



Customer Guidelines for Sub-transmission Connected Embedded Generation

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Revision History

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Glossary of Terms

Regulatory Terms

Term	Description
AEMO	Australian Energy Market Operator
DNSP	The owner and operator of the electricity distribution network (grid) to which the customer is connected. The retailer's energy must be delivered to the customer via the DNSP's poles and wires (network); the DNSP charges for this service. Sometimes referred to as a Distribution Network Service Provider (DNSP).
Embedded Generator	An entity which owns and operates generating units, which are connected within the distribution network and do not have direct access to the transmission network.
ESC	Essential Services Commission.
LNSP	Local Network Service Provider
Market Generator	A Generator which sells all of its sent-out electricity on the national spot market and accepts payments from AEMO.
NER	National Electricity Rules
Network Service Provider	NSP is the owner and operator of a transmission network or a distribution network.
Non-Market Generator	A Generator which sells all electricity under contract to a retailer, or to a customer at the same connection point.
NSP	Network Service Provider.
Point of Connection	The point on a distribution feeder at which an embedded generator is connected to the DNSP's network.
Retailer	The seller of electrical energy (as a market commodity) to customers otherwise than through the wholesale electricity market. Sells energy to any customer independent of location.

Technical Terms

Term	Description
Active Power	The component of an AC electric current which is converted to mechanical power or to heat.
Demand	The power consumed by a customer at any point in time; normally measured by integrating kilowatt hours of energy consumed over a period 15 or 30 minutes, and expressed as an average in kilowatts. May sometimes be defined, measured and expressed in kilovolt-amperes.
Distribution Feeder	An electric line and associated equipment operating at a voltage of 6.6kV, 11kV or 22kV, which a DNSP uses to distribute electricity.
Distribution Network	A network which is not a transmission network.
Distribution System	A distribution network, together with the connection assets associated with the distribution network, which is connected to another transmission or distribution system. Connection assets on their own do not constitute a distribution system.
Fault Level	The maximum electrical current, usually expressed in thousands of amperes (kA), which can flow at a point in the supply network if one phase of the supply is short-circuited to earth or to one or more of the other phases.
Power Factor	A measure of the relative proportions of active power and reactive power in an AC load current; if p.f. = 1, all current is used in producing heat or mechanical power; if p.f. = 0, then all is used in maintaining magnetic or electric fields.
Quality of Supply	(At a point of supply to a customer): The degree to which the voltage of the electricity supply departs from a pure 3-phase sinusoidal waveform of constant magnitude and frequency.
Reliability of Supply	(To a customer) The extent to which power supply is available without interruption or curtailment over a long period of time. Usually quantified as availability (no. hours available/total no. hours).
Sub-Transmission	The Sub-transmission in Powercor is the 66kV network. In CitiPower the Sub-transmission can be either 66kV or in some instances 22kV.
VEDC	Victorian Electricity Distribution Code.
Zone Substation	The origin of distribution feeders at 6.6, 11 or 22 kV; contains transformers which reduce voltage from sub-transmission level (usually 66kV) to distribution level (6.6, 11 or 22 kV).

1. Introduction and Purpose

These guidelines are intended to cover the installation of generating sources typically greater than ten megawatt (10 MW) which existing or new customers wish to connect to the CitiPower/Powercor sub-transmission (nominally 66kV) system that is part of the CitiPower/Powercor distribution system network.

The guideline also describes:

- the connection process
- the information required to be provided by the customer,
- the technical requirements and information
- the technical assessments required to be provided by the customer and CitiPower / Powercor
- the role of all parties including external parties

2. The Power Network

As a guide, a generating plant of capacity in excess of 10 megawatt cannot be connected to the high voltage distribution system, and must be connected to the 66 kV sub-transmission system.

This limit is indicative only, being dependent on the location, the nature of other loads on the relevant network section, and other local factors. It is sometimes necessary for CitiPower/Powercor to upgrade local networks to and/or modify the operational regime of the network to accommodate a generating plant whilst maintaining the required quality of supply to other customers.

Refer to The CitiPower/Powercor website for further information about the distribution network.

www.powercor.com.au

The connection process will identify the extent of network extension and augmentation that is required to facilitate a generator connection.

3. Connection Process

Customers seeking to install an embedded generation plant must apply in writing to CitiPower/Powercor's Manager Network Customer Projects.

3.1. Connection Enquiry

A preliminary Connection Enquiry must be made before an "Application to Connect". The preliminary enquiry must include the type, magnitude and timing of the proposed connection.

The following information is to be provided with a preliminary enquiry. Information to be in accordance with NER Schedule 5.4.

- Type of plant – (e.g. Gas turbine generating unit; wind turbine etc.)
- Preferred site location – (listing any alternatives in order of preference as well).
- Maximum power generation or demand of whole plant (maximum MW and/or MVA, or average over 15 minutes or similar).
- Expected energy production or consumption (MWh per month).
- Plant type and configuration – (e.g. Number and type of generating units)
- Nature of any disturbing load (size of disturbing component MW/MVAr, duty cycle, nature of power electronic plant which may produce harmonic distortion).
- Technology of proposed generating unit (e.g. Synchronous generating unit, induction generator, photovoltaic array etc.).
- When plant is to be in service – (e.g. Estimated date for each generating unit).
- Name and address of enquirer, and, if relevant, of the party for whom the enquirer is acting.
- Single Line Diagram.
- Site Layout Plan including intended location for point of connection to the Network.

3.2. Connection Enquiry Feasibility Study

CitiPower/Powercor will require the customer to complete a feasibility study including a preliminary load flow study that details:

- Load flow outputs showing voltage profiles at the connection site and adjacent zone substations as well as line loadings.

- Voltage fluctuation studies showing the impact at CitiPower/Powercor's adjacent zone substation HV & LV buses for the loss of full generation only and the loss of full generation with the loss of the connecting feeder.
- Fault level contribution of the generator at full generation showing fault level increases at adjacent zone substations.

CitiPower/Powercor will provide the basic network information needed to facilitate the customer's feasibility study.

A formal review of the studies will be completed by CitiPower/Powercor at cost to the customer. This review will provide comments on the studies, and will allow for a high level functional scope of the works required for the connection to be achieved.

Based on the geographic location and size of the connection, the enquiry may be better responded to by another LNSP or require another LNSP input for response. The customer may, notwithstanding this advice and if reasonable, request that CitiPower/Powercor process the connection enquiry.

