CHAPTER 10

Renewable energy

10 Renewable energy

Key highlights

- This chapter explores the potential for the connection of variable renewable energy (VRE) generation (wind and solar PV) to Powerlink's transmission network.
- Powerlink has a central role in enabling the connection of VRE in Queensland.
- System strength has been a focus for VRE generators and Powerlink, including power systems analysis using Electromagnetic Transient-Type (EMT-type) modelling for Queensland.
- Through active collaboration with solar and wind farm proponents and associated equipment manufacturers, Powerlink is implementing innovative cost-effective technical solutions to maximise the VRE hosting capacity of the Queensland transmission network and reduce the connection costs of proponents.
- Powerlink is working closely with the Queensland Government on the establishment of new Queensland Renewable Energy Zones (QREZ) development areas.

10.1 Introduction

Queensland is rich in a diverse range of renewable resources – solar, wind, geothermal, biomass and hydro. This makes Queensland an attractive location for large-scale VRE generation development projects. During 2021/22, 740MW of semi-scheduled VRE generation capacity has been committed in the Queensland region, taking the total to 4,935MW that is connected, or committed to connect, to the Queensland transmission and distribution networks (refer to Section 8.2).

To date Powerlink has completed connection of 22 (21 VRE + 1 BESS) large-scale solar, wind farm and Battery energy storage system (BESS) projects in Queensland, adding 3,130MW of generation capacity to the grid. A significant number of formal connection applications, totalling about 11,000MW of new generation capacity, have been received and are at varying stages of progress.

To date, 3,595MW of VRE generation have connected or committed with Powerlink. Approximately 1,340MW of embedded semi-scheduled renewable energy projects exist or are committed to Energy Queensland's network. In addition to the large-scale VRE generation development projects, rooftop photovoltaic (PV) in Queensland exceeded 4,808MW in July 2022.

Figure 10.1 shows the location and type of generators connected and committed to connect to Powerlink's network. Department of Energy and Public Works (DEPW) also provides mapping information on proposed (future) VRE projects, together with existing generation facilities (and other information) on its website. For the latest information on proposed VRE projects and locations in Queensland, please refer to the DEPW website.

