CHAPTER 8

Renewable energy

8 Renewable energy

Key highlights

- This chapter explores the potential for the connection of variable renewable energy (VRE) generation to Powerlink's transmission network.
- Powerlink has a key role in enabling the connection of VRE infrastructure in Queensland.
- System strength has been a focus for VRE generators and Powerlink, including development of the Electromagnetic Transient (EMT-type) model for Queensland.
- Powerlink has actively engaged in a Rule change proposal through Energy Networks Australia (ENA) to enhance information availability, focussing on improving outcomes for connecting parties.

8.1 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. In response, Powerlink introduced this chapter of the TAPR in 2016 to facilitate exploration of Queensland VRE opportunities.

Rooftop solar in Queensland exceeded 2,400MW in February 2019, with existing and committed utility scale connections of VRE generation totalling to 2,457MW. Large scale wind and solar connections to Powerlink's transmission network make up 1,630MW of this capacity. Further information on these connections can be found in Section 6.2.

Utility scale 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. The distributed nature of VRE generation is changing the way the transmission network is operated, including managing system strength, changes to flow patterns and utilisation.

A number of changes to the regulatory environment have been introduced through the National Electricity Rules (NER). These Rule changes, which impact how generation can connect to Powerlink's network, have been put in place to ensure that system stability and security are able to be maintained now and into the future. The Rule changes most relevant to the information provided in this chapter are:

- Managing Power System Fault Level
- Transmission Connection and Planning Arrangements
- Generator Performance Standards.

This chapter also provides information on:

- Renewable Energy Zones (REZs)
- emerging constraints on the transmission system
- Marginal Loss Factors (MLFs)
- Powerlink's role.

8.2 Managing power system fault level

In September 2017, the Australian Energy Market Commission (AEMC) finalised the 'Managing Power System Fault Levels' rule. The Rule provides for a holistic, flexible and technology neutral solution to issues arising from the forecast reduction in system strength.

The Rule, which came into effect on 1 July 2018, requires AEMO to develop a system strength requirements methodology from which it can determine the minimum required fault level at key 'fault level nodes' and then assess whether a fault level shortfall exists or is likely to exist in the future.

Powerlink has worked with AEMO to develop a probable assessment of the minimum fault level in Queensland. This assessment has considered the displacement[1] of existing synchronous plant in Queensland. The minimum fault level is used to assess that the system can be operated safely and reliably now and into the future.

[1] Displacement may occur for periods when it is not economic for a synchronous generator to operate, and is distinct from retirement which is permanent removal from the market.

The required minimum fault level will be subject to an annual review in accordance with the guidelines. This may require that the minimum fault level is amended at one or more key nodes to ensure safe and reliable operation of the system.

Where AEMO identifies an emerging shortfall, Powerlink will consider how best to address this gap. Solutions include, but are not limited to:

- network reconfiguration
- contracting with existing synchronous generation (network support) and
- installation of synchronous condensers.

TNSPs have a holistic perspective of their network and will be able to address system strength in a manner that considers the best options for the entire network, including consideration of other key services such as inertia. These synergies should result in more efficient outcomes for consumers in the long-term.

In accordance with the Rule, AEMO also published the System Strength Impact Assessment Guidelines (the guidelines) on 29 June 2018. The guidelines require Powerlink to consider the impact of VRE generating systems operating in areas of low system strength, as well as the interaction of multiple VRE generating systems with each other and system voltage control devices. Powerlink is required to undertake a Preliminary Assessment at the connection enquiry phase to assess this impact. If Preliminary Assessment criterion are breached, then a Full Assessment is required.

The Rule 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.

8.2.1 Preliminary Assessment

The Preliminary Assessment uses steady state power system analysis tools to assess the likelihood of an adverse system strength impact. At the enquiry stage, detailed information on the characteristics of the connection are unlikely to be available, and as such the Preliminary Assessment balances the need for meaningful insight against the time and cost of undertaking more rigorous analysis.

A Full Assessment is required if the screening criteria are breached.

8.2.2 Full Assessment

The Full Assessment requires EMT-type studies, and is carried out as part of the connection process as per the 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.

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. Powerlink is obligated to undertake due diligence on projects, including EMT-type studies even where Full Assessment is not indicated by the Preliminary Assessment.

8.2.3 Development of integrated system strength model

Powerlink is working with committed proponents, equipment manufacturers' and AEMO to enhance the EMT-type model for the Queensland network.

Work on the integrated system strength model has been very challenging due to complex interactions between plants and the sensitivity to plant model updates. The model development involved numerous iterations to inform not only the models of the plant seeking connection, but also for existing synchronous plant and dynamic voltage control devices[2].

The integrated system strength model also identified issues with generator models and plant performance that were not previously visible. This has led to delays in assessing a number of applications.