Within 2 weeks of the initial request CitiPower/Powercor will advise who else should be advised in the planning process, who else should be paid for distribution or transmission services and whether a separate agreement is required, what works are contestable and provide a preliminary works program for the project.

Within 4 weeks of the initial request CitiPower/Powercor will provide advice on the Access Standards required for connection and details of AEMO involvement in Access Standards development. CitiPower/Powercor will also provide written advice on further information the Applicant must prepare to allow for proper assessment of the application including technical data, relevant commercial information, project fees and third party costs.

3.3. Connection Application

An application to connect must include:

- All technical (including models) and commercial information required by CitiPower/Powercor.
- Payment of the required application fee (including AEMO fees).
- Proposed negotiated Access Standards must be submitted with the application with supporting evidence.

CitiPower/Powercor, the customer and AEMO must agree on the access standards applicable for the Application to Connect. Access Standards are developed with input from CitiPower/Powercor, the turbine manufacturer and the customer.

Modeling completed by the customer will be reviewed by CitiPower/Powercor to ensure the studies demonstrate the proposed connection is feasible, as a pre-condition to works commencing to develop Access Standards. CitiPower/Powercor's review will be undertaken at the customer's cost and will require the provision of specific technical data and a public domain model of the generator.

The commencement of works to develop Access Standards constitutes the end of the preliminary enquiry process and the start of the formal application process. Once Access Standards are agreed a Connection Agreement can be prepared.

3.4. Offer to Connect

In order to provide an Offer to Connect CitiPower/Powercor will need to complete line route assessments, preliminary design works, survey works, environmental impact assessments, easement negotiations and project management activities. The timeframe for this work is project dependant. The cost and timeframe for this work is advised prior to the Connection Application being submitted.

CitiPower/Powercor's Connection Agreement consists of an Augmentation Agreement and Export Agreement. These are separate documents and both require execution to complete offer acceptance. The Augmentation Agreement covers the costs and commercial arrangements for the Connection Works. The Export Agreement covers the technical and commercial conditions of the export of electricity into CitiPower/Powercor's Network.

3.5. Implementation Plan

Before making an offer to provide connection services to an intending Embedded Generator, CitiPower/Powercor will request a copy of a suitable implementation plan giving the following information:

- Listing of activities to be undertaken by the Embedded Generator and by others in planning, designing, procurement, construction and commissioning of the plant.
- A schedule of target dates for those activities.

3.6. Commissioning Plan

A detailed Schedule of proposed pre-commissioning tests and commissioning procedures will be required by CitiPower/Powercor from the customer for review prior to the commencement of pre-commissioning tests.

3.7. Operating Plan

An Operating Plan will be required by CitiPower/Powercor for review, and must include a detailed description of proposed operating procedures (for both normal operation and in emergencies) for all equipment and plant, together with details of the proposed operating staff including their contact details. This is required prior to the construction and commissioning phase, and is to address the ongoing in service operation of the plant.

3.8. System Model

The customer has to provide a public domain dynamic system model representing the generation installation in PSSE format. This model will be used for future generation connection system studies where there is a requirement to study the impact of other existing generation.

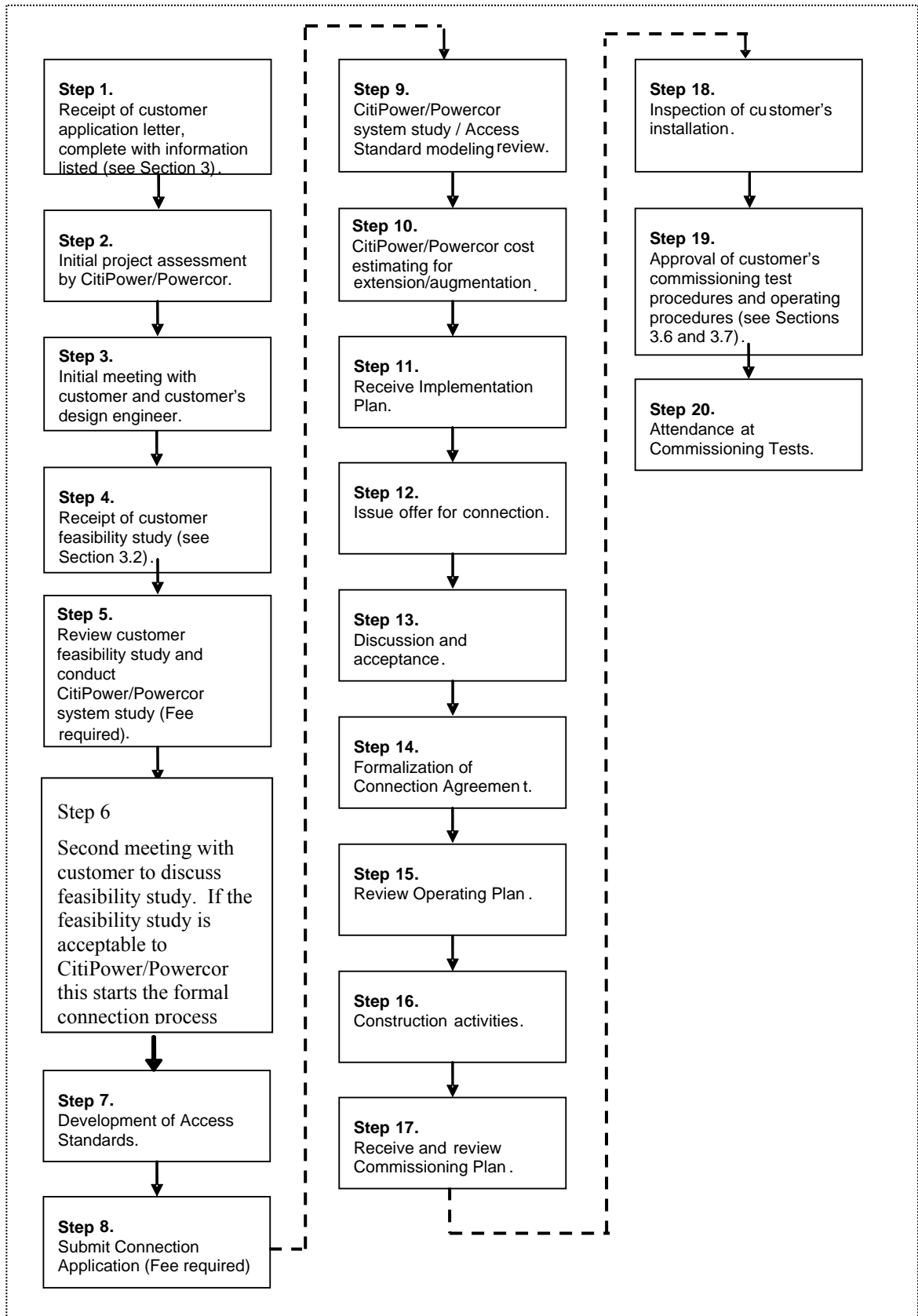
Should the generation installation be modified, then the revised public domain dynamic generation system model shall be provided to CitiPower/Powercor.