Figure 10.1 Under construction and existing connection projects since 2018

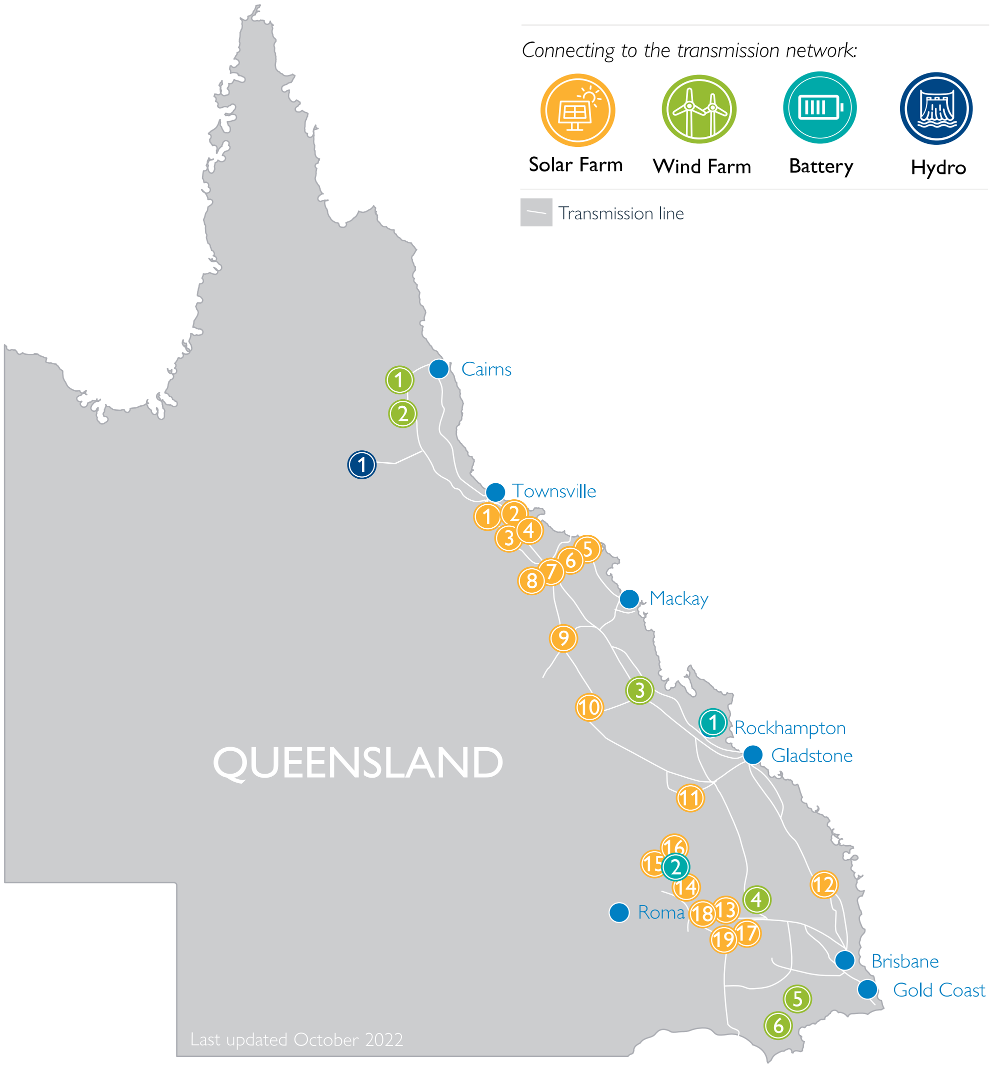

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Table 10.1 Under construction and existing connection projects since 2018

Map ID	Generator	Location	Available capacity MW generated (1)
Hydro-electric (1)			
1	Kidston Pumped Hydro Storage	Kidston	250
Solar PV (2)			
1	Ross River	Ross	116
2	Sun Metals	Townsville Zinc	121
3	Haughton	Haughton River	100
4	Clare	Clare South	100
5	Whitsunday	Strathmore	57
6	Hamilton	Strathmore	57
7	Daydream	Strathmore	150
8	Hayman	Strathmore	50
9	Rugby Run	Moranbah	65
10	Lilyvale	Lilyvale	100
11	Moura	Moura	82
12	Woolooga Energy Park	Woolooga	176
13	Blue Grass	Chinchilla	148
14	Columboola	Columboola	162
15	Gangarri	Wandoan South	120
16	Wandoan South	Wandoan South	125
17	Edenvale Solar Park	Orana	146
18	Western Downs Green Power Hub	Western Downs	400
19	Darling Downs	Braemar	108
Wind (2)			
1	Mt Emerald	Walkamin	180
2	Kaban (3)	Tumoulin	152
3	Clarke Creek (3)	Broadsound	440
4	Coopers Gap	Coopers Gap	440
5	MacIntyre (3)	Tummaville	922
6	Karara (3)	MacIntyre Intermediate Switching Station	103
Battery (2)			
1	Bouldercombe 2h BESS (3)	Bouldercombe	50
2	Wandoan South 1.5h BESS	Wandoan South	100

Notes:

(1) Shown at full capacity. However, output can be limited depending on water storage levels.

(2) VRE generators and batteries shown at maximum capacity at the point of connection. The capacities are nominal as the generator rating depends on ambient conditions.

(3) Generators undergoing construction are shown at future maximum expected capacity at the point of connection. Actual available generating capacity will vary over the course of the commissioning program.

