Generation Capacity Guide

December 2018

This guide outlines the potential generation capacity which may be available at various locations across Powerlink's transmission network. The data presented is not comprehensive. This information is preliminary only and is not intended to replace the existing processes that must be followed to seek connection to Powerlink's transmission network.

The data has been prepared using the methodology and assumptions outlined in this document, noting that capacity is a dynamic concept and that it changes in response to real time network conditions, environmental conditions and constraints. In practice, higher or lower capacities than those listed in Table 2 may be achievable at different points in time. Powerlink encourages interested parties to contact Powerlink's Business Development team by phoning (+617) 3860 2111 during business hours, or by emailing BusinessDevelopment@powerlink.com.au.

A complementary resource, Network Limitation Advices are provided on Powerlink's website and provide further preliminary information for proponents considering connection of renewable generation to the transmission network.

Interested parties are also encouraged to refer to Powerlink's Transmission Annual Planning Report (TAPR), which provides information relevant to the development of new generation projects.

The information presented in this document is current at 14 December 2018, including taking into account the System Strength Impact Assessment Guidelines published by the Australian Energy Market Operator (AEMO) in June 2018.

Updated network capacity information may be published on Powerlink's website from time to time, and interested parties should check this information. 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.

Calculation methodology

Indicative available generation connection capacity is outlined at more than 60 locations across Powerlink's transmission network. Powerlink has assessed the available generation connection capacity at a number of locations across the network predominantly at the 275kV and 132kV level. Locations close to major urban areas were considered less likely to host a large Variable Renewable Energy (VRE) project and were excluded from the assessment.

Powerlink and Energex and Ergon Energy (part of the Energy Queensland Group) are required to liaise regarding the assessment of new connections. While the arrangements for connection differ due to the Rules that apply to a Distribution Network Service Provider (DNSP) and Transmission Network Service Provider (TNSP), the obligations around system strength and system security relating to generators apply equally to new connections on the network as a whole.

Analysis is based on the existing and committed transmission network arrangements. The analysis also takes account of recent generator commitments. Possible (uncommitted) future network changes, including those outlined in chapters five and seven of Powerlink's 2018 TAPR, may alter the level of supportable generation.

The calculation methodology is based on the Guidelines published by AEMO, continuing to build upon the existing technical standards that currently apply to transmission network design and power system performance. Changes to these standards have the potential to change the network capacity available to generators.

Congestion

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. Depending on these system conditions sections of Powerlink's transmission network may constrain under system normal and contingency conditions. The exposure to congestion may increase with new generation commitments.

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 from VRE generation in an area of the network.

Where constraints occur on the network due to thermal, voltage or transient stability limits, AEMO will constrain generation based on the market system rules within the National Electricity Market Dispatch Engine (NEMDE) to maintain system security.

Three criteria are published for each connection point as described below.

1. Thermally supportable generation

A connection point's thermal capacity relates to the highest level of generation that can be exported through a connection point without exceeding the rating of a transmission circuit following the loss of a network element. This field is applicable to all forms of generation.

The thermally supportable generation only relates to constraints on the local network, including the network adjacent to the connection point and between the connection point and the main transmission system. It is not intended to provide information on intra-network or inter-network constraints, further information on which can be found in chapter six of Powerlink's 2018 TAPR. Generators may be required to implement a mitigation scheme if seeking to operate in a constrained network area.

The levels of thermally supportable generation reported in Table 2 are based on the single generation dispatch shown in Table 1. This generation profile is applied to a typical summer noon load and coincident output for the committed VRE generation projects.

The thermally supportable generation at a connection point may be substantially greater or lower with different generation patterns, network configurations and load levels. For example, the thermally supportable generation available at Strathmore 132kV is reported as being 100-150MW (refer to Table 2). However, under lower Far North Queensland and Ross generation and higher North generation the available generating capacity at Strathmore 132kV can be less than 50MW.

Table 1 Base summer noon generation dispatch assumptions for the available thermal capacity guide

Zone/Interconnector	Generation sent out (MW)
Far North	260
Ross	449
North	282
Central West	2,537
Gladstone	1,223
Wide Bay	233
Surat	144
Bulli	2,070
South West	1,925
Moreton	494
Qld-NSW Interconnector Southerly Flow (swing)	300
Terranora Interconnector Southerly Flow	50

Each connection point's thermal capacity was calculated by iteratively applying increasing levels of generation to the connection point, (balanced by changing power flows on the Queensland to New South Wales Interconnector), and performing contingency analysis. The thermal limit of a connection point was assessed as being reached when a rating breach was identified within the local network.

