations.

The location, type and capacity of future VRE generation connections in Lilyvale, Blackwater and Bowen Basin areas may also impact on the emergence and severity of this network limitation. The type of VRE generation interest in this area is predominately large-scale solar PV. Given that the coal mining load in the area has a predominately flat profile it is unlikely that the daytime PV generation profile will be able to successfully address all emerging limitations.

7.2.4 CQ-NQ grid section transfer limit

Based on the medium economic forecast outlined in Chapter 2 and the committed generation described in tables 6.1 and 6.2, network limitations impacting reliability or the efficient economic operation of the CQ-NQ grid section are not forecast to occur within the 10-year outlook of this TAPR.

However, as discussed in sections 7.2.1, 7.2.2 and 7.2.3 there have been proposals for large coal mine developments in the Galilee Basin, and development of coal seam gas (CSG) processing load in the Bowen Basin and associated port expansions. The loads could be up to 580MW (refer to Table 2.1) but have not reached the required development status to be included in the medium economic forecast of this TAPR.

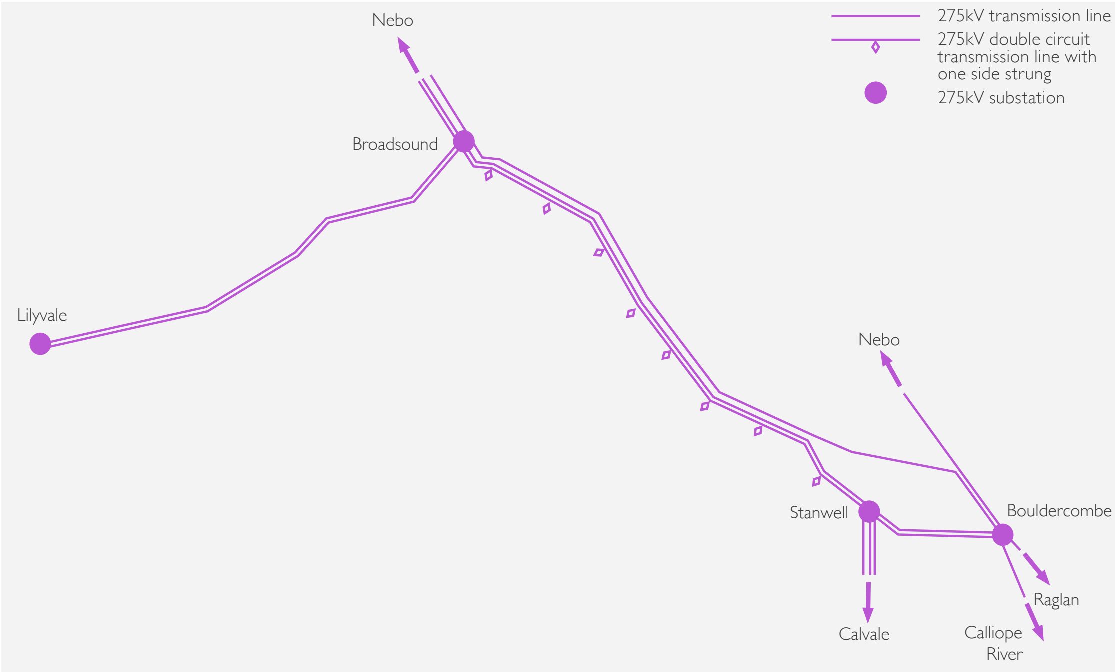
Network limitations on the CQ-NQ grid section may occur if a portion of these new loads commit. Power transfer capability into northern Queensland is limited by thermal ratings or voltage stability limitations. Thermal limitations may occur on the Bouldercombe to Broadsound 275kV line during a critical contingency of a Stanwell to Broadsound 275kV transmission line. Voltage stability limitations may occur during the trip of the Townsville gas turbine or 275kV transmission line supplying northern Queensland.

Currently generation costs are higher in northern Queensland due to reliance on liquid fuels, and there may be positive net market benefits in augmenting the transmission network. The current commitment of VRE generation in North Queensland and any future uptake of VRE generation would be taken into account in any market benefit assessment, including consideration of the location, type and capacity of these future connections.