Utility scale and rooftop connections of VRE generation, both in Queensland and the rest of the National Electricity Market (NEM), has brought with it a number of challenges to which Powerlink is responding. One of the main contributors to this challenging environment is system strength. The distributed nature of VRE generation is also changing the way the transmission network is operated, including changes to flow patterns and network utilisation.

This chapter provides information on:

- the current system strength obligations placed on Powerlink and connecting proponents of large-scale inverter-based plant under the National Electricity Rules (NER)
- the recommendations from the Australian Energy Market Commission's (AEMC) investigation into System Strength Frameworks
- how Powerlink has and continues to meet the system strength challenges
- the fault level shortfall declared by Australian Energy Market Operator (AEMO) in December 2021 and updated in May 2022 and how Powerlink is addressing this shortfall
- the current system strength environment and the opportunities for future investment in VRE generation.

10.2 Current management of system strength and National Electricity Rules (NER) obligations

On 1 July 2018, the AEMC rule for 'Managing Power System Fault Levels' came into effect.

Under the Rule

- AEMO develops a system strength requirements methodology guideline and determines the location of fault level nodes in each region, plus the minimum three phase fault levels and any projected fault level shortfalls at those fault level nodes.
- Transmission Network Service Providers (TNSPs) or jurisdictional planning bodies, as the System Strength Service Providers for each region, are responsible for procuring system strength services to meet a fault level shortfall declared by AEMO. These services must be made available by a date nominated by AEMO which is at least 12 months from the declaration of the shortfall, unless an earlier date is agreed with the System Strength Service Provider.
- Network Service Providers (NSPs) undertake system strength impact assessments to determine whether a proposed new or altered generation or market network service facility connection to their network will result in an adverse system strength impact.
- Applicants pay for system strength connection works undertaken by a NSP to address an adverse system strength impact caused by their proposed connection to the NSP's network or propose a system strength remediation scheme[1] .

Consistent with this methodology, Powerlink worked with AEMO to determine the required minimum fault level at key 'fault level nodes' within the Powerlink network (refer to Table 10.2). The minimum fault level is used to assess that the system can be operated safely and securely. The initial assessment was completed in mid-2018.

The guidelines require the minimum fault level to be reassessed no more than once in every 12 month period to determine whether a fault level shortfall exists or is likely to exist in the future. This assessment considers the displacement[2] of existing synchronous plant in Queensland.

1 Obligation on the connecting generator to 'do no harm' came into effect 17 November 2017 with AEMO publishing the 'System Strength Impact Assessment Guidelines' in 2018

2 Displacement may occur for periods when it is not economic for a synchronous generator to operate, and is distinct from

In May 2022[3] AEMO published an update to the system strength and inertia assessments for the NEM. In Queensland, the previous inertia shortfall[4] was removed due to improved outlook for available fast frequency control ancillary services (FCAS), but a potential future shortfall remains a possibility as the market changes. However, for system strength AEMO declared a fault level shortfall, under Clause 5.20C.2(c) of the NER, at the Gin Gin 275kV node. Powerlink's response to this declared fault level shortfall is discussed in Section 10.4.

10.2.1 System Strength Frameworks Review

On 21 October 2021 the AEMC published its final Rule determination on the Efficient Management of System Strength on the power system. The previous framework (refer Section 10.2 above) has been shown in practice to be reactive and slow to provide system strength, resulting in a lack of this essential system service. Shortfalls of this essential service in recent years have resulted in delays in the connection of new inverter-based renewable (IBR) generators, as there has been insufficient system strength to allow them to connect securely.

The AEMC concluded that these delays, and the resultant uncertainty they create, impose costs on connecting new generation. These costs are ultimately passed through to customers. A lack of system strength in the system has also meant that lower-cost, lower emissions, renewable generators are being constrained off, again increasing costs to customers.

The energy mix is rapidly transforming and solutions to the system strength issues require sufficient time to be delivered. The AEMC concluded that the short-term reactive approach to deliver a theoretical minimum system strength level is not workable and does not sufficiently enable planning for the long-term management of issues.