It may be possible for generation to be exported in excess of the thermally supportable generation if a mitigation scheme is agreed that limits generation output in the event of local network contingency events.

Powerlink has assessed each connection point individually, and has not assessed whether multiple generators in a region are likely to result in congestion on the transmission network backbone.

2. System strength supportable generation

Powerlink's 2018 TAPR outlines that advances in renewable energy technologies and displacement of existing synchronous generation is driving a transformation in energy throughout the NEM. The displacement of this synchronous generation with asynchronous VRE generation is likely to significantly reduce the system fault levels. This reducing system strength can impact the stability and security of the power system.

In response to these challenges, the Australian Energy Market Commission (AEMC) finalised Rule 2017 No.10 (Managing Power System Fault Levels). This rule created a framework in the National Electricity Rules (NER) for the management of system strength in the NEM. As required under the rule, the AEMO published the final System Strength Impact Assessment Guidelines 29 June 2018.

An adverse impact on system strength may be caused by the aggregation of multiple electrically close VRE generating units, or by a large plant on its own. Where multiple VRE generating systems are connected in close proximity, a screening index that can account for nearby asynchronous generation is required. The guidelines require that Powerlink undertake a Preliminary Assessment at the connection enquiry phase to assess this impact.

The methodology calculates the Available Fault Level (AFL) at the proposed connection point for the VRE – generator. This is then used to calculate the aggregate Short Circuit Ratio (SCR). Where the aggregate SCR is less than three, it will be necessary for the proponent to undertake a Full Assessment. The Full Assessment requires Electro-Magnetic Transient (EMT) type studies as part of the application process. This is to ensure that any adverse system strength impact is adequately addressed as part of the connection application either via a system strength remediation scheme or system strength connection works.

Where the aggregate SCR is greater than three, the strength of the connection point is sufficient for power electronic connected systems, such as VRE generation, to maintain stable operation. The aggregate SCR at the connection point strongly influences a plant's ability to operate satisfactorily both in steady state and following a system disturbance.

New VRE generation may also adversely interact with existing network voltage control devices[1]. The possibility of adverse interactions with these devices can be estimated by the change in the voltage at the point where the new VRE generation is connecting. Where the interaction is greater than 3%, it will be necessary to undertake a Full Assessment. This requirement is independent of the aggregate SCR assessment described above, and either assessment can trigger the requirement for Full Assessment.

The methodology also takes account the possible displacement[2] of synchronous generation in Queensland as a result of new entrants in Queensland. The commitment of new VRE generation, currently approximately 2750MW, is expected to significantly alter the generation patterns of synchronous plant. Powerlink does not know the nature or extent of how this will impact synchronous generation profiles in the future. To reasonably account for this impact, existing synchronous generation has been offset throughout the state to achieve possible generation profiles. Other synchronous generation profiles are possible that may result in different system strength limitations.

Powerlink has assessed this displacement against daytime minimum loads. In 2017, the daytime minimum delivered load in Queensland fell below 4300MW, in comparison to a night-time minimum delivered load of below 4250MW. Due to the prevalence of solar PV generation in Queensland, the minimum synchronous generation profile is expected to occur through the middle of the day, particularly in April, May, August and September.

Due to the interaction of non-synchronous VRE generation in the network, Powerlink has assessed the available capacity from a system strength perspective in each zone, rather than at each connection point. Some connection points may have been excluded where they offer significantly less capacity than others in a region. Other connection points within a zone may offer more capacity than indicated, but would impact on other connection points within that zone.

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.

1 Including Static VAr Compensators (SVCs) and Static Synchronous Compensators (STATCOMs)
2 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.

3. VRE supportable generation

VRE generation, including most forms of solar and wind generation, will be subject to the most-limiting of the thermally supportable generation and the system strength supportable generation. As such, the lower of these two parameters at each location is presented in Table 2 as the VRE supportable generation (i.e. it is simply the minimum of the thermally supportable and system strength supportable generation values).

Indicative supportable generation

The results of the application of the calculation methodology described above are presented below in Table 2. The VRE supportable generation metric is also displayed geographically on the AREMI spatial data platform. AREMI enables the supportable generation data to be viewed in conjunction with other datasets which may be of interest to prospective renewable generation developers.

This information is provided as a guide only and is not a substitute for the information obtained during the connection process.