3.9. Distribution Loss Factor

For large generators with an output greater than 10MW the National Electricity Rules require site-specific DLFs to be calculated by the distribution company. The site-specific DLF is specially calculated for the particular distribution connection point.

For a site-specific DLF to be calculated for an embedded generator, the proponent needs to provide CitiPower/Powercor with the expected annual generation duration curve and expected annual generation volume.

3.10. The connection process followed by CitiPower/Powercor is described by the flowchart below.



4. Technical Requirements for Connection of Embedded Generation

The technical requirements have been written to provide the generator with details that have to be considered and addressed in the determination of any connection.

Technical requirements surrounding the connection of generation to a network are essential and must be addressed to ensure the overall integrity of the network, its impact on public health and safety, existing customers, the network assets and any future connection or network configuration.

4.1. Asset Interface Labeling

Where the generation is connected permanently and synchronised to the network the asset interface must be clearly labeled and defined for ownership and responsibility at the point of connection.

4.2. Quality of Supply

The Victorian Electricity Distribution Code (VEDC) requires electricity DNSPs to maintain the quality of electricity supply to its customers in respect of:

- Steady state voltage
- Voltage fluctuations
- Harmonic voltages
- Voltage unbalance

In turn, customers are required by the same Code to control:

- The power factor of their generation.
- The harmonic currents generated by their generators.
- The load balance between phases.
- The magnitude and rate of occurrence of generation fluctuations (which cause corresponding voltage fluctuations to be imposed on other customers).

The regulatory limits applicable to each of the above quality indicators may be found in the Victorian Electricity Distribution Code, which can be viewed on the website of the Essential Services Commission at www.esc.vic.gov.au.

CitiPower/Powercor will nominate the quality of supply parameters the customer must comply with. In setting the parameters, CitiPower/Powercor will consider the requirements of the VEDC and NER.

4.3. Reliability of Supply

In connecting onto the network the level of reliability should be taken into account. In general the highest level of reliability exists in built-up areas where intermeshed sub-transmission systems exist. In rural areas the level of reliability may be significantly affected by long radial sub-transmission systems. In such areas the network is predominantly of bare overhead conductors subject to many external influences.

4.4. Operation of Generators and the effect on network and customers

For large generation it is expected that the generation will ride through transmission, sub-transmission and distribution faults as specified in the NER.

The stability performance of the generator shall be such as not to impact adversely on existing CitiPower/Powercor customers. Stability studies are required to confirm this.

The individual machine model will need to be proven to match the machine specification and designated response.

4.5. Fault Levels

As per the VEDC an embedded generator must design and operate its embedded generating unit so that it does not cause fault levels in the distribution system to exceed the levels specified in Table 1 below.

Voltage Level kV	System Fault Level MVA	Short Circuit Level kA
66	2500	21.9
22	500	13.1

11	350	18.4
6.6	250	21.9
<1	36	50.0

Table 1 - VEDC Fault Level limits

CitiPower/Powercor shall nominate the amount of short circuit fault current the customer's generator is permitted to contribute. In setting the limit CitiPower/Powercor will consider the requirements of the VEDC fault level limitations. The calculation of short circuit currents will be in accordance with the latest version of Australian Standard AS 3851

4.6. Connection Configuration

The following are examples of acceptable minimum connection configurations.

