Chapter 7:
Renewable energy

7 Renewable energy

Key highlights

- This chapter explores the potential for the connection of variable renewable electricity generation to Powerlink's transmission network.
- Due to fundamental shifts in the external environment, Powerlink has a key role in enabling the connection of variable renewable electricity infrastructure in Queensland.
- Over the past year, Powerlink has supported a high level of connection activity, responding to more than 80 connection enquiries comprising over 15,000MW of potential variable renewable electricity generation.
- In 2016/17, Powerlink finalised seven renewable renewable electricity generator Connection and Access Agreements totalling 718MW.

7.1 Introduction

Queensland is rich in a diverse range of variable renewable electricity (VRE) resources – solar, wind, geothermal, biomass, and hydro. This makes Queensland an attractive location for large-scale VRE generation development projects.

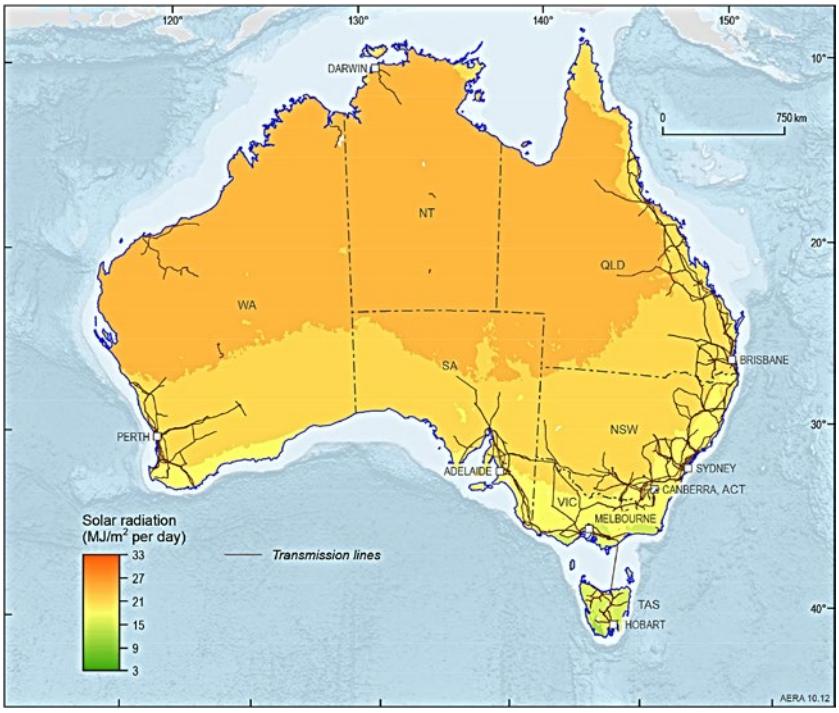
In February 2017, the level of roof top solar installations in Queensland exceeded 1,700MW, and is presently increasing at approximately 15MW each month. This uptake provides a strong indication that Queensland consumers are no longer meeting their energy requirements entirely through conventional means. The development of complementary technologies, such as energy storage, smart appliances, and electric vehicles are changing the way customers consume and produce energy. During the past year there has been a significant increase in the development of large-scale solar and wind generation farms. Fundamental external shifts such as these are shaping the operating environment in which Powerlink delivers its transmission services.

Powerlink is committed to supporting the development of all types of energy projects requiring connection to the transmission network. In addition, due to these fundamental shifts in the external environment, Powerlink will also have a key role in enabling the connection of VRE infrastructure developments which aim to provide a sustainable, low carbon future for electricity producers and users in Queensland. The network capacity information presented in this chapter is applicable to all forms of generation including energy storage[1].

The Australian Government Department of Geoscience has published an assessment of Australia's energy resource. The report acknowledges that Australia's potential for VRE generation is very large and widely distributed across the country. Figures 7.1 and 7.2 highlight Queensland's solar and wind energy potential and the proximity of Powerlink's high voltage transmission infrastructure to this energy resource.

