Appendix B Powering data centres - A guide to Queensland grid integration

The purpose of this appendix is to help prospective data centre developers make informed decisions during the early stages of project development, including site selection, connection pathways, and key technical and planning considerations. It provides practical guidance on connecting large-scale data centre load to Queensland's transmission network and highlights information that can support a more efficient connection assessment process.

All developers seeking to connect to the transmission network are required to follow the connection process prescribed under Chapter 5 of the National Electricity Rules (NER). This appendix does not replace or modify the requirements of the NER. Rather, it is intended to assist developers in understanding the connection process, the information required at each stage, and opportunities to engage early with Powerlink to help facilitate a more efficient connection process.

B.1 General advice

One of the factors that can have the greatest influence on the efficient progression of a connection project is the experience level of the technical advisers engaged by the proponent. Data centre developers are encouraged to engage suitably qualified power system engineers with experience in the National Electricity Market (NEM), and preferably with an understanding of Queensland's power system and the Powerlink transmission network.

Experienced advisers can assist developers in navigating the connection process, developing realistic connection strategies, and undertaking the technical studies required to support a connection application. Early identification of potential network constraints, technical issues, or compliance requirements can reduce the risk of costly redesigns and project delays later in the development process.

Consultants with a strong understanding of transmission network planning, system strength, power system security, and local network conditions can also assist developers in identifying suitable connection locations and in assessing the relative advantages and challenges of different connection options. This can help streamline the connection process and improve project outcomes.

B.2 Important upfront information

Providing comprehensive information to Powerlink as early as possible in the connection process enables more effective early engagement and assessment. Early information sharing can help identify potential technical, regulatory, or network-related constraints, allowing issues to be addressed before they affect project timelines. The key information that supports an efficient and informed assessment is outlined below.

B.2.1 Proposed data centre substation layout

A single-line diagram showing the proposed customer electrical system behind the connection point, including the major plant and equipment to be installed, should be provided. This enables Powerlink to better understand the intended network configuration and assess any connection-related technical considerations at an early stage. Understanding the type and characteristics of the proposed plant also allows Powerlink to provide more targeted advice on connection requirements, technical studies, and the overall connection process.

The customer should identify any credible common-mode failures within the data centre that could cause a large and sudden loss of load and describe the proposed approach for managing this risk. This should include relevant design, protection, operational and load-recovery measures. For example, a loss of a common auxiliary supply, cooling system, control system, busbar section, or transformer could result in a large proportion of the data centre load disconnecting simultaneously. Where such events are credible, developers should outline how the facility has been designed to minimise the amount of load that can be lost from a single failure and how demand would be restored in a controlled manner following the event.

B.2.2 Load forecast and profiles

A key aspect of the connection assessment is determining whether the proposed demand can be supplied using existing network capacity or whether network augmentation will be required. To support this assessment, developers should provide detailed forecasts of the data centre's demand and energy requirements, including proposed staging and commissioning timelines.

Understanding when demand is expected to materialise is critical. Information on whether the full load is required from the outset or will be progressively deployed over time enables Powerlink to assess the ability of the network to reliably supply the required capacity and identify any augmentation, investment, or operational measures that may be necessary to support the connection.

For each increment in the load forecast, it is also important to understand the expected daily load profile. Network planning assessments consider a range of system operating conditions that can occur throughout the day. These conditions are influenced by factors such as generator dispatch, renewable energy output and network outages. Understanding the expected demand profile enables Powerlink to assess network capability under these varying operating conditions and identify any potential constraints or connection requirements.

Where limitations are identified it is important to understand whether the load must be supplied continuously or can be managed with some level of operational flexibility.

B.3 Location matters

B.3.1 Proximity to generation

Data centres are generally advantaged when located in areas with strong access to existing and future generation resources. Connecting demand closer to generation can reduce power transfer requirements across the transmission network, helping to alleviate congestion, improve access to available network capacity, and potentially accelerate connection timeframes. This can also increase speed to market whilst reducing the need for network augmentation, lower overall system costs, and minimise the social and environmental impacts associated with additional network infrastructure.

Connection locations with strong network interconnection are also advantageous. Substations that are connected to multiple transmission pathways can provide access to a broader range of generation sources and may offer greater flexibility in meeting the connection's power requirements.

Powerlink's Transmission Annual Planning Report (TAPR), TAPR Portal, and other publicly available information sources can assist developers in identifying existing, committed, and anticipated generation developments when considering potential connection locations.