Generator proponents are also encouraged to refer to Powerlink's 2018 TAPR, which provides more detail on these issues, particularly:

- Chapter 5 describes possible and proposed changes to the network in the five-year and 10-year outlook period.
- Chapter 6 presents existing capacity and performance of the main transmission network backbone.
- Chapter 7 identifies network limitations that may arise within the 10-year outlook period due to new loads within the resource rich areas of Queensland or at the associated coastal port facilities whose development status is not yet at the stage that they can be included (either wholly or in part) in the medium economic forecast of Chapter 2.
- Chapter 7 also provides a summary of the technical challenges due to the changing mix of generation and the role TNSP's will play in providing directly or facilitating system security services.
- Appendix C illustrates sample power flows at time of peak demand (which is typically late in the day).
- Appendix D provides the Powerlink derived intra-regional limit equations, which are implemented in the national electricity market dispatch engine to constrain the generation dispatch within the technical capabilities of the network.
- Appendix E provides indicative minimum and maximum short circuit currents and lowest plant rating at connection points providing an indication of required switchgear ratings.

Table 2 Indicative connection point supportable generation capacities by zone

Zone	Voltage Level (kV)	Thermally supportable generation (MW)	System strength supportable generation (MW)	Non-synchronous supportable generation (MW)	Includes the substations:
Far North	275	300-400	up to 50	up to 50	Chalumbin, Walkamin
	132	150-200			Chalumbin, Edmonton, Innisfail, Kamerunga, Turkinje
Ross	275	800+	up to 50	up to 50	Ross
	132	150-200			Cardwell, Clare South, Ingham South, Tully
North	275	800+	up to 100	up to 100	Nebo
	132	100-150			Alligator Creek, Kemmis, Mackay, Moranbah, Nebo, Newlands, Peak Downs, Pioneer Valley, Proserpine
Central West	275	600-700	up to 100	up to 100	Bouldercombe, Broadsound, Calvale, Lilyvale, Stanwell
	132	100-150			Biloela, Blackwater, Bouldercombe, Lilyvale, Moura, Pandoin
Gladstone	275	300-400	up to 300	up to 300	Calliope River, Larcom Creek, Wurdong
	132	300-400			Calliope River, Gladstone South, Larcom Creek
Wide Bay	275	300-400	up to 350	up to 300	Gin Gin, Teebar Creek, Woolooga
	132	250-300			Gin Gin, Teebar Creek, Woolooga
Bulli	330	800+	600-700	up to 700	Braemar, Bulli Creek, Millmerran
	275	800+			Braemar, Western Downs
Surat	275	800+	up to 300	up to 200	Columboola, Wandoan South
	132	150-200			Chinchilla, Columboola, Wandoan South
South West	330	800+	400+	400+	Middle Ridge
	275	800+			Halys, Middle Ridge, Tarong
	110	400+			Middle Ridge
Moreton	275	500-600	400+	up to 250	Mt England, Palmwoods
	132	200-250			Palmwoods
	110	400+			Blackstone

Key modelling assumptions

1. Thermally supportable generation capacity has been assessed using a single, indicative, summer midday pattern of load and generation, taking account of constraints on the local network only. The thermally supportable generation at a location may be substantially greater and/or lower with different load and generation patterns, and does not take account of intra-regional or inter-regional constraints on the main transmission network.
2. All analysis is based on the existing configuration of the transmission network with committed changes to the network applied. Possible future network changes, including those outlined in chapters four and six of Powerlink's TAPR may alter the level of supportable generation.
3. New non-synchronous generators are assumed to be able to operate with a short circuit ratio of three, and to comply with NER automatic access standard for reactive power capability.

General notes

1. The provided figures are indicative. Detailed and project specific analysis is undertaken as part of the connection application process, including an assessment of stability, network congestion and compliance with the generator performance standards.
2. Generation opportunities presented in this section are not cumulative. If a new generator commits, it may impact the supportable generation at multiple locations.
3. Transmission network connections do not confer firm access to the NEM. The dispatch of generation within the NEM, including management of any congestion, is the responsibility of the AEMO. Powerlink proactively monitors the potential for congestion to occur in accordance with the NER, and will assess the potential network augmentations and/or non-network options to maximise market benefits using the AER's Regulatory Investment Test for Transmission (RIT-T). Where augmentations are found to be economic, Powerlink may augment the network or implement non-network solutions to ensure that the electricity market operates efficiently and at the minimum overall long run.

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