Powerlink worked closely with the AEMC and through Energy Network Australia (ENA) in the development of this important Rule change. The result is that the AEMC's final rule determination has increased the emphasis on medium to long-term planning for system strength needs. The rule specifies three main elements:

- Supply side: System strength will be supplied through a Transmission Network Service Provider (TNSP) led procurement service. TNSPs, would be responsible for providing efficient levels of system strength on a forward looking basis over a given timeframe. Planning for the standard is rolled into the existing Transmission Annual Planning Report (TAPR) and Regulatory Investment Test for Transmission (RIT-T) processes.
- Coordination: Connecting parties with IBR generators would have the choice between paying to use the system strength provided by the TNSP or providing their own system strength by remediating their impact. This mechanism would mean that while customers would bear some of the initial cost of providing system strength services, over time this cost will be recovered from connecting parties, with minimal stranded asset risk borne by consumers.
- Demand side: New access standards, to ensure that connecting parties with IBR generators would only use the efficient volumes of this valuable common pool resource. The new access standards also underpin the coordination measures, by allowing generators to undertake actions to reduce the amount of system strength they require. IBR generators must meet two new requirements; a minimum Short Circuit Ratio (SCR) and a phase shift capability.

AEMO has published the System Strength Requirements Methodology (SSRM), and is consulting on the System Strength Impact Assessment Guidelines (SSIAG) and the Power System Stability Guidelines (PSSG) in accordance with clauses 5.20.6, 4.6.6, 4.3.4 and the Rules consultation procedures in rule 8.9 of the NER to operationalise the AEMC Rule change. The NER requires AEMO to publish the final SSIAG by 30 November 2022. Powerlink is working very closely with AEMO on this important change.

retirement which is permanent removal from the market.

[3] AEMO published an update to the December 2021 System Security Reports in May 2022. The update accounted for the identification of the Step Change scenario as the most likely of the development scenarios for AEMO's 2022 Integrated System Plan (ISP).

[4] AEMO published the initial system strength and inertia assessments for the NEM in December 2021 based on the Progressive Change scenario.

Key dates in the implementation of this new system strength Rule change include:

- By 30 November 2022, TNSPs must update their pricing methodologies to include the new requirements to provide the minimum level of system strength together with the efficient level of system strength to host the forecast of VRE generation and submit it to the Australian Energy Regulator (AER) for approval. The AER must publish its final decision on the proposed amended pricing methodology by 31 January 2023.
- By 1 December 2022, AEMO is to publish its first system strength report that defines the binding system strength requirements for TNSP's (that are System Strength Service Providers) for three years' time (December 2025). The fault level shortfall framework described in Section 10.2 is retained for a period of three years.
- From 15 March 2023, the new access standards commence and system strength mitigation requirement commences, replacing the existing 'do no harm' obligations, such that parties pay the system strength charge or self-remediate. TNSPs are also required to publish transmission prices that include the system strength charge.
- An applicant who submits a connection enquiry by 15 March 2023 will come under the new system strength mitigation requirement and access standard arrangements.
- An applicant who submits an application to connect by 15 March 2023, but has not received an offer to connect, will come under the existing arrangements, unless the applicant requests the NSP to process them under the new framework.
- From 1 July 2023 the system strength charges come into effect.

10.3 Understanding system strength is essential to meet future challenges

Fundamental to the understanding of system strength challenges has been the development of a system-wide EMT-type model. This has allowed the study of system strength and its impact on the stability and performance of the power system.

Powerlink has developed an EMT-type model that extends from Far North Queensland (FNQ) to the Hunter Valley in New South Wales (NSW). It includes plant specific models for all VRE and synchronous generators (including voltage control systems) and transmission connected dynamic voltage control plant (Static VAr Compensators and Statcoms). This allows Powerlink to quickly process generator connections and is a comprehensive model with the inverter-based plants modelled at the controller level and with simulation time steps in micro-seconds.