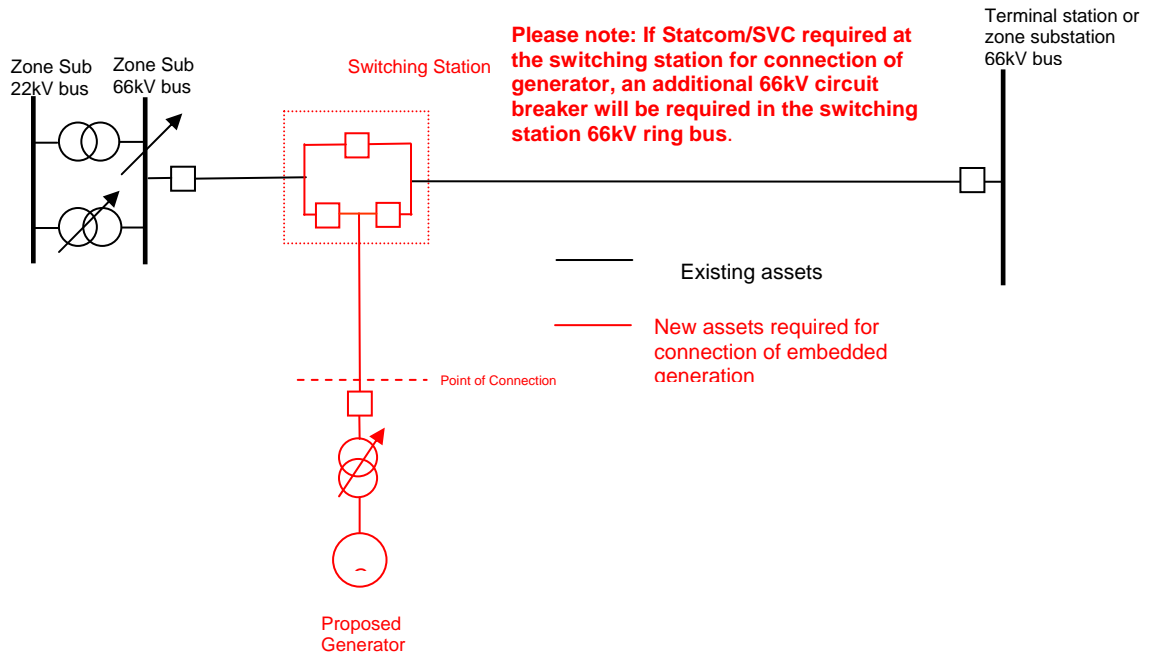


Figure 1 - Minimum requirement for "tee off" connection on 66kV line

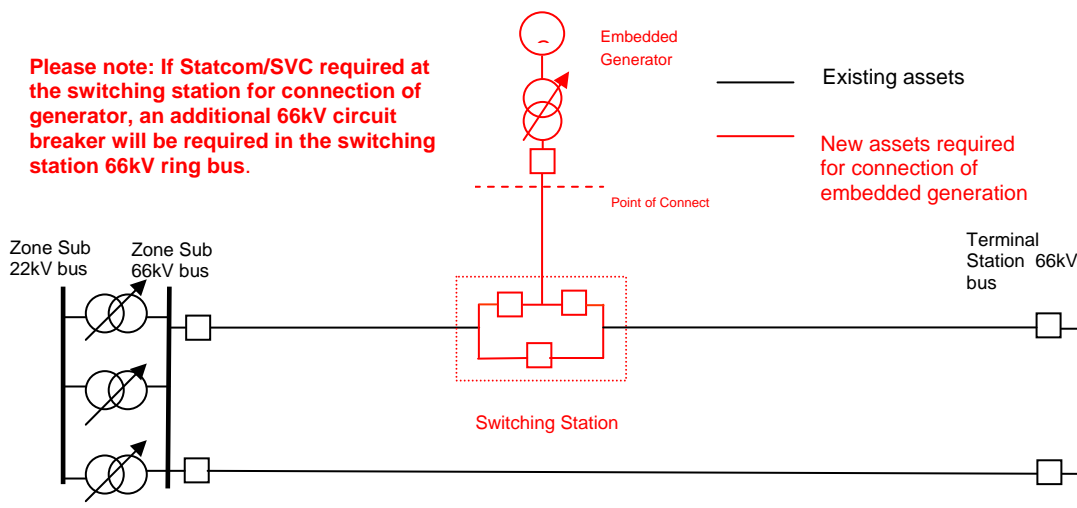


Figure 2 - Minimum requirement for connection in 66kV loop arrangement

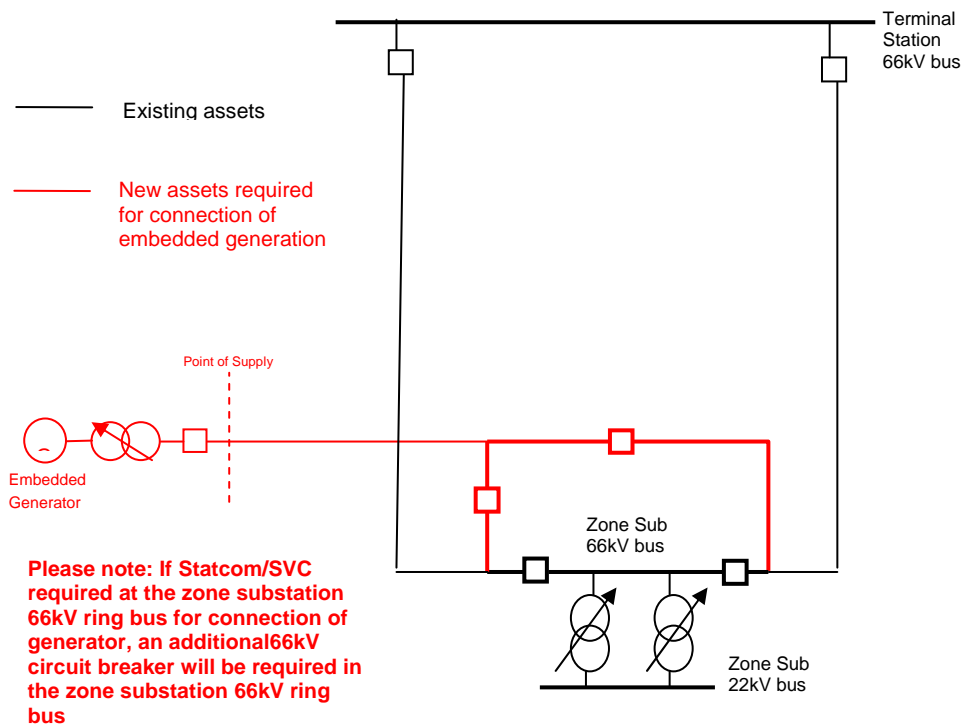


Figure 3 - Minimum requirement for direct connection into Zone Substation

4.7. CitiPower/Powercor Existing 66 kV Sub-transmission Network Augmentation

The impact of embedded generation on the CitiPower/Powercor 66 kV sub-transmission lines depending on the connection configuration may require augmentation of existing lines if the thermal capacities are exceeded. This augmentation include inter-poling, uprating the line by lifting the conductor or re-conductoring the line which involves replacing the existing conductor with a larger conductor. The customer will incur any line augmentation costs caused by the connection of any embedded generator.

4.8. CitiPower/Powercor 66 kV Line for Sub-transmission Connection

The CitiPower/Powercor standard 66 kV line construction for rural customer connections uses 19/4.75 AAC bare conductors on wood poles and is rated at 1060 amps (summer) and 1110 amps (winter), while for urban customer connections the construction standard uses 37/3.75 AAC bare conductors on wood poles and is rated at 1200 amps (summer) and 1255 amps (winter).

The CitiPower/Powercor 66 kV line construction standard for all new lines includes the installation of a single fiber optic cable subsidiary to the line.

4.9. CitiPower/Powercor Zone Substation Augmentation

The impact of embedded generation on the CitiPower/Powercor zone substations depending on the connection configuration may require augmentation of zone substation assets if thermal capacities are exceeded. These assets may include circuit breakers, bus conductor, switches, isolators, current transformers, etc. If the embedded generator 66 kV line is directly connected into a zone substation (see Figure 3), zone substation augmentation will include the building of new 66 kV bus work to

form a ring bus and the addition of 66 kV circuit breakers in the ring bus. The customer will incur any zone substation augmentation costs caused by the connection of any embedded generator.

4.10. Auto Reclose

The CitiPower/Powercor system standard is for single shot auto reclose on all sub-transmission lines. For sub-transmission lines the source line end will auto reclose first while the remote line end will auto reclose after a further time delay provided that no auto reclose block signal is present via 'Dead Line Blocking'. (Dead line blocking means the remote CB will only auto reclose if the line becomes alive from source end.) Generator manual or automatic restart facilities following a fault and system separation must make allowance for auto reclose operations.