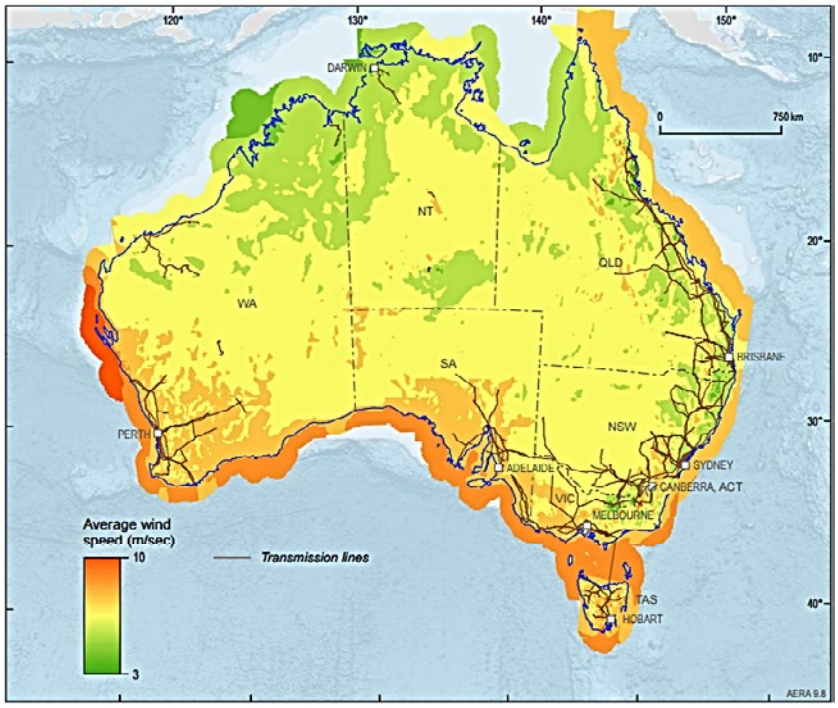
[1] The impact of new synchronous generator connections on existing fault levels has not been considered in the assessments conducted in this chapter. For further information on existing fault levels and equipment rating, please refer to Appendix E.

Figure 7.1 Australian annual average solar radiation



Source: Geoscience Australia and Bureau of Meteorology[2]

Figure 7.2 Australian annual average wind speed



Source: Geoscience Australia and Windlab Systems Pty Ltd[2]

[2] Geoscience Australia and BREE, 2014, Australian Energy Resource Assessment. 2nd Ed. This product is released under the Creative Commons Attribution 3.0 International Licence. http://creativecommons.org/licenses/by/3.0/legalcode

7.2 Connection activity during 2016/17

Powerlink is currently managing a high level of interest in transmission connections for VRE projects. In 2016/17, Powerlink received more than 80 new connection enquiries totalling in excess of 15,000MW.[3]

Figures 7.3 and 7.4 illustrate record levels of connection enquiries over the last year.

Figure 7.3 Historical number of variable renewable electricity generation connection enquiries[3]