B.3.2 Network capacity and location considerations

Available transmission network capacity is not a fixed value and can be difficult to quantify using simple metrics. Network capability varies over time due to changing generation dispatch patterns, demand levels, network outages, and weather conditions. As a result, the amount of additional load that can be accommodated at a particular location can differ significantly between operating scenarios.

Detailed power system modelling provides developers with information on the capability of the network to support a proposed data centre connection and determine whether any network augmentation may be required.

To assist developers with their preliminary site selection activities, Powerlink publishes a range of planning information, including the TAPR and the TAPR Portal. Powerlink will also be providing feeder flow time-series data through the TAPR Portal, giving developers greater insight into transmission line utilisation and network loading patterns across the system.

When evaluating potential connection locations, developers should engage with experienced consultants who can provide market modelling advice on likely generation output and potential congestion over time. Locations with strong access to generation and a well-developed transmission network may offer connection advantages, while substations connected through multiple transmission feeders and supply pathways may provide greater operational flexibility and a broader range of potential connection configurations. These factors can materially influence connection feasibility, costs and the need for future network augmentation, subject to available network capacity and detailed assessment.

B.4 Connection arrangement

B.4.1 Proposed connection point

Large-scale loads will generally require a direct connection to a Powerlink substation. Connection locations that are well interconnected to the broader transmission network are often advantageous, as they can provide access to multiple supply pathways and improve supply flexibility.

As part of the early engagement process, developers should nominate their preferred connection point to enable an initial assessment of network capability and connection feasibility.

Substation configuration can also affect connection outcomes. Substations with spare bay capacity may offer a simpler and potentially faster connection pathway, while locations requiring significant substation modifications or expansion works are likely to involve additional complexity, cost, and delivery time.

B.4.2 Suitable voltage level

Selecting an appropriate connection voltage is a key consideration for large load developments. The most suitable voltage will depend on the load's size and characteristics, available network capacity, connection costs and anticipated future growth.

As a general guide, Powerlink encourages loads greater than approximately 300MW to connect to the 275kV transmission network. Loads below 300MW may be suitable for connection at 132 or 110kV. Smaller loads, particularly those below approximately 100MW, may also have opportunities to connect to the Energy Queensland distribution network. All connection options remain subject to network capability and applicable connection requirements.

Developers should consider both the initial and longer-term implications of the connection voltage. While a lower-voltage connection may reduce initial connection costs, it may also consume available capacity, bring forward network constraints or require additional transformation capacity as the load grows. A higher-voltage connection may provide greater capacity and scalability for large or expanding loads.

The preferred connection voltage should therefore provide the most efficient overall solution, balancing cost, network impacts, available capacity and future development requirements.

B.4.3 Reliability requirements

Developers should clearly communicate their reliability requirements as part of the early engagement and connection assessment process. This information assists Powerlink in determining the appropriate connection configuration and identifying any reliability or network augmentation requirements.

Unless otherwise agreed, the default transmission connection arrangement will typically be designed to satisfy N-1 reliability criteria, such that the loss of a single network element does not result in an interruption to supply.

Where a proponent is willing to accept a lower level of reliability, this should be explicitly identified during the connection process. In some circumstances, accepting a reduced reliability standard may provide additional flexibility in connection design, reduce infrastructure requirements, or improve connection timeframes. However, the appropriateness of such arrangements will be assessed on a case-by-case basis.

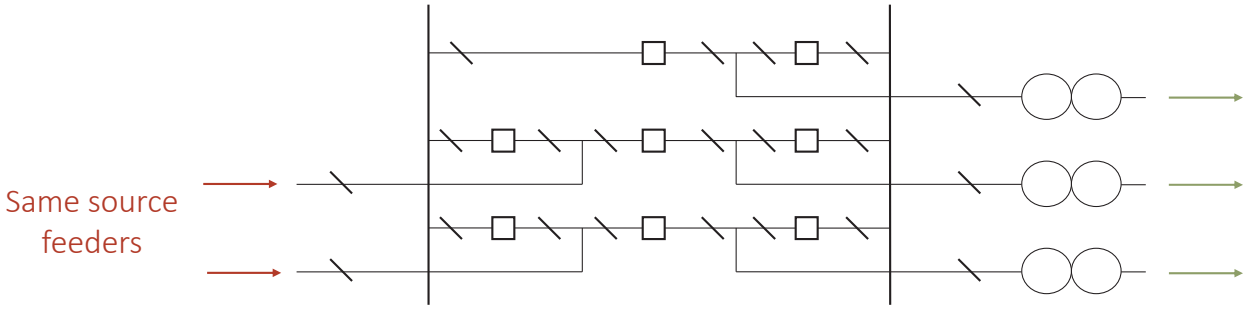
B.4.4 Number of feeders and substation diameters required for load size

Power system security considerations can influence the maximum load that can be supplied via a single feeder or connection point. Large, sudden changes in demand as a result of a credible contingency can result in significant system impacts. Therefore, the size and configuration of the connection must be assessed as part of the connection process.