The customer shall ensure that an auto reclose block signal is generated after a 66 kV Line trip, (loss of 66 kV CitiPower/Powercor system connection), unless all of the following conditions are satisfied:

- All Generator LV CBs are open, **and**
- Voltage support STATCOM is disconnected (if installed), **and**
- Any voltage & power factor control capacitors on the customers distribution (LT) bus are disconnected (if installed), **and**
- No voltage is present on the customer's distribution (LT) bus.

All these conditions **must** be met to ensure that CitiPower/Powercor do not initiate a close of the 66 kV incoming CB, whilst one or more of the customers generators is capable of being connected to the system or when voltage support plant items are connected to the customers sub station.

This Auto Reclose Block signal will be in the form of a voltage free normally open contact available at the secondary interface.

4.11. Synchronisation

The CitiPower/Powercor system standard is for **no** synchronism check facilities associated with auto reclose on distribution lines. All embedded generation synchronism requirements **shall** be provided within the customer's generation installation.

The customer's synchronism check can be either automatic or manual, although the CitiPower/Powercor preference is for automatic synchronism check.

An out-of-synchronism reconnection can result in:

- Damage to the generator windings, shaft, couplings and prime mover.
- Damage to other synchronous plant in the region.
- Mal-operation of protective relays on other utility feeders.

It is therefore essential to prove during commissioning that, for all normal conditions of preloading, disconnection of the customer substation from the CitiPower/Powercor network due to a fault results in automatic disconnection of the generator/s in a time which is safely less than the auto reclose delay time.

4.12. Islanding

Islanding of an embedded generator occurs when a protection or control operation separates the embedded generator connection from the general body of the network and leaves it to supply the local (islanded) load.

An automatic operation elsewhere on the CitiPower/Powercor system that could result in the generating station being islanded to CitiPower/Powercor customers (load) may require initiation of a remote trip of the customers incoming 66 kV CB via the protection signaling communication scheme to prevent islanding occurring.

The customers embedded generation substation protection, generator protection and/or inherent generator design and control system philosophy shall ensure that under all reasonable circumstances, should the customers substation separate from part of the CitiPower/Powercor network, the generator CB's or the incoming 66 kV CB shall trip ensuring that the embedded generation cannot be islanded to the CitiPower/Powercor load.

The customer's generator/s may continue to supply the customer's own load down stream of the network connection point, but must not continue to supply any CitiPower/Powercor customers.

4.13. Communications

4.13.1. General

There are four (4) different communication paths required into the customer substation:

- A protection signaling path between the CitiPower/Powercor zone substation or switching station and the customer substation for current differential protection and protection/control remote signaling.
- A SCADA signaling path between the CitiPower/Powercor control room master station and the customer substation for remote control and monitoring via the CitiPower/Powercor RTU.
- A power quality metering communication facility that may also go via the fiber optic cable to the CitiPower/Powercor zone substation or switching station and then via Next G modem to the CitiPower/Powercor network metering hub.
- A telephonic communications by Telstra line, 3G modem or other as required.

Generally the protection signaling and SCADA signaling will be via the fiber optic cable, subsidiary to the new 66 kV line, to the CitiPower/Powercor zone substation or switching station. The SCADA signaling will then be via point-to-point radio or other communication channels to the master station.

For some network connection locations protection signaling paths, SCADA signaling paths or power quality metering signaling paths may be available via existing CitiPower/Powercor communication networks.

The failure of the protection signaling system may necessitate different actions depending on the actual network connection configuration.

Possible actions that may be required are:

- a trip of the incoming 66 kV CB,
- a reduction in the level of generation,
- a blocking of the 66 kV line auto reclose function,
- a block of the closing of customer's CB's that are used for generator synchronisation.

CitiPower/Powercor Communications Services will provide real time monitoring to AEMO of the site in accordance with the NER.

4.13.2. Radio

Depending on local geographic or signal strength conditions the point-to-point radio for SCADA communications or the Next G modem for power quality metering may have to be installed at the customer's substation rather than at the CitiPower/Powercor zone substation or switching station. This may require the installation of a pole or other mast assembly to support the radio antenna.

4.13.3. Fiber Optic Cable

For the CitiPower/Powercor fiber optic cable the customer is required to run a suitable conduit from the customer substation boundary fence to a nominated location on the control room where CitiPower/Powercor will install a small wall mounted fiber optic termination box.

4.13.4. Telstra Next G Network Access

At some location CitiPower/Powercor will be accessing the Telstra Next G Network for downloading the CitiPower/Powercor Power Quality Meter. This will require the installation of a small antenna on the outside of the control room and the running of a communications cable between the CitiPower/Powercor cubicles and this antenna. This work will be carried out by CitiPower/Powercor in consultation with the customer.

4.13.5. Telephone Line Isolation

If copper based telecommunications circuits are required at the customer substation, the customer will need to provide the required high voltage isolation for copper based telecommunications circuits entering the substation and it is expected that the customer will have to install an appropriate Telecom Entry Point (TEP) box, Telecom Services Interface Unit (TSIU) and a HV communications cable between the two. The TSIU will need to be appropriately equipped with the necessary isolation devices for the services entering the substation.

It should be noted that isolation equipment in the TSIU for Public Switched Telephone Network (PSTN) dial up lines requires either a 24V or 48V DC supply.

CitiPower/Powercor do not require any Telstra Communications service at the customer substation except access to a standard landline telephone if available for operational and maintenance testing voice communications.

4.13.6. AEMO Metering Communications

AEMO have requirements for possibly three (3) different types of metering data associated with embedded generators.

The need and level of information depends on the Access Standard applicable, level of generation and is negotiated between the wind farm proponent and AEMO.

Under the National Electricity Rules CitiPower/Powercor are responsible for providing the communication system to provide AEMO with this data.

The types of data that are/may be required are;

1. Revenue Metering (Energy) Data – Can include MWatts, Mvars, Volts, Amps.
2. Real Time SCADA operational system data.

3. Additional weather and system data. – Ambient Temperature, Wind Speed, Wind Direction.

CitiPower/Powercor have a strong preference for these three types of data to be supplied via a fiber optic communication link from the customer to the CitiPower/Powercor communications infrastructure for networking back to the AEMO connection point for monitoring the data.

It is also preferred that the data from the customer is in DNP3.0 Protocol format.

The actual method of providing the communication path may vary depending on a number of factors and will be negotiated between CitiPower/Powercor and AEMO.

4.14. CitiPower/Powercor Network Protection

4.14.1. Existing CitiPower/Powercor Network Protection

A variety of different types of protection schemes may exist on the CitiPower/Powercor distribution network adjacent to the connection point for the customer's substation. The ability to augment this protection may depend on a number of factors including existing communication infrastructure and geographic location.