Possible network solutions

In 2002, Powerlink constructed a 275kV double circuit transmission line from Stanwell to Broadsound with one circuit strung (refer to Figure 7.1). A feasible network solution to increase the power transfer capability to northern Queensland is to string the second side of this transmission line.

Figure 7.1 Stanwell/Broadsound area transmission network



7.2.5 Central West to Gladstone area reinforcement

The 275kV network forms a triangle between the generation rich nodes of Calvale, Stanwell and Calliope River substations. This triangle delivers power to the major 275/132kV injection points of Calvale, Bouldercombe (Rockhampton), Calliope River (Gladstone) and Boyne Island substations.

Since there is a surplus of generation within this area, this network is also pivotal to supply power to northern and southern Queensland. As such, the utilisation of this 275kV network depends not only on the generation dispatch and supply and demand balance within the Central West and Gladstone zones, but also in northern and southern Queensland.

Based on the medium economic forecast defined in Chapter 2 and the existing and committed generation in tables 6.1 and 6.2, network limitations impacting reliability are not forecast to occur within the 10-year outlook period of this TAPR. This assessment also takes into consideration the likely retirement of the Callide A to Gladstone South 132kV double circuit transmission line within the next 10 year (refer to Section 5.7.4).

However, the committed VRE generation in tables 6.1 and 6.2 in North Queensland is expected to increase the utilisation of this grid as generation in the Central West and Gladstone zones or southern generators is displaced. Whilst not impacting reliability of supply, the committed VRE generation in North Queensland has the potential to cause congestion depending on how the thermal generating units in Central Queensland bid to meet the NEM demand.

Powerlink recognised the vulnerability of this grid section to congestion and proposed a network project under the Network Capability Incentive Parameter Action Plan (NCIPAP) for the 2018-22 Revenue Reset period. This project involves increasing the ground clearance of 11 spans on Bouldercombe to Raglan 275kV and three on Larcom Creek to Calliope River 275kV transmission lines to increase the thermal rating of these lines. This project was accepted by the Australian Energy Regulator (AER). Powerlink now has final approval, as per the National Electricity Rules (NER), and plans to implement these improvements by June 2019.

In addition, there are several developments in the Queensland region that would change not only the power transfer requirements between the Central West and Gladstone zones but also on the intra-connectors to northern and southern Queensland. These developments include new loads in the resource rich areas of the Bowen Basin, Galilee Basin and Surat Basin and also the connection of VRE energy generation, in particular large-scale solar PV and wind farm generation. Such generation, together with what it displaces, has the potential to further significantly increase the utilisation of this grid section. This may lead to significant limitations within this 275kV triangle impacting efficient market outcomes despite the uprating from the NCIPAP project. Network limitations would need to be addressed by dispatching out-of-merit generation and the technical and economic viability of increasing the power transfer capacity would need to be assessed under the requirements of the RIT-T.

Possible network solutions

Depending on the emergence of network limitations within the 275kV network it may become economically viable to increase its power transfer capacity to alleviate constraints. Feasible network solutions to facilitate efficient market operation may include:

- transmission line augmentation between Calvale and Larcom Creek substations and rebuild between Larcom Creek and Calliope River substations with a high capacity 275kV double circuit transmission line
- rebuild between Larcom Creek, Raglan, Bouldercombe and Calliope River substations with a high capacity 275kV double circuit transmission line.

7.2.6 Surat Basin north west area

Based on the medium economic forecast defined in Chapter 2, network limitations impacting reliability are not forecast to occur within the next five years of this TAPR.

However, there have been several proposals for additional CSG upstream processing facilities and new coal mining load in the Surat Basin north west area. These loads have not reached the required development status to be included in the medium economic forecast for this TAPR. The loads could be up to 300MW (refer to Table 2.1) and cause voltage limitations impacting network reliability on the transmission system upstream of their connection points.