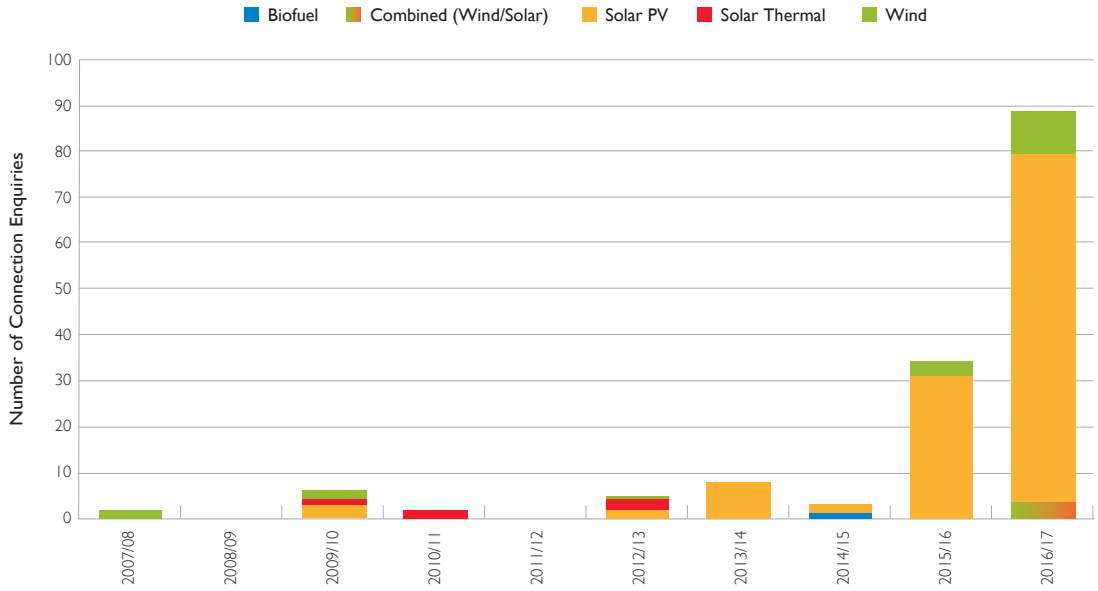
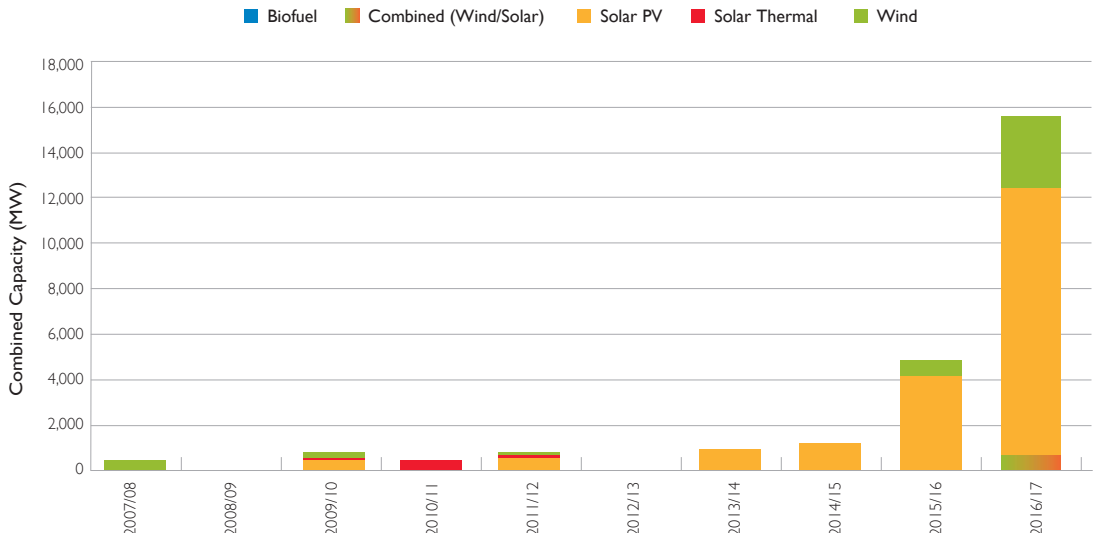


Figure 7.4 Historical capacity of variable renewable electricity generation connection enquiries[3]



During 2016/17, Powerlink finalised seven connection and access agreements for new non-scheduled generation, totalling 718MW[3] (refer to Table 7.1).

[3] Connection activity details as at 1 June 2017

Table 7.1 Transmission connected VRE generation projects committed during 2016/17

Zone	Project	Registered capacity (MW)	Connection location
Far North	Mt Emerald Wind Farm	180	New Walkamin Substation near Chalumbin
Ross	Ross River Solar Farm	125	Ross
Ross	Clare Solar Farm	136	Clare South
North	Hamilton Solar Farm	57	Strathmore
North	Whitsunday Solar Farm	57	Strathmore
Wide Bay	Teebar Solar Farm	53	Teebar Creek
Bulli	Darling Downs Solar Farm	110	Darling Downs

Additionally, Powerlink has been advised of 117MW of committed semi-scheduled renewable projects connecting downstream within the distribution network.