4.14.2. CitiPower/Powercor Connection to Customer Substation

For all 66 kV sub-transmission line connections to a customer substation with embedded generation, either from a zone substation or from a switching station, duplicate current differential protection with inbuilt back-up distance protection is the current standard line protection. These schemes incorporate sensitive directional earth fault, bidirectional remote trip facilities, current check based CB failure protection and auto reclose.

The current differential schemes operate over the single CitiPower/Powercor fiber optic cable that runs subsidiary to the new 66 kV line. In the event of failure of this single fiber optic cable, the line will still be adequately protected by the inbuilt duplicate back-up distance protection.

Additional bidirectional remote trip facilities are provided via independent equipment if required.

In some network connection locations protection signaling paths may be available via the existing CitiPower/Powercor fiber optic network.

4.14.3. Adjacent Existing CitiPower/Powercor Zone Substations

Augmentation of existing protection schemes may be required dependent on the functionality of the existing protection schemes, the network configuration and the proposed network connection arrangement.

These augmentations could involve replacement of existing line protection, duplication of line protection, zone acceleration schemes, (if required for fault clearance times), duplication of sub-transmission bus protection or addition of CB failure protection.

Additionally 66 kV line overload and/or line overvoltage protection may be required.

In some instances the following may be required; additional CT cores, additional line VT's, control room extensions or in extreme cases a new control room.

As a minimum a protection setting review will be required at adjacent stations.

4.14.4. Adjacent Existing SPAusNet Terminal Stations

Augmentation of existing protection schemes may be required dependent on the functionality of the existing protection schemes and network configuration and the proposed connection arrangement.

These augmentations could involve replacement of existing line protection or zone acceleration schemes (if required for fault clearance times).

As a minimum a protection setting review will be required at adjacent stations.

4.14.5. Fault Clearing Times

Reduced fault clearing times can be achieved on sections of the CitiPower/Powercor sub-transmission system by the application of zone acceleration. Such acceleration schemes require station-to-station communication systems that may not currently exist or may be inadequate. Any upgrade of these communication schemes to provide acceleration would be at the customers cost. (For example: Digital point-to-point radio + teleprotection signaling equipment.)

4.15. Customer Substation

The customer substation requirements will depend upon the type of network connection. Substations must be designed by an experienced electrical power engineer and the following drawings forwarded to CitiPower/Powercor for approval:

- The station layout and earthing arrangements.
- Control room layout detailing all cubicle and wall mounted equipment positions.
- A single line protection diagram.
- Schematic diagrams of protection and control schemes.
- Details of primary and secondary interfaces to the network.

Every customer substation which interfaces an embedded generating plant with CitiPower/Powercor's network must include:

- An incoming circuit breaker, together with the associated protection systems detailed in Section 4.15.
- A mechanically interlocked line disconnect switch and earthing switch combination is to be provided for on the CitiPower/Powercor network side of the incoming circuit breaker. The earth switch shall be on the line side of the isolating switch and the interlocking shall prevent both switches being closed at the same time.

All work must conform to the appropriate Australian Standards. The customer is responsible for arranging all planning and building permits.

For a 66 kV point of connection, CitiPower/Powercor has additional specific requirements for the Customer's substation regarding:

- Building space provision for CitiPower/Powercor protection and control equipment cubicles and wallboxes.
- Personnel access to switchyard and control building.

- Signage, nameplates and labels.

4.16. Embedded Generation Transformer Connection Requirements

The generation station transformer/s must be connected to the CitiPower/Powercor distribution network via an unearthed winding to prevent the generating station being a source of earth fault current. (i.e. There must be no zero sequence source.)

4.17. CitiPower/Powercor Primary Plant Requirements in Customer Substation

The customers incoming 66 kV CB shall be fitted with at least two (2) electrically independent trip coils. Access to both these trip coils is required by CitiPower/Powercor to facilitate independent tripping of this CB from the duplicate 66 kV Line protection. (X & Y).

The customer shall make available to CitiPower/Powercor:

- Two off three phase sets of protection class CT's for CitiPower/Powercor protection application,
- One off three phase set of metering class CT's for CitiPower/Powercor metering application.

The standard CitiPower/Powercor protection CT ratios and performance required are as follows:

- Urban network customer connection
1600/1200/900/5 0.2PX100 R=0.15 ohm on 300/5
- Rural network customer connection
900/500/300/5 0.35PX100 R=0.15 ohm on 300/5

These CT cores shall be installed on the customer's transformer side of the customer's transformer protection CT's such that the CitiPower/Powercor and the customer's protection zones overlap.

The minimum requirement for CitiPower/Powercor metering CT ratios and performance are as follows:

- 800/600/5 30 VA Class 0.5M on 200/5

Note that the Retailer's Tariff metering provider will require access to an additional dedicated tariff metering set of CT's of the appropriate class and a dedicated tariff metering VT winding of the appropriate class. (Refer to Section on Tariff Metering.)

The customer shall also make available to CitiPower/Powercor one off three phase set of 66 kV voltages from protection class VT's for CitiPower/Powercor protection and metering applications.

CitiPower/Powercor requires the VT ratio to be $66,000/\sqrt{3}$ to $110/\sqrt{3}$ and performance to be at least 0.5M1P. A Rated Voltage Factor of 1.9 for 30 seconds is required.

The VT's that this supply is derived from must be mounted on the 66 kV line side of the customers incoming CB.

All protection and metering CT and VT connections shall be made available at the designated secondary interface.

Details of the customer's main transformer/s and installation shall be provided to CitiPower/Powercor as soon as known and shall include at least the following details:

- Vector group.
- Impedance.
- Tapping range and tap percentage.
- Cable/overhead line impedance between transformer and associated LT transformer CB. (Not required if both transformer and CB are located in the customer substation switchyard.)

If a Neutral Earthing Resistor is connected between the transformer neutral and station earth CitiPower/Powercor require the following information:

- Resistance in ohms of the resistor.
- Short time current rating and related time.

4.18. CitiPower/Powercor Protection in Customer Substation

For all 66 kV sub-transmission line connections to a customer substation with embedded generation, the matching 66 kV line differential and back-up distance protection scheme equipment to that installed at the interconnecting CitiPower/Powercor network zone substation or switching station must be installed at the customer substation. The current standard line protection comprises duplicate current differential protection with inbuilt back-up distance protection incorporating sensitive directional earth fault, bidirectional remote trip capability, current check based CB failure protection and single shot auto reclose with dead line blocking.