As a general guide, loads in excess of approximately 500MW on a single feeder may warrant additional assessment, although the acceptable limit will depend on the characteristics of the network, local system conditions, the location of the connection and the impact on the mechanism to manage power-system security.

The design of the connection arrangement should also consider N-1 contingency conditions. Following the loss of a feeder, the remaining connection infrastructure must be capable of supplying the load without creating unacceptable power system security risks. For example, a 1,000MW data centre would generally require more than two feeders as the loss of one feeder would result in the full 1,000MW load being transferred onto the remaining feeder. This would generally be unacceptable, unless the load is flexible and contracted to reduce post-contingent to an acceptable level. As illustrated in Figure B.1, a 1,000MW load that is not flexible may require the demand to be distributed across multiple feeders and diameters. This helps ensure that, following the loss of a single feeder or other credible contingency, the remaining feeder is not required to carry load in excess of 500MW. By spreading demand across multiple supply feeders, the connection can better satisfy power system security and reliability requirements while reducing the risk of losing a large load under a single contingency.

Figure B.1 Typical 1½ CB (Breaker and a Half) bus configuration – radial supply



Connection arrangements should also consider substation reliability. To minimise the risk of a single substation busbar fault interrupting the entire load, feeders are typically expected to be supplied from separate busbar sections or diameters where practicable. This ensures that a single busbar-related contingency or circuit breaker fail event does not result in the loss of all supply to the data centre and supports compliance with reliability and security requirements.

The number of feeders and the configuration of those feeders will therefore depend on the size of the load, the required level of supply reliability, and the specific network conditions and substation arrangements at the proposed connection location.

B.4.5 Connection options

Data centre developers have several options when considering how to connect to the Queensland transmission network. The preferred option will depend on the size of the load, project timing, network capability, access to generation, and the proponent's operational requirements.

Early engagement with Powerlink is recommended to assess the viability of each connection approach. Powerlink's Network Configuration Document – Selection for New Substations – Framework, available from the Network Connections webpage, provides guidance on the preferred arrangements for new transmission-connected developments.

The document outlines the circumstances where a connection may be achieved through a cut-in to an existing transmission line versus a direct connection to an existing substation. The preferred solution is influenced by a range of factors, including the distance from existing substations, network configuration, reliability requirements, and the scale of the proposed connection.

Developers should review this framework during site selection and connection planning, as the chosen connection approach can have a significant impact on project costs, delivery timeframes, land requirements, and the extent of network infrastructure required to support the connection.

Early consideration of these factors can help identify suitable connection locations and reduce the risk of pursuing sites that may require more complex or costly network solutions.

Direct connection into substation

For large-scale data centre developments, the preferred connection option is typically a direct connection to an existing Powerlink transmission substation. This arrangement provides direct access to the transmission network and is generally best suited to large loads with long-term growth requirements.

Direct transmission connections can provide access to multiple supply pathways, support higher levels of reliability, and offer greater scalability as demand increases over time. They also enable more flexibility in connection design and can provide access to a broader range of generation sources across the transmission network.

Where suitable network capacity and substation infrastructure exist, a direct substation connection will often provide the most straightforward and robust long-term solution for large data centre developments. However, the suitability of a particular substation will depend on factors such as available network capacity, bay availability, reliability requirements, and the potential need for future network augmentation.

Cut into existing feeders

Creating a new connection by cutting into an existing transmission line and establishing a new substation is only feasible where the proposed arrangement satisfies the requirements outlined in Powerlink's Network Configuration Document. As a general principle, feeder cut-in substations (at 275kV) are typically only considered where an existing Powerlink substation is located more than 15km from the proposed connection point. This approach is consistent with the Network Configuration Framework, which seeks to balance connection efficiency, network reliability, and the long-term development of the transmission network.

The suitability of a feeder cut-in arrangement depends on a number of factors, including the distance from existing substations, network configuration, reliability requirements, and the impact of credible contingency events.