Depending on the location and size of additional load, voltage stability limitations may occur following outages of the 275kV transmission lines between Western Downs and Columboola, and between Columboola and Wandoan South substations (refer to Figure 7.2).

Possible network solutions

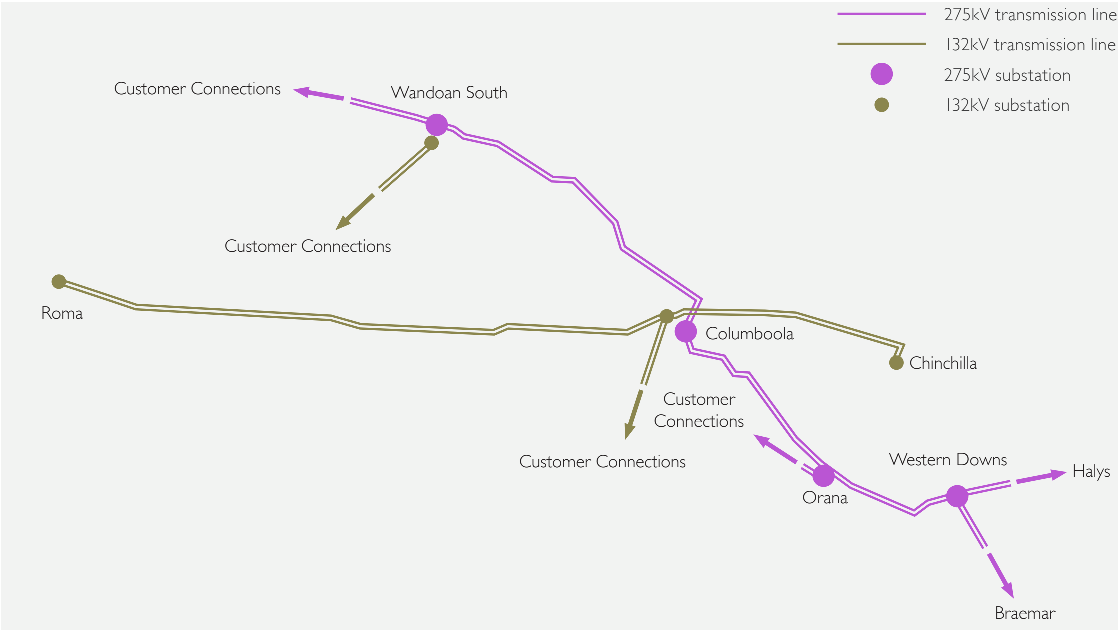
Due to the nature of the voltage stability limitation, the size and location of load and the range of contingencies over which the instability may occur, it may not be possible to address this issue by installing a single Static VAr Compensator (SVC) at one location.

The location, type and capacity of future VRE generation connections in the Surat Basin north west area may also impact on the emergence and severity of these voltage limitations. The type of VRE generation interest in this area is large-scale solar PV. Given that the CSG upstream processing facilities and new coal mining load has a predominately flat load profile it is unlikely that the daytime PV generation profile will be able to successfully address all emerging voltage limitations. However, voltage limitations may be ameliorated by these renewable plants, particularly if they are designed to provide voltage support 24 hours a day.

To address the voltage stability limitation the following network options are viable:

- SVCs, Static Synchronous Compensators (STATCOMs) or Synchronous Condensors (SynCons) at both Columboola and Wandoan South substations
- additional transmission lines between Western Downs, Columboola and Wandoan South substations to increase fault level and transmission strength
- a combination of the above options.

Figure 7.2 Surat Basin north west area transmission network



7.3 Technical challenges from the changing generation mix

Industry collaboration and consultation with stakeholders and regulatory and rule making bodies is essential to identify the most cost-effective solutions to the future power system security challenges. These technical challenges have been recognised and are being addressed through various reviews and working groups. This section focuses on two challenges where the AEMC has placed clear obligations on TNSPs: managing the rate of change of power system frequency, and fault levels.