The current differential schemes operate over the single CitiPower/Powercor fiber optic cable that runs subsidiary to the new 66 kV line. In the event of failure of this single fiber optic cable the line will still be adequately protected by the inbuilt duplicate back-up distance protection.

Additional bidirectional remote trip facilities are provided via independent equipment if required. These additional remote trips may be sent from CitiPower/Powercor zone substation or switching station for line overload or over voltage protection operations.

Protection Trips from CitiPower/Powercor to Customer via Secondary Interface:

- 'X' trip of incoming 66 kV CB,
- 'Y' trip of incoming 66 kV CB,
- Back-up trip of customer transformer LT CB/CB's or generator CB/CBs or STATCOM.

These trips will be in the form of voltage free normally open contacts available at the secondary interface.

These trips shall trip the respective incoming 66 kV CB or customer transformer LT CB/CB's or generator CBs and trip any Voltage Support STATCOM. If generation is occurring at the time of the incoming 66 kV CB trip, this trip signal shall also initiate an automatic control reduction in generation to zero or a trip of all individual generator CB's or a trip of other intermediate customer CB's. Refer Section on Auto Reclose.

Protection Operation Alarms and CB Status Signals from CitiPower/Powercor to Customer via Secondary Interface.

- CitiPower/Powercor zone substation or switching station 66 kV line CB's, tripped from overvoltage, line overload or for a line loss. (as required)
- CB closed status 66 kV CB's at the CitiPower/Powercor zone substation or switching station.

These alarms and statuses will be in the form of voltage free normally open contacts available at the secondary interface.

4.19. Customer Substation Protection

The customer substation protection design shall be based on detecting all faults within the customer's substation or associated distribution system and operating the customer's CB's to isolate the fault without impacting the CitiPower/Powercor system.

The protection design should include primary protection and back-up protection. Back-up protection can be via duplicated unit protection schemes with local CB failure schemes or via non-unit protection schemes.

CitiPower/Powercor expect that customers duplicate protection schemes ('X' and 'Y') are supplied from separate 'X' & 'Y' DC supplies and trip the incoming 66 kV via the CB 'X' and 'Y' trip coils, similar to CitiPower/Powercor protection schemes.

The back-up protection must cover all sections of a primary plant and must provide protection for both relay failure and CB failure.

The CitiPower/Powercor protection preference is for as many unit protection schemes as possible since this reduces the degree of protection coordination required. (For example: Transformer differential, bus differential.)

The protection design shall be carried out to 'best industry practice' and shall include the following:

- CT performance specifications such that protection mal-operations will not occur under the most severe system fault conditions as a result of CT saturation.
- Overlapping protection zones with CT's located such that there are no 'blind spots'.

It must also incorporate neutral displacement protection to detect and isolate all phase-to-ground faults on the immediate customer substation to CitiPower/Powercor network zone substation or switching station interconnection, which can be back-fed from the customer's unearthed transformer delta winding.

A degree of back-up protection may be available from the remote CitiPower/Powercor protection schemes at the zone substation or switching station, but this will depend on system configuration and the type of protection schemes utilised.

The CitiPower/Powercor line protection equipment will incorporate CB failure protection for the customer's incoming CB, which will be initiated by the line protection and which will send a back-up trip to customer's transformer LT CB/CB's.

If the capacity of the embedded generation exceeds the agreed export capacity, then reverse power protection shall be installed and set to the agreed export limit.

The customer shall submit to CitiPower/Powercor a single line protection diagram of all protection proposed for acceptance. Detailed design should not proceed until acceptance is received.

Protection Operation Alarms Signals required from Customer to CitiPower/Powercor via **Secondary Interface**:

- Customer incoming 66 kV CB tripped alarm from each customer protection scheme that trips incoming CB, connected in parallel.
- Customer protection scheme relay fail alarm from each customer protection scheme that trips incoming 66 kV CB, connected in parallel.

These alarms and statuses will be in the form of voltage free normally open contacts available at the **secondary interface**.

4.20. Customer Generator Protection

Notwithstanding requirements of the Section on Islanding, 4.13, it is the customer's responsibility to determine all further performance requirements for the generator protection, given that the functionality will depend on the type of machine and its method of electrical coupling.

The generator protection/control schemes shall allow the generators to ride-through CitiPower/Powercor network faults as prescribed by the NER.

4.21. Protection Coordination

The settings of the customer's non-unit protection schemes must be coordinated with the CitiPower/Powercor's network protection schemes. CitiPower/Powercor therefore requires full details of the customer's protection proposals during the design stage of the project.

Details must include the following:

- Protective relay types and configurations.
- Protective relay operating characteristics.
- Proposed relay settings.

4.22. CitiPower/Powercor Remote Control, Monitoring and Metering Requirements

SCADA remote control and monitoring from the CitiPower/Power control centre is required to enable operational switching to be carried out for both planned and unplanned outage situations.

The following outlines the local and remote control, plant/equipment status and alarms and metering required by CitiPower/Powercor to operate the system. These requirements are additional to all other interface requirements specified elsewhere in this document.

4.22.1. SCADA Control Requirements

- CitiPower/Powercor requires manual trip control of the incoming 66 kV customer CB.
- CitiPower/Powercor generally does not require manual trip control of any other customer CB.

4.22.2. SCADA Monitoring

All the signals below will be in the form of voltage free normally open contacts available at the secondary interface:

- Open and closed status of incoming 66 kV circuit breaker.
- Open and closed status of incoming 66 kV line disconnect switch.
- Open and closed status of incoming 66 kV line earth switch.
- All incoming circuit breaker condition alarms (spring discharge, low gas, low gas lockout).
- All customer protection operations for protection in embedded generation customer substation (transformer protection, bus protection etc.).
- All customer protection and control equipment failure alarms (relay failure, control system failure, power supply failure etc.).
- Station service supply failure.
- All DC supply failure alarms (charger failure, DC system under-voltage etc.).

- Other relevant alarms or plant status conditions as appropriate depending upon the system and generation configuration.

4.22.3. CitiPower/Powercor Metering

CitiPower/Powercor metering quantities shall be derived from a CitiPower/Powercor power quality meter that is connected to the customer metering CT's and VT's supplies specified elsewhere. (Typically MWatt (bi-directional), MVar (bi-directional), 66 kV line current (three phase) and 66 kV line voltage (three phase))

4.22.4. Additional SCADA Monitoring

If capacitor banks, statcoms or SVC's are installed as part of the customers embedded generator substation, then the following additional statuses, as appropriate, are to be provided at the secondary interface for local and remote monitoring:

- Capacitor bank in service.
- Capacitor bank out of service.
- Statcom in service.
- Statcom out of service.
- SVC in service.
- SVC out of service.