Powerlink will assess the impact of the proposed connection on network performance under both normal and contingency conditions. This includes consideration of bidirectional power flows, the transfer of power following a network outage, and the ability of the network to continue meeting reliability and security standards following the loss of a transmission line, transformer, or other network element.

Where a feeder cut-in arrangement cannot satisfy these requirements, a direct connection to an existing substation or an alternative network solution may be required.

Behind the meter

A data centre may also be co-located with a generating system or Battery Energy Storage System (BESS) and connect behind the generator's connection point. In this arrangement, some or all of the data centre's demand is supplied directly from the adjacent energy source rather than wholly through the transmission connection. Depending on the configuration, this approach may reduce the need for network infrastructure; however, it introduces additional technical, commercial, and regulatory considerations that need to be assessed. A grid forming BESS can also provide system strength further simplifying the connection analysis.

Each connection model presents different opportunities and constraints. Developers are encouraged to discuss potential connection arrangements with Powerlink during the early stages of project development to identify the most appropriate solution for their project objectives.

B.5 Connection process/timeline

Powerlink has developed services further to the Chapter 5 NER obligations to support developers to expedite suitable projects connecting to the Transmission Network.

Visit our website for further information on these processes.

B.5.1 Early engagement

Powerlink can undertake an early engagement assessment that is aimed at identifying any immediate challenges or red flags for the potential connection of a project. It is not an exhaustive assessment and is aimed at sanity checking a project's details before committing to a connection enquiry, and the associated fees.

There remains the potential for further connection challenges to be identified during the connection enquiry process, as early engagement does not cover all detailed studies that the enquiry process does. Including all information identified in Section B.2 of this document will assist in expediting and delivering the greatest value from the early engagement process.

B.5.2 Connection Enquiry

A Connection Enquiry is typically the first formal step in the Chapter 5A connection process under the NER. At this stage, it is important for developers to identify their preferred connection point to the Powerlink network, as the enquiry response will be based on the information provided in the submission.

The Connection Enquiry response provided to developers may provide information on:

- the network's ability to supply the requested load on a firm basis
- Where applicable, indicative system strength charges if system strength services are to be provided by Powerlink
- fault level information at the proposed connection location
- proposed connection arrangements and configuration options
- indicative operating and maintenance cost information associated with any required Dedicated Connection Assets, Dedicated Network Assets, or Identified User Shared Assets.

Where the network is unable to supply the full requested load on a firm basis, alternative connection arrangements may be available. In some circumstances, a staged or non-firm connection may be feasible until network augmentation can be completed. Such arrangements would typically require the customer to provide operational flexibility, including the ability to curtail load under defined network conditions or following specified contingencies.

Early identification of these requirements can assist developers in evaluating project timelines, connection costs, and the potential benefits of incorporating flexible operating capability into the data centre design.

B.5.3 Connection Application

As part of the process for establishing a new connection under Chapter 5.3 of NER, and following the submission of a Connection Enquiry, a proponent is required to lodge a Connection Application. A Connection Application is considered formally complete when it includes all information required under the NER and satisfies Australian Energy Market Operator's (AEMO) Connection Application Checklist. The typical package required from developers includes, but is not limited to:

- Customer Performance Standards (CPS) document
- Plant simulation models, model adequacy demonstration, user manuals, OEM documentation, and Releasable User Guides (RUGs)
- Benchmarking report demonstrating alignment between the submitted simulation models
- Power system study report, including sufficient supporting evidence to demonstrate compliance with each relevant CPS clause
- Single Line Diagram (SLD).

To support an efficient assessment process and minimise the time required to progress to an Offer to Connect, including completion of the Full Impact Assessment (FIA), CPS due diligence studies, and agreement of performance standards (including the issuance of the NER 5.3.4A letter), Powerlink's preferred approach is to stage the delivery of technical studies across the following three phases:

- Preliminary Design Package
- FIA Package
- Full Package.

However, the project proponent has the option to submit the Full Package as its initial submission. Alternatively, the Preliminary Design Package and FIA Package may be submitted together, should the proponent choose to do so.

Prior to commencing detailed studies, developers are strongly encouraged to engage with Powerlink and undertake sufficient high-level technical discussions to establish a common understanding of the proposed connection arrangement, study scope, modelling requirements, and assessment expectations.

B.6 Technical considerations

B.6.1 Customer Performance Standards

The NER require customer loads to comply with the performance requirements specified in Schedule 5.3 (S5.3). Under the NER, a load is classified as an Inverter-Based Load (IBL) where it is supplied through power electronic devices and may be susceptible to converter control instability.