[2] Transmission connected Static VAr Compensators (SVC), load balancing SVCs and Static Synchronous Compensators (STATCOM).

This work has provided an important insight into the complexity of system strength and how it impacts on managing non-synchronous connections and the network in general. This understanding is now being applied to future assessments.

8.2.4 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. This may be a localised issue, however for outages on key 275kV corridors, as well as some 275/132kV transformers, the reduction in system strength may impact on 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.

8.3 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 sets 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.

Since the implementation of the Rule from July 2018, Powerlink has continued to refine the documentation available and processes used to meet Powerlink's obligations under the NER. Documents updated include the 'Network Configuration Document – Selection for New Substations'. Parties seeking connection to Powerlink's network should ensure that they are referencing the most up to date documentation.

During 2018/19, connection activity at both the enquiry and application stages decreased. Powerlink considers that this is not a result of the new connection arrangements, but rather the market reaching a point where the developments already under consideration are focussing on the impact of the Rule changes and the obligations under the GPS on their pending investment decisions.

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

8.4 Indicative available network capacity – Generation Capacity Guide

Powerlink provides a significant amount of information for parties seeking connection to the transmission network in Queensland, including the Generation Capacity Guide (GCG) and the Network Limitations Advice. Proponents are encouraged to utilise this information to make informed proposals, however we encourage early engagement with Powerlink's Business Development team.

The GCG is published on Powerlink's website separate to the TAPR to facilitate updates to the GCG as required making available the most up to date data for VRE developers.

The GCG includes capacity and congestion information for customers seeking to connect to Powerlink's transmission network. The calculation methodology is based upon the existing configuration of the transmission network and the technical standards that currently apply to transmission network design and power system operation. Only generation that has an executed Connection and Access Agreement (CAA), an agreed GPS, and acceptance by AEMO of any requirements under NER 5.3.4A and 5.3.4B, is included in the calculation. The analysis also assumes that the proposed generation facility will comply with the NER's automatic access standard for reactive power capability (NER S5.2.5.1). Changes to the network configuration and the technical standards that apply to new connections have the potential to change the network capacity available to new generators.

Under the NEM's open access regime, it is possible for generation to be connected to a connection point in excess of the network's capacity, or for the aggregate generation within a zone to exceed the capacity of the main transmission system. Where this occurs, the dispatch of generation may need to be constrained. This 'congestion' is managed by AEMO in accordance with the procedures and mechanisms of the NEM. It is the responsibility of each generator proponent to assess and consider the consequences of potential congestion, both immediate and into the future.

Powerlink also provides more detailed information on its website in the form of the Network Limitations Advice. These maps provide indicative available capacity for non-synchronous generation at substations throughout each region. It is important to note that the capacities provided are not cumulative. Information is also available in the 'New generator connections data' TAPR template.

It is important to note that the indicative capacity for non-synchronous generation is based on simple 'screening metrics' consistent with the Preliminary Assessment methodology. Detailed EMT-type analysis will be required to confirm the capacity (refer to the calculation methodology section of the Powerlink Generation Capacity Guide for further description and additional assumptions).

More detail on the methodology for assessment of capacity for the transmission network is provided in the Generation Capacity Guide.

8.5 Transmission congestion and Marginal Loss Factors

As part of normal planning processes, Powerlink proactively monitors the potential for congestion to occur, and will assess the potential network investments to maximise market benefits using the Australian Energy Regulator's (AER) Regulatory Investment Test for Transmission (RIT-T)[3]. Where found to be economic, Powerlink may augment the network to ensure that the electricity market operates efficiently and at the lowest overall long run cost to consumers. Generator proponents are encouraged to refer to Chapter 5 and Chapter 7, which provides more detail on potential future network development as well as emerging constraints.

Where Powerlink is aware of emerging constraints, Powerlink must demonstrate that the economic benefit to the market must exceed the cost of addressing the constraint. In the case of emerging constraints across the CQ-SQ and Gladstone grid sections (refer to Chapter 7), the potential investments to address these constraints are likely to be significant. Powerlink is considering these constraints holistically with emerging condition based drivers as part of its normal planning processes. Potential development decisions will be undertaken using the RIT-T consultation process, where the benefits of non-network options will also be considered.

The development, displacement or retirement of generating plant, changes to generation dispatch and/or load patterns, and/or changes to the underlying transmission network may alter transmission losses within the high voltage (HV) system. This will result in changes to the Marginal Loss Factors (MLFs) used within the NEM dispatch and financial settlement processes. AEMO is responsible for the calculation of MLFs, and interested parties seeking further information on this are encouraged to contact AEMO, or refer to the AEMO website.

As a TNSP, the scheduling of generation is not part of Powerlink's role and the indicative connection point generation capacity limits are not related to the MLF or scheduling and dispatch of generation in the NEM.

[3] Details of the RIT-T, including the market benefits which can be considered, are available on the AER's website.