All these signals will be in the form of voltage free normally open contacts available at the secondary interface.

4.23. CitiPower/Powercor Auxiliary Supply Requirements

4.23.1. DC Supplies

The CitiPower/Powercor preferred option for DC supplies is that the customer install the station battery/batteries, charger/s and DC panel and make at least a single, protected, DC supply available to CitiPower/Powercor. (Duplicated 'X' and 'Y' supplies are preferred.)

The CitiPower/Powercor standard protection relay auxiliary DC voltage is 125V and CitiPower/Powercor have a strong preference for the customer's station battery to be 125V DC. (Otherwise additional non-standard equipment may need to be purchased and held as system spares at the customer cost.)

The customer's DC supply system shall be monitored and alarmed for 'Battery Under-voltage' and 'Battery Charger Fail' to CitiPower/Powercor.

These alarm signals will be in the form of voltage free normally open contacts available at the secondary interface.

Typically the characteristics of the DC supplies required by CitiPower/Powercor are:

Nominal Voltage	125V DC
Maximum variation	+ 10%
Maximum load required	5A DC continuous
Standby capacity	10 hours at max load (For loss of AC supply to charger)
Maximum ripple	<1% of the battery charger DC output voltage

4.23.2. AC Supplies

A single phase 240V AC, 50 Hz 10A supply from the customer's station service panel is required. This supply shall be protected by an MCB with residual current detection.

The AC station service supply status shall be monitored and alarmed for Station Service Supply Fail to CitiPower/Powercor.

This status signal will be in the form of voltage free normally open contact available at the secondary interface.

All AC station services supplies shall conform to AS 3000.

4.24. Standby Power Supplies

If an embedded generating plant is associated with an industrial or commercial premise, it is likely that provision must be made for an external source of power to meet essential loads when generator(s) are out of service for maintenance.

If the customer requires a standby power supply CitiPower/Powercor will provide an estimate of the costs of the alternate supply and the conditions relating to it.

4.25. Interfaces between Customer and CitiPower/Powercor Network Assets

The physical interfaces between the customer's plant and CitiPower/Powercor's assets must be clearly defined in regards to ownership and responsibility and appropriately labeled in a clear and unambiguous manner.

The location of interfaces at a particular site will depend on the agreed designs for network connection. It should be noted that there are generally four categories of interface at a customer substation:

- Asset Ownership.
- The primary (power) interface.
- The operational interface.
- The secondary (protection, control and monitoring) interface.

The secondary interface will generally be a row or rows of terminals within a CitiPower/Powercor cubicle, rack frame or wall box.

Exact details will depend on the CitiPower/Powercor network and customer embedded generation connection and will be detailed in a "CitiPower/Powercor Interface Requirements" document that will be prepared after details of the customers system and protection design proposals have been received and accepted by CitiPower/Powercor.

5. Operating and Maintenance Process

Every embedded generator is connected to a part of the network on which maintenance work must be carried out by CitiPower/Powercor or its contractors. Under such conditions CitiPower/Powercor must ensure that the affected section of the network is isolated not only on the zone substation side but also on the generator side. CitiPower/Powercor will in general require the line disconnect switch and earth switch at the customer's point of supply to be lockable to ensure the safety of maintenance personnel. The line disconnect switch shall be under joint operational control of CitiPower/Powercor and the customer. The line earth switch shall be under the sole operational control of CitiPower/Powercor.

Written operating procedures for the generating plant and associated connection assets must be submitted for CitiPower/Powercor's agreement prior to commissioning of the plant, and a formal copy held by each party which has been signed by both parties. These operating procedures must not be modified without consultation and agreement with CitiPower/Powercor.

The presence of an embedded generator may also impact on other lines and feeders due to load transfer arrangements on the network. CitiPower/Powercor operations and maintenance personnel may need to contact operators of embedded generators at short notice prior to carrying out any urgent maintenance work on the associated network.

Safety considerations will, on occasion, require a visit to premises by CitiPower/Powercor operations personnel to check the status of the customer's generator installation. On these occasions the generating plant operators must be available on site at short notice.

The customer's generating plant and its auxiliaries should be regularly inspected and maintained by suitably qualified and trained personnel in accordance with the instructions of the relevant equipment manufacturers. In particular, work on a gas-fuelled plant must be carried out only by specialist maintenance engineers.

CitiPower/Powercor reserve the right to view any maintenance records at any time and records must be up to date as agreed between the parties involved.

6. Installation Approvals

Prior to the connection of embedded generating plant, CitiPower/Powercor's representative will inspect the electrical switchgear and the protection and control equipment. CitiPower/Powercor also wishes to be present when the plant safety features are being proven, and may carry out its own tests prior to commissioning of the plant on the CitiPower/Powercor network. In doing so, CitiPower/Powercor assumes no liability in respect of the safety of the customer's plant.

Subsequent to commissioning of the plant, CitiPower/Powercor must be consulted prior to any modification of the plant, equipment, protection or control schemes.

7. Revenue Metering

The key principles for revenue metering, which are detailed in Chapter 7 of the NER and in the Victorian Electricity Customer Metering Code, are as follows:

- Each connection point must have a revenue metering installation.
- The responsibility for the provision, installation and maintenance of a metering installation may lie either with the local Network Service Provider or with the Embedded Generator, as determined by the latter.
- Costs associated with a metering installation are to be borne by the Embedded Generator.
- Metering installations must be installed and maintained by a Metering Provider who is registered with the AEMC.
- Metering installations must be secure and capable of providing data for electronic transfer.

For Market Generators, the NER assigns primary responsibility for the provision, installation and maintenance of a metering installation to the local Network Service Provider (CitiPower/Powercor) unless otherwise elected by the Market Generator.

CitiPower/Powercor will make an offer for the provision of these services on request and, on acceptance, will provide AEMO with details of the metering installation.

If CitiPower/Powercor's offer is not accepted, the Market Generator assumes responsibility, and must engage a Metering Provider who is registered with the AEMC. The Market Generator must provide AEMO with details of the metering information.

For Non-market Generators, i.e. those selling electricity to a retailer, the requirements are detailed in the Victorian Electricity Metering Code, which is available on the ESC website at www.esc.vic.gov.au.

Contact Details

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