Powerlink undertakes a Full Impact Assessment (FIA) using system-wide EMT–type model for all VRE generation applying to connect to the Powerlink network regardless of the size of the proposed plant. This is because only an EMT-type analysis can provide information on the impact of potentially unstable interactions with other generators at this stage. Powerlink is exploring a novel method using small signal analysis to understand the impact of potentially unstable interactions with other generators. The FIA is carried out as part of the connection process as per AEMO's System Strength Impact Assessment Guidelines. This is to ensure that any adverse system strength impact is adequately identified and addressed as part of the connection application either via a system strength remediation scheme or through system strength connection works.

It is vital that proponents provide high-quality EMT-type models as per AEMO's Power System Model Guidelines[5] for the FIA process. One of the most common delays to project assessments is the need to request changes to proponent models. Generation must meet the NER Generator Performance Standards (GPS), and generation proponents are required to demonstrate that their proposed generation technology is able to meet these standards during the connection process.

AEMO's System Strength Impact Assessment Guidelines provides additional details regarding the assessment process and methodology, while AEMO's Power System Model Guidelines provides additional information regarding modelling requirements.

5 AEMO, Power System Model Guidelines, July 2018.

10.3.1 Increasing renewable energy hosting capacity

Powerlink continues to work closely with AEMO, developers and inverter manufacturers to maximise the VRE generation hosting capacity of the Queensland transmission network.

Powerlink has redesigned and commissioned changes to the voltage controller at nine Static VAr Compensators (SVCs) in North and Central Queensland (CQ). At two transmission connected SVCs in North Queensland the control systems were modified by adjusting gain and phase parameters to allow more VRE generation to be supported. This innovative solution has substantially reduced the proponent's connection costs compared to the much higher priced system strength remediation that would otherwise have been required.

The changing network conditions also required Powerlink to reduce the gain control of seven other SVCs in the region so they could continue to operate as designed.

Powerlink has also worked with developers and equipment manufacturers to explore and implement changes to controller settings and plant voltage control strategies. The outcome of this work recommended that the bandwidth of the voltage control system be higher to counter the 8Hz to 15Hz control interactions that have been observed in Powerlink's network. These changes have addressed controller interactions that would otherwise limit the VRE hosting capacity and significantly increase system strength remediation costs to developers. Powerlink is now requesting that this same voltage control strategy be adopted as a proactive measure for new proponents connecting in South Queensland in order to minimise the cost of connections.

Further to these initiatives, that have now influenced the approach by other TNSPs and AEMO, Powerlink is exploring the role that 'grid forming' inverter technology can play in supplying the synthetic inertia and in the portfolio of solutions available to System Strength Service Providers (SSSP) in meeting the efficient level of system strength under the new Rule discussed in Section 10.2.

Initially Powerlink has received funding from Australian Renewable Energy Agency (ARENA) to investigate technical, commercial and regulatory solutions to address system strength challenges. There were several stages to this project[6]. The final stage focused on building an understanding of the role grid forming inverter (GFI) technology with battery (referred to as 'grid forming battery') can play in contributing to system strength. Powerlink modelled a 'grid forming' battery solution from a manufacturer in system-wide EMT-type analysis. The analysis demonstrated that the 'grid forming' battery could increase the system strength and help support the operation of VRE generation in a similar manner to synchronous condensers.

The analysis demonstrated that advanced inverter controls can facilitate a higher penetration of inverter-based renewable generation (e.g. wind and solar) without compromising grid stability. ARENA published the Powerlink report on the outcome of this assessment in April 2021[7].

10.4 Declaration of fault level shortfall at Gin Gin node

In December 2021 AEMO published the 2021 System Security Reports. System strength and inertia assessments for this report were based on the Progressive Change scenario. For the Queensland region, AEMO identified a fault level shortfall at the Gin Gin 275kV fault level node and an inertia shortfall.