As modern data centres typically incorporate significant power electronic equipment and inverter-based technologies, Powerlink considers it essential that their performance be assessed against the requirements of S5.3.

Accordingly, all data centre developers are required to develop, document and negotiate Customer Performance Standards (CPS) demonstrating compliance with all S5.3 clauses. The CPS and associated documentation should clearly describe the technical capability of the facility and demonstrate that the connection will not adversely impact the security, reliability or stability of the power system.

Developers should also be aware that the Australian Energy Market Commission (AEMC) is currently progressing the 'Improving the NEM Access Standards – Package 2' rule change process. The Draft Determination proposes several enhancements to the customer access standards in S5.3, including requirements relating to ride-through capability during frequency and voltage disturbances (S5.3.12 and S5.3.13), as well as instability monitoring and detection capability (S5.3.14).

Pending finalisation of the rule change process, Powerlink's current position is that data centre applicants should demonstrate compliance with the proposed draft requirements to the extent reasonably practicable, to support an efficient assessment process and minimise the risk of future redesign or remediation.

B.6.2 Inverter based load requirements

Powerlink's 'Technical Requirements for Inverter-Based Load Connections document, establishes the connection requirements applicable to IBLs, including data centre facilities. Applicants should refer to the latest version of the document when developing their connection application and supporting studies. The guideline provides additional detail on applicable technical requirements, performance standard expectations, modelling and simulation requirements, and the evidence required to demonstrate compliance with the NER and Powerlink's connection requirements.

B.6.3 System strength

Under the current system strength framework, IBLs are required to either provide a self-remediation solution to manage their system strength impact or elect to pay system strength charges to the relevant System Strength Service Provider (SSSP). During the Connection Enquiry stage, Powerlink will provide developers with information on the applicable system strength node, system strength locational factor and prevailing system strength unit price.

The framework requires technical assessments to evaluate the impact of the proposed connection on power system stability and system strength. Depending on the chosen compliance pathway, this may involve a Full Impact Assessment (FIA) in accordance with NER Clause 5.3.4B and the applicable System Strength Impact Assessment Guidelines, or a Stability Assessment. Both assessment types require detailed wide-area Power Systems Computer Aided Design (PSCAD) studies using an accurate PSCAD model of the proposed facility. Where an applicant elects to pay system strength charges, a Stability Assessment remains necessary to demonstrate that the facility can operate satisfactorily and maintain stable performance under the expected system conditions.

B.7 Operational considerations

B.7.1 Flexible vs Firm and associated benefits

Data centres that can provide demand flexibility by reducing or shifting load during periods of network congestion or system stress can deliver benefits to both the power system and the project. Flexible load capability can help defer or avoid network augmentation, improve utilisation of existing network infrastructure and potentially reduce the overall costs associated with supplying large loads.

For developers, demand flexibility may create opportunities to access connection arrangements that would otherwise require significant network investment or result in longer delivery timeframes. For the broader power system, flexibility can reduce the need for network augmentation and help minimise the costs that are ultimately recovered from all consumers through network charges.

Powerlink is currently developing a Flexible Load Framework aimed at recognising and valuing load flexibility which can reliably support network operations including helping to manage network congestion and improving overall network utilisation. The objective is to support more efficient use of existing infrastructure, reduce the need for augmentation, and place downward pressure on long-term electricity costs.

In parallel, policy and regulatory reforms are being considered across the NEM that may alter how augmentation costs are allocated to large transmission-connected loads. These reforms include consideration of mechanisms that would increase the extent to which developers fund the network investments required to support their connections, rather than recovering these costs from all network users.

Where the existing network cannot supply the full requested load on a firm basis, Powerlink may determine the maximum firm capacity available and assess whether additional load could be accommodated through a non-firm connection arrangement.

This approach may enable a project to proceed earlier than would otherwise be possible, with the non-firm component transitioning to firm supply once the required network augmentation is commissioned. Any such arrangement would need to clearly define the operating conditions under which load curtailment may be required, together with the associated risks, obligations, and performance requirements.

Data centre developers are encouraged to consider demand flexibility during the initial design phase of their projects. As network conditions, load forecasts, and connection requirements evolve over time, the ability to modulate demand may provide significant benefits to both the proponent and the broader power system.