7.3.1 Managing the rate of change of power system frequency

In order to maintain the power system in a secure operating state, a number of physical parameters must be controlled. Rapid changes in frequency or large deviations from normal operating frequency can lead to instability and wide-spread loss of load. Rotating inertia (provided historically from synchronous generators) controls the rate of change of frequency for a given disturbance. As the generation mix shifts to smaller and more non-synchronous VRE generation, inertia is not provided as a matter of course giving rise to increasing challenges to arrest the frequency change and restore the frequency to normal operating levels.

The AEMC have established new Rules to address these emerging problems. The Final Determination (September 2017) placed an obligation on TNSPs to procure minimum required levels of inertia or alternative frequency control services such that the rate of change of frequency is controlled for prescribed extreme events (e.g. loss of interconnection and islanding of regions) and such that the inertia sub-network can be returned to a secure state.

The AEMC considered that TNSPs were best incentivised under the Regulatory framework to deliver this service at the least cost possible to consumers. TNSPs are best placed to provide the required levels of inertia within each sub-network and to coordinate the location of inertia with other network support services, including obligations related to minimum system strength (refer to Section 7.3.2). This co-optimisation of services will assist in minimising the overall costs to consumers.

The final rule requires AEMO to assess the levels of inertia being provided in each inertia sub-network, assess whether there is likely to be an inertia shortfall and forecast of the period over which that shortfall will exist. The assessment should be across a planning horizon of at least five years. AEMO is required to publish its projections and whether a shortfall is likely to exist.

Where an inertia shortfall is identified there is an obligation on the relevant TNSP to make continuously available minimum required levels of inertia. The TNSP can provide the inertia itself or procure inertia services from third parties such as generators. There is also ability for TNSPs to invest in or contract with third-party providers of alternative frequency control services ('inertia support activities'), including fast frequency response (FFR) services, as a means of reducing the minimum required levels of inertia, with approval from AEMO. AEMO will publish the first periodic review for the Queensland region as part of the ISP in July 2018. It is expected that AEMO will not identify any sub-networks within the Queensland region that are required to be able to operate independently as an island. It is also expected that AEMO will not identify any shortfall in inertia exists, or is likely to exist over the five-year forecast in the Queensland region.

7.3.2 Managing power system fault levels

System strength is a characteristic of a power system that relates to the size of the change in voltage following a fault or disturbance. System strength is correlated with the availability of fault current at a given location (should a fault occur). High levels of fault current are found in a strong power system while low fault levels are representative of a weak power system. When the system strength is high, 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 varies more with the same change in loading.

Synchronous machines are the primary source of fault current and system strength. As the penetration of VRE generation increases and synchronous generators are displaced/retired, the system strength will decrease. This can mean that the system strength is not sufficiently high to keep the remaining generators stable and connected to the power system following a major disturbance, which introduces the risk of a cascading outage and a major supply disruption (or widespread blackouts).

On 19 September 2017, the AEMC published a final rule concluding that TNSPs are best positioned to maintain system strength such that the power system can be kept in a secure operating state. The existing incentive based economic regulatory framework will provide an incentive for the TNSP to meet this obligation at the lowest long-term costs for consumers.

The AEMC 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 and power quality, all of which become more difficult as system strength reduces. 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.

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'). This methodology has been developed collaboratively with TNSPs. AEMO must then undertake an assessment of any fault level shortfall. If AEMO assesses that there is likely to be a shortfall AEMO must specify the extent of the fault level shortfall and the date by which the TNSP must provide services to address the shortfall. When procuring these services, the TNSP is required to identify and implement the least cost option or combination of options.

AEMO will publish the first periodic review for the Queensland region as part of the ISP in July 2018. It is expected that AEMO will not identify system strength requirements within the Queensland region. It is also expected that AEMO will not identify any shortfall in system strength, or is likely to exist over the five-year forecast in the Queensland region.

The final rule also 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.

When a new generator is negotiating its connection with the relevant NSP, a system strength impact assessment is 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 is discussed in detail in Section 8.3.1).

TNSPs must also consider the impacts on the level of system strength to maintain the security of the power system when making investment and reinvestment decisions (eg. network consolidation, network rearrangement or retirement).