In May 2022, the system strength and inertia assessment for the NEM was updated to reflect the identification of the Step Change scenario as the most likely of the development scenarios for AEMO's 2022 Integrated System Plan (ISP). The update removed the previous inertia shortfall due to improved outlook for available fast frequency control ancillary services (FCAS), but a potential future shortfall remains a possibility as the market conditions change. However, for system strength AEMO reaffirmed a fault level shortfall, under Clause 5.20C.2(c) of the NER, at the Gin Gin 275kV fault level node.

The minimum three phase fault levels, from AEMO, for the Queensland fault level nodes are shown in Table 10.2.

6 Powerlink, Managing System Strength During the Transition to Renewables, May 2020.
7 PSCAD Assessment of the Effectiveness of Grid Forming Batteries.

Table 10.2 Three phase fault levels for Queensland fault level nodes

Fault level node	2021 minimum fault level (MVA) (post-contingency)
Ross 275kV	1,175
Lilyvale 132kV	1,150
Gin Gin 275kV	2,250
Western Downs 275kV	2,550
Greenbank 275kV	3,750

The declared fault level shortfall is a result of AEMO's market model forecasting lower synchronous generator dispatches in Central Queensland compared to dispatches that define the current minimum fault level requirements in Table 10.2. The forecast synchronous generator dispatches are from AEMO's 2022 ISP Step Change scenario. The shortfall ranges from 33MVAr to 90MVAr and will exist for the full five year outlook at the Gin Gin 275kV fault level node.

Powerlink has the responsibility to address the fault level shortfall in the Queensland region. Powerlink must also address these technical issues as efficiently as possible. Powerlink must use reasonable endeavours to make the system strength services available by the date of 31 March 2023, as specified by AEMO in the notice issued under clause 5.20C.2(c) of the NER.

10.4.1 Actions undertaken to address the fault level shortfall

Immediately following the fault level shortfall declaration, Powerlink commenced an Expression of interest (EOI) process seeking both short and long-term non-network solutions to the fault level shortfall at the Gin Gin 275kV fault level node (refer to Section 6.8).

In this instance the declared fault level shortfall is at the Gin Gin 275kV fault level node. However, consideration of the declared shortfall location in isolation may not capture technical components of the system strength shortfall or indicate from where the particular problem is most efficiently addressed. Both of these can only be informed through system-wide EMT-type analysis and in the context of the location and technical nature of any proposed solutions. That is, options which address the technical power system performance issues elsewhere in Central and North Queensland may reduce or remove the fault level shortfall at the Gin Gin 275kV fault level node.

Submissions for the EOI closed on 24 June 2022 and Powerlink is currently reviewing and evaluating proposals and submissions to address the identified shortfall and to meet regulatory obligations. Submissions were received from seven proponents with nine proposed solutions. These included operation of existing generators, gas turbine synchronous condenser conversions, BESS and Pumped Hydro Energy Storage (PHES).

Powerlink is currently clarifying submission information and performing technical and economic feasibility assessments for system security shortfall. Following detailed assessment of the selected solutions, Powerlink will negotiate contract terms, engage with AEMO and seek approval to execute the contract/s to meet the required timeframes and requirements.

The agreed system strength response to the declared shortfall at the Gin Gin 275kV fault level node is planned to be published in March 2023.

10.5 Transmission connection and planning arrangements

In May 2017, the AEMC published the Final Determination on the Transmission Connections and Planning Arrangements Rule change request. The Rule set out significant changes to the arrangements by which parties connect to the transmission network, as well as changes to enhance how transmission network businesses plan their networks.