7.3 Network capacity for new generation

Powerlink has assessed the potential generation capacity which could be accommodated at various locations across the transmission network. This information is available on Powerlink's website. The data presented is not comprehensive, and is not intended to replace the existing processes that must be followed to seek connection to Powerlink's transmission network.

7.3.1 Calculation methodology

Powerlink has assessed the available generation connection capacity at 60 locations across the network. Locations close to major urban areas were considered unlikely to host a large VRE project and were excluded from the assessment. In addition, substations operating at 275kV and 330kV were excluded from this study as connections at these voltages will generally accommodate generation levels in excess of 400MW.

Thermally Supportable Generation

A connection point's thermal capacity relates to the highest level of generation that can be injected into a connection point without exceeding the rating of a transmission circuit following the loss of a network element. It may be possible for generation to be installed in excess of this level if a fast generation run-back scheme is implemented to limit generation output following the relevant network contingency events.

Each connection point's thermal capacity was calculated by applying generation of increasing levels to a connection point, displacing QNI transfer, and performing contingency analysis. The thermal limit of a connection point was assessed as being reached when a rating breach was identified.

System Strength Supportable Generation

A connection point's network strength capacity relates to the ability of power electronic connected systems to maintain stable operation. Short Circuit Ratio (SCR) is a commonly used metric for quantifying the power system's strength at a connection point, and is calculated by dividing the short circuit power (in MVA) at a connection point by the installed level of power electronic connected generation (also in MVA). The SCR at the connection point strongly influences a plant's ability to operate satisfactorily both in steady state and following a system disturbance[4]. Powerlink has assumed a SCR of two to determine generation capacity.

Multiple independent power electronic connected systems in an area can interact with each other. Any interaction between such systems, including non-synchronous generation and certain network infrastructure[5], may reduce the system strength capacity available at that location.

[4] "Connection of wind farms to weak AC networks", CIGRE WG B4.62, December 2016.
[5] Including Static VAr Compensators (SVCs) and Static Synchronous Compensators (STATCOMs)

Overall Non-Synchronous Supportable Generation

The overall non-synchronous supportable generation is the lower of the thermally supportable generation and the system strength supportable generation at each location.

7.3.2 Network capacity results

As mentioned in Section 7.2, Powerlink has received more than 80 new connection enquiries and finalised seven connection agreements for new VRE generation since publication of the 2016 TAPR. As a consequence, the capacity results calculated via the methodology described in Section 7.3.1 are continually changing. On this basis, the revised approach is to present the detailed calculation results on Powerlink's website in order to more efficiently address the dynamics of this evolving environment and best serve the needs of customers (refer to Powerlink's Generation Capacity Guide). Powerlink expects to maintain this data as required and encourages proponents to make informed investment decisions through the established connection enquiry process. This process includes the provision of detailed capacity and congestion information for customers seeking to connect to Powerlink's transmission network. To join Powerlink's Non-network Engagement Stakeholder Register (NNESR) and be notified of any updates to this data, please email networkassessments@powerlink.com.au.

The calculation methodology assumes the existing configuration of the transmission network and the technical standards that currently apply to transmission network design and power system operation. Changes to either of these have the potential to change the network capacity available to generators. The analysis also assumes that the proposed generation facility will comply with the NER's automatic access standard for reactive power capability.

Under the open access regime which applies in the National Electricity Market (NEM), 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 backbone. Where this occurs, this 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 proactively monitors the potential for congestion to occur, and will assess the potential network augmentations to maximise market benefits using the Australian Energy Regulator's (AER) Regulatory Investment Test for Transmission (RIT-T)[6]. Where augmentations are found to be economic, Powerlink may augment the network to ensure that the electricity market operates efficiently and at the minimum overall long run cost to consumers. Generator proponents are encouraged to refer to other sections of this document which provide more detail.