The capability to reduce, shift, or temporarily curtail demand during periods of peak network utilisation or under defined operating conditions, may improve connection outcomes and reduce the need for network augmentation. This may become increasingly important where future regulatory frameworks may require large loads to bear a greater share of the costs associated with network investments needed to support their connection.

Developers that incorporate flexibility into their operational design from the outset may be better positioned to take advantage of these evolving frameworks while supporting more efficient development of the electricity system and potentially reducing overall connection and network-related costs.

B.7.2 Ramp rates

Developers should provide information on the expected ramp rates of the data centre, including how quickly demand may increase or decrease during normal operations and under foreseeable operating scenarios.

While data centres are often considered continuous loads, demand can vary over time depending on workload scheduling, commissioning activities, AI training cycles, cooling requirements, and operational practices. Understanding these characteristics assists Powerlink and AEMO in assessing the impact of the load on both the transmission network and the broader power system.

Large and rapid changes in demand can influence network loading, power system operation, generation dispatch, and market outcomes. As a result, developers may be requested to provide information on maximum expected ramp rates, load step changes, commissioning schedules, and the operational flexibility of the facility.

Data centres that can manage or limit demand ramp rates, either through operational controls or battery energy storage systems, may be better positioned to support efficient network and system operation while reducing potential impacts on other network users. It should be noted that regulatory requirements relating to load ramp rates are currently under consideration for inclusion in the NER.

B.8 Annual forecast updates

Under the NER, all transmission-connected customers are required to provide Powerlink with an updated 10-year demand and energy forecast each year. Powerlink will typically issue a formal request during the first quarter of each year seeking the latest forecast outlook. However, customers are encouraged to advise Powerlink of any material changes to their demand forecasts as soon as they become known, rather than waiting for the annual forecasting cycle.

Early engagement with Powerlink is particularly important where significant increases in demand are being considered. Capacity is not reserved on the transmission network and is continually reassessed based on the latest demand forecasts, network utilisation, and connection activity. Consequently, historic demand levels and demonstrated utilisation of existing capacity may influence future network planning assessments.

Where new network infrastructure is required, delivery timeframes can be substantial. Easement investigations, planning approvals, land acquisition, environmental assessments, procurement activities, and construction works can result in augmentation lead times of five years or more, depending on the scale and complexity of the project.

For this reason, developers are encouraged to provide timely updates on forecast demand growth and to consider opportunities to stage or flex demand where practical. Accurate forecasts and realistic deployment schedules are critical inputs to network planning, helping ensure that network investments are only progressed where there is a genuine and demonstrated need for additional capacity. This supports more efficient outcomes for both developers and electricity consumers while reducing the risk of project delays associated with network augmentation.

B.9 How to improve speed to market

B.9.1 Engage with Powerlink early

Project developers intending to connect to Powerlink's transmission network are encouraged to engage experienced power system consultants and commence discussions with Powerlink as early as possible. Early engagement can help identify suitable connection options, understand network and regulatory requirements, and highlight potential constraints before significant project commitments are made. This can improve the efficiency of the connection process and reduce the risk of avoidable delays later in project development. Initial contact with Powerlink can be made via the Powerlink Queensland **website**. A prospective project developer can leave brief information and contact details. A member of the Market Development team will respond to the enquiry. An initial conversation will take place to better understand the development aspirations and to outline expectations on progressing the project along the connection pathway.

If it is deemed the project may be viable to progress through the connection process, and the project developer wishes to seek further clarity or information, an Early Engagement Assessment may be recommended.

Further detail on this process is outlined via the Powerlink Queensland website.

B.9.2 Early and ongoing community engagement

Best-practice community engagement should be embedded throughout data centre project development and assessment to understand local priorities, identify and address potential social impacts, and build and maintain social licence in host communities. This is particularly important given large facilities require significant land, electricity, water and supporting infrastructure, and may create construction, traffic and noise impacts for surrounding communities. Experience demonstrates that early, transparent and ongoing engagement is critical to building trust, managing concerns and ensuring communities can meaningfully inform project planning and share in long-term benefits.

B.9.3 Prioritise connection pathways that support network and social licence outcomes

While speed to market is often a key project objective, experience has shown that the fastest connection outcomes are typically achieved through disciplined project selection and robust early planning. Connection pathways that are technically credible, minimise community and landholder impacts, enable efficient shared network investment, and avoid unnecessarily complex or bespoke arrangements are generally more straightforward to assess and deliver.

Projects that align with these principles have historically progressed through the connection process more efficiently and with lower overall project risk.