From July 2018 new categories of connection assets were defined, namely Identified User Shared Assets (IUSA) and Dedicated Connection Assets (DCA). All new DCA services, including design, construction, ownership and operation and maintenance are non-regulated services. IUSA assets with capital costs less than $10 million are negotiated services that can only be provided by Powerlink. IUSA assets with capital costs above $10 million are non-regulated services. Powerlink remains accountable for operation of all IUSAs and any above $10 million must enter into a Network Operating Agreement to provide operations and maintenance services.

In July 2021 the AEMC finalised a rule to facilitate more efficient investment in, and use of, transmission assets built to connect generation to the shared network. The finalised rule establishes a new framework for designated network assets (DNAs). The new arrangements replace the current arrangements for large dedicated connection assets.

A DNA is a radial transmission extension greater than 30km in length. DCAs remain for connections less than 30km unless a proponent voluntarily chose to opt into the DNA framework. DNAs will not be subject to the open access regime that applies elsewhere on the transmission network. Instead, a DNA owner, i.e. the party that made the investment and funded the asset, is responsible for administering third-party access to its DNA. For this reason DNAs only apply to radial configurations.

A DNA is not a connection asset, but rather transmission network. It differs to the shared transmission network as the design, construction and ownership of the DNA are non-regulated services. As for IUSAs, Powerlink remains accountable for operation and maintenance of all DNAs. A special access framework for DNAs is set out in the NER Chapter 5.

As DNAs will form part of the transmission network, operated by a TNSP, the point where an individual proponent connects to a DNA will be a transmission network connection point (TNCP). This allows for the application of existing arrangements for settlement, metering, calculation of loss factors, transmission use of system charges, system strength and performance standards, with only minor modifications.

Powerlink is focused on delivering a timely and transparent connection process to connecting generators including coordination of the physical connection works, GPS and system strength.

10.6 Developing Renewable Energy Zones (REZ)

Queensland Energy and Jobs Plan (QEJP) modelling indicates that 25GW of renewable generation is required by 2035. Looking beyond 2035, it is likely that Queensland will need even more renewable generation, when taking account of additional electricity demand created by new industries and electrification of existing industries such as mining and electric vehicle (EV) uptake. AEMO's 2022 ISP Step Change scenario suggests Queensland will require 48GW of renewable generation by 2050.

To facilitate this level of renewable energy connection, Powerlink is working with the Queensland Government on the establishment of new Queensland Renewable Energy Zones (QREZ) development areas. Development of a REZ allows multiple grid-scale renewable energy developments to be connected in a geographic location to realise economies of scale in REZ infrastructure and enable renewable connections in a more cost-effective and coordinated manner. An uncoordinated approach, where developers act independently, is unlikely to support scale-efficient and least-cost generation developments sufficient to meet Queensland's needs.

The coordination availed by REZ developments will facilitate a better forecast of the specific location, mix, timing and type of renewable energy connections. This will also assist Powerlink plan and implement cost-effective solutions to provide the necessary efficient levels of system strength. REZs will also be coordinated with broader investments in the interconnected transmission system, energy storage and other firming services. Therefore, REZs allows Powerlink to optimise where renewable energy is connected and integrated within the existing system to achieve renewable targets at least overall cost to customers.

Section 2.3 provides details of initial REZ development plans in Northern, Central and Southern Queensland. The combined hosting capacity of these initial plans is approximately 7GW. Therefore, considerably more needs to occur to have 25GW of renewable energy generation connected by 2035. In response, Powerlink is working on developing further REZs. The REZ development approach will facilitate efficient network connection and speed to market for Powerlink's generation proponents.

These next renewable energy plans are in development with the Queensland Government and take into account modelling outcomes from the 2022 ISP, Queensland Energy and Jobs Plan, resource mapping and market intelligence from existing and future proponents. Powerlink considers that broadly this offers the most efficient and cost-effective delivery mechanism for the grid-scale renewable energy developments required. Notwithstanding, individual connections to existing transmission infrastructure will remain an option. Powerlink encourages potential proponents to engage with Powerlink early in development planning process such that the best outcome for all parties can be achieved.