As a transmission network service provider, the scheduling of generation does not form part of Powerlink's role and as such, the indicative connection point generation capacity limits are not related to the scheduling and dispatch of generation in the NEM.

7.4 Potential changes in technical standards

As higher levels of non-synchronous VRE sources are introduced into the NEM, new technical and regulatory challenges arise. The characteristics of the power system vary as synchronous generators, which inherently provided services such as inertia and system strength are displaced. Impacts such as the management of frequency and performance standards under weak system conditions require different approaches. This section summarises a number of initiatives in response to these challenges.

[6] Details of the RIT-T, including the market benefits which can be considered, are available on the Australian Energy Regulator's website: Regulatory investment test for transmission (RIT-T) and application guidelines 2010

New Rules[7] have been created that include a new classification of contingency event, known as the protected event, which allows power system security under particular non-credible event circumstances to be managed using a combination of ex-ante and ex-post actions. The new rules include a framework to regularly review current and emerging power system frequency risks, both under and over frequency risks, and to identify and implement the most efficient means for their management.

The Australian Energy Market Commission (AEMC) is also conducting a review into regulatory frameworks that affect system security in the NEM. This system security review addresses two key issues:

- the management of frequency following contingency events and
- system strength in a power system with reduced levels of synchronous generation.

A directions paper[8], published in March, details the AEMC's proposed approach and measures, which include potential obligations on new non-synchronous generators to:

- be capable of providing a fast frequency response
- withstand higher rates of change of frequency (RoCoF) and
- improve system strength at its connection point for existing generators to continue to meet their performance standard.

The "Independent Review into the Future Security of the National Electricity Market"[9] published in June 2017 also recommends a review of the connection standards. In particular, the connection standards review is to focus on system strength, reactive power, voltage control, generator performance and active power control. Powerlink will continue to monitor changes in technical standards as they develop.

7.5 Supporting variable renewable electricity infrastructure development

As part of Powerlink's commitment to innovation and responding effectively to the needs of customers, Powerlink has made a number of refinements to its connection process during 2016/17.

At Powerlink's Transmission Network Forum held in July 2016, an interactive breakout session was held to seek input and feedback from stakeholders on how the transmission network can enable large-scale VRE generation. A summary of the feedback received is available on Powerlink's website[10], and the following sections outline the specific measures Powerlink has implemented in response. Powerlink will continue to seek and respond to feedback throughout 2017/18.

7.5.1 Connection cost

Proponents highlighted the cost of grid connection is a critical factor in progressing VRE generation projects. In response to the range of measures proposed to reduce or defer the cost of connection, Powerlink has implemented targeted changes that provide strategic benefits for proponents, including plant with asset lives matched to the 25 year project life and shortening of lead times and cost through standardisation.

7 Emergency frequency control schemes for excess generation
8 System Security Market Frameworks Review
9 Independent Review into the Future Security of the National Electricity Market
10 Stakeholder Engagement/Engagement Forums

7.5.2 Provision of information

Considerable stakeholder feedback related to Powerlink providing additional information to proponents regarding connection opportunities and the connections process, including:

- cost estimates being provided earlier in the process
- greater transparency on other connection enquiries active in an area
- establishing the information proponents will be required to provide earlier in the process and
- provision of site-specific information to enable proponents to determine site viability in a Geospatial Information Systems (GIS) format, which could then be updated in 'real time'.

In response, Powerlink has established a process to provide proponents, in a timely way, with project specific details of:

- connection options available, including viable connection locations, and cable/overhead infrastructure options
- network capacity, constraints and operational issues
- easement issues, including existing easements and Powerlink-owned land, as well as potential consultation requirements and
- capital cost and connection charge estimates.