8.6 Supporting new generation development in Queensland

Powerlink supports a number of initiatives associated with the establishment of new generation in Queensland. Further information on these is provided in the following sections.

8.6.1 Renewable Energy Zones (REZs)

REZs can be used to deliver an effective, lower cost connection to a number of parties. Powerlink is working to enhance the concept of the REZs based on recent experience around the connection of VRE projects. However this is not without challenges such as system strength, constraints and regulatory obligations.

Significant opportunities exist for new VRE generation in Queensland that is not adjacent to existing infrastructure. Powerlink is committed to providing as much information as it can to developers to assist, with an example of this being the Rule change submitted by Energy Networks Australia (ENA) to provide information about current enquiries and applications discussed in Section 8.7.2. This proposed rule change will increase transparency of information, and provide information to VRE developers that may assist in the development of REZs in the NEM.

The 2018 Integrated System Plan (ISP) provides an overview of REZs. A range of REZs were assessed across the NEM, with information on a select number of these published. In assessing REZs, AEMO has considered the following:

- resource quality, diversity and demand requirements
- existing transmission network capacity and access to the main transmission network
- system strength and
- network losses, including MLFs.

In the broader context of supporting VRE generation connections, the concept of a REZ may involve:

- a high-capacity radial transmission line, with renewable projects connecting along the length of this line
- the establishment of a centralised hub, from which radial connections to individual renewable projects emanate
- a hybrid of these two options, with hub substations placed along the length of a new high-capacity transmission line.

Further to the concepts discussed above, providing system firming services to facilitate the connection of new VRE generation may provide benefit, particularly in areas where the interest in VRE generation exceeds the available system strength. Powerlink considers that new VRE generation may be able to utilise one, or a combination of the following methods to mitigate system strength issues:

- installation of a synchronous condenser to improve system strength
- contracting with existing synchronous generation to access system strength
- modifying the scope of the connection works
- the use of non-synchronous plant based on grid forming converter technologies and
- establishing intertrip schemes to mitigate against critical contingencies[4].

As with the establishment of a central hub and the high capacity line concept, system firming services may be utilised as a standalone solution or in combination with the other methods to deliver a REZ.

8.6.2 Changes impacting on REZs

Currently, TNSPs cannot disclose information about connecting parties seeking to connect to the transmission network in the same area. As a result, information that may assist Powerlink and connecting parties to optimise connection outcomes is often not available in a timely or coordinated manner.

[4] Powerlink considers that these schemes are used to mitigate against single credible contingencies that result in a significantly lower plant capacity that is compliant compared to the next most critical contingency, and where the resultant loss of generation does not introduce any further constraint on the system.

Energy Networks Australia (ENA), of which Powerlink is a member, has proposed a rule change to the AEMC relating to confidentiality of information in the NEM. Similar requests have also been received from AEMO and the Australian Energy Council. This rule change has been sought to assist connecting parties and Powerlink optimise connection investment decisions and outcomes.

Further information is available on the AEMC website.

8.6.3 Other sources of renewable energy

There is value in securing energy from diverse sources of renewable energy in Queensland. The developments over the last few years have centred on solar photovoltaic (PV) and wind generation sources. These are not the only source of renewable energy in Queensland, with the Department of Natural Resources, Mines and Energy (DNRME) website also considering biomass, hydro-electric and geothermal energy as potential sources of renewable energy.

Depending on the nature and type of connection, not all of the information relating to the assessments highlighted may apply. For example, a new synchronous generator would not require a Full Assessment even if seeking connection in a weak network. It remains the case that generation must meet the NER Generator Performance Standards, and generation proponents are required to demonstrate that their proposed generation technology is able to meet these standards during the connection process.

8.6.4 Energy storage

Currently, the level of VRE development in Queensland may lead to constraints during periods of high VRE output. The pathway to a low emissions future indicates that for VRE to be able to reliably supply energy, storage will play a key role in shifting this energy.

Energy storage can take a number of forms, for example:

- hydro-electric, in particular pumped storage
- thermal storage, such as molten salts
- battery energy systems, similar to those used in South Australia
- compressed air storage and
- hydrogen.

A number of the technologies listed above are based on synchronous machines, however battery energy storage and other inverter connected plants (e.g. Variable Speed Drive coupled hydro-electric machines) would require the system strength assessment highlighted in Section 8.2 be carried out as part of the connection process.

8.6.5 Proposed renewable connections in Queensland

DNRME provide 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 DNRME website.

8.6.6 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 Network Service Providers (NSP) must apply when dealing with connection enquiries. Powerlink will continue to engage with interested parties who have lodged connection enquiries under the previous Rules framework for connection of generation. Should an interested party wish to utilise the connection framework referred to in Section 8.4, it will be necessary to submit a new connection enquiry.

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Figure 8.1 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.