10.7 System strength during network outages

Throughout the year, it is necessary to remove plant in the transmission network from service. In the majority of circumstances planned outages are necessary to maintain or replace equipment. It may also be necessary to remove plant from service unexpectedly. During these planned and unplanned outages, Powerlink and AEMO must ensure that the system continues to be operated in a secure state.

Network outages may lead to reductions in system strength. While this may be a localised issue, outages on key 275kV corridors, as well as some 275/132kV transformers, may impact the system strength of a number of VRE generators. To address this, Powerlink is working with AEMO to develop constraint equations to be implemented in the National Energy Market Dispatch Engine (NEMDE). The purpose of these equations is to maximise the dispatch of VRE generators in the Queensland system within the available system strength.

To maximise the output from VRE generators under planned outages, Powerlink is developing a Wide Area Monitoring, Protection and Control System (WAMPAC) based Special Protection Scheme (SPS). This scheme will monitor the status of major transmission lines in North and Central Queensland in real time and send a trip command to pre-selected VRE generators. The scheme will also allow VRE generators in North and Central Queensland to operate at much higher output reducing generator constraints.

10.8 Transmission congestion and Marginal Loss Factors (MLF)

The location and pattern of generation dispatch influences power flows across most of the Queensland system. Power flows can also vary substantially with planned or unplanned outages of transmission network elements. Power flows may also be higher at times of local area or zone maximum demand or generation, and/or when embedded generation output is lower.

Maximum power transfer capability may be set by transient stability, voltage stability, thermal plant ratings (transformer and conductor ratings) or protection relay load limits. System strength may also be a constraint that limits the output semi-scheduled inverter-based generation in an area of the network.

Where constraints occur on the network, AEMO will constrain generation based on the market system rules within NEMDE to maintain system security.

Rapid changes in demand and generation patterns will likely result in transmission constraints emerging over time. Forecasting these constraints is not straightforward as they depend on generation development and bidding patterns in the market. For example, with the existing and committed inverter-based renewable generation in NQ, the utilisation of the Central West to Gladstone and Central to South Queensland grid sections are expected to further increase over time.

Powerlink monitors the potential for congestion to occur and assesses the need for network investments using the AER's RIT-T. Where found to be economic, Powerlink will augment the network to ensure the electricity market operates efficiently and at the lowest overall long run cost to consumers.

Generator proponents are encouraged to refer to Chapter 6 for more detail on potential future network development as well as emerging constraints.

MLFs have also emerged as an important consideration for new generator entrants, especially for PV generators in NQ. MLFs adjust the spot price to account for the marginal impact of losses from additional generation. They are calculated as a volume-weighted average for the full year and are determined based on historical generation and demand profiles adjusted for known forward commitments.

In NQ the local supply and demand balance is significant due to the long distances of the transmission system from North to South Queensland. The coincident generation from PVs has resulted in large drops in the MLFs for PV generators in NQ over recent years. The situation is not as significant for wind generators in NQ as a large amount of the wind export is not coincident with the PV output and hence does not coincide with the large demand and supply imbalance in the region. However, this same situation may emerge in NQ as more large-scale wind farms connect to the transmission network.

MLF reductions across NQ provide an opportunity for additional loads (or storage) to locate in NQ.

10.9 Further information

Powerlink will continue to work with market participants and interested parties across the renewables sector to better understand the potential for VRE generation, and to identify opportunities and emerging limitations as they occur. The NER (Clause 5.3) prescribes procedures and processes that NSPs must apply when dealing with connection enquiries. Should an interested party wish to utilise the connection framework referred to in Section 10.5, it will be necessary to submit a new connection enquiry.

Figure 10.2 Overview of Powerlink's existing network connection process

Proponents who wish to connect to Powerlink's transmission network are encouraged to contact BusinessDevelopment@powerlink.com.au. For further information on Powerlink's network connection process please refer to Powerlink's website.