In relation to details of active connection enquiries, Powerlink is limited by the confidentiality requirements of the National Electricity Rules (NER). Powerlink has provided overviews in engagement forums and in Section 7.2 to communicate aggregate metrics regarding connection activities.

7.5.3 Shared network connections

There was also significant feedback relating to shared network connections, including the concept of 'Renewable Energy Zones' (REZs). In particular, proponents highlighted the need for active involvement from a range of stakeholders (including Government) for the concept to generate value. Stakeholders enquired about the potential for different funding models to incentivise clustering and overcome 'first mover' risk. Some raised concerns about aggregating high volumes of a single form of generation at a single point, with a potential impact upon intermittency, the risk of land banking, and the potential for additional delays in the connection process.

In response to this feedback, Powerlink is working with the Queensland Government on two initiatives, which are discussed in Section 7.5.4.

Powerlink acknowledges the potential for issues to arise from co-locating large volumes of homogeneous intermittent generation. The REZs concept works most efficiently when used to connect diverse forms of generation that are unlikely to achieve maximum output coincidently. The impact of increasing levels of generation intermittency on Frequency Control Ancillary Services (FCAS) requirements has recently been investigated by the Australian Energy Market Operator's (AEMO) Future Power System Security Program. AEMO has presented on the results of this study, with a final report yet to be published.

7.5.4 Renewable Energy Zones (REZs)

Powerlink is committed to supporting the development of VRE projects in Queensland. Where economies of scale can be achieved through project clusters, Powerlink may consider the development of Renewable Energy Zones (REZs), subject to regulatory approvals and the conditions of its Transmission Authority.

The implementation of a REZ would require that consideration be given to a range of criteria, including economic benefit to customers, energy resource potential, infrastructure availability and access, stakeholder and local authority support, environmental suitability, and where possible, opportunity for deferral or replacement of planned network investment projects.

A REZ may be viewed as a network expansion into the zone of interest, as a high capacity transmission line or a connection hub, either of which would be aimed at supporting clusters of diverse VRE projects. These arrangements are generally more cost effective than the creation of multiple connection paths to the grid as infrastructure sharing reduces the need for asset duplication. Although this concept is aimed at identifying priority areas for development, it is not intended to preclude the development of VRE projects outside the targeted zones.

While the majority of recent interest focuses on solar related activity, Powerlink recognises considerable opportunity also exists for wind, biomass, geothermal and hydroelectric projects in Queensland. Powerlink believes the REZ concept works most efficiently when used to connect diverse forms of generation unlikely to achieve maximum output coincidently, allowing a portion of the infrastructure's capacity to be shared between parties with limited congestion.

As illustrated in figures 7.5 and 7.6, a REZ may involve:

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

Figure 7.5: REZ with high capacity transmission line

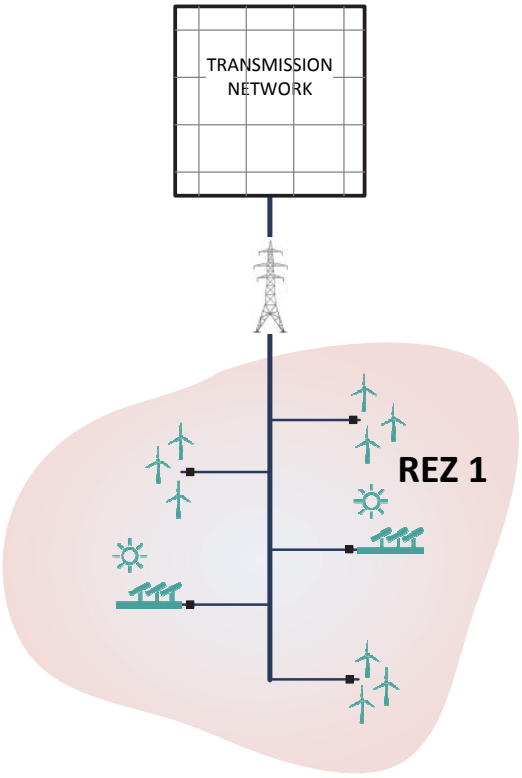
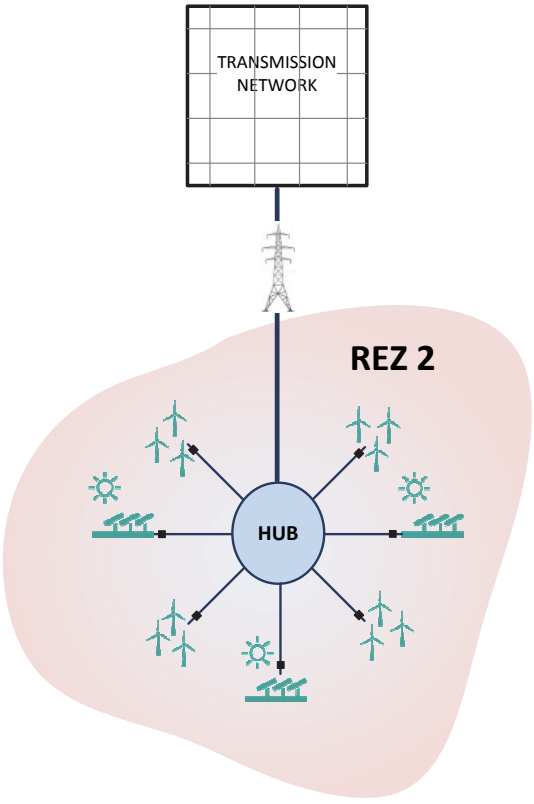


Figure 7.6: REZ with dedicated connection hub



7 Renewable energy

Powerlink is working with the Queensland Government to progress two initiatives:

- Economic Development Queensland (EDQ) on the Aldoga Renewable Energy Zone project

  This project involves utilising a 1,250 hectare site adjacent to Powerlink's Larcom Creek Substation, with the potential to support up to 450MW of generation capacity. As a flagship project, it is envisaged that the Aldoga development will act as a catalyst for further opportunities. More information about this project is available on the website of the Queensland Department of Infrastructure, Local Government and Planning (DILGP).

- Powering North Queensland Plan (DEWS)

  This project includes a feasibility study into the development of strategic transmission infrastructure in north and north-west Queensland to support a clean energy hub. More information about this project is available on the Department of Energy and Water Supply (DEWS) website.

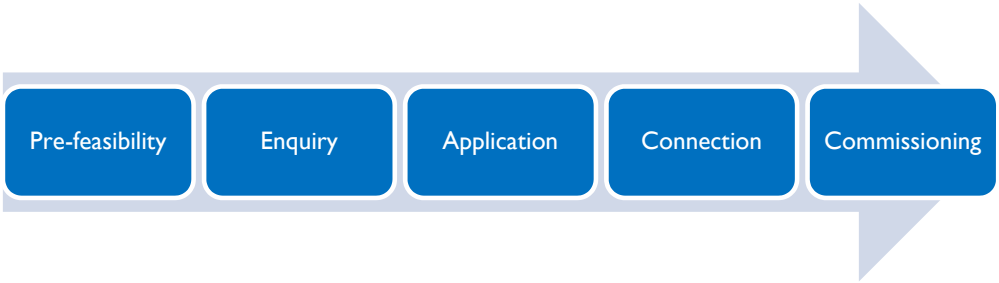
7.5.5 Proposed renewable connections in Queensland

DEWS 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 DEWS website.

7.5.6 Further information

Powerlink will continue to work with market participants and interested parties across the renewables sector to better understand the potential for VRE, and to identify opportunities and emerging limitations as they occur. The National Electricity Rules (Clause 5.3) prescribes procedures and processes that Network Service Providers must apply when dealing with connection enquiries. Powerlink uses a five-stage approach as illustrated in Figure 7.7 below to facilitate this process.

Figure 7.7: 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[11] www.powerlink.com.au.

[11] Refer to Connecting to Powerlink's Network on the Powerlink website.