

CitiPower Pty Ltd/
Powercor Australia Ltd

Technical Guidelines for Low Voltage Embedded Generation Connections

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Contents

| | | |
|-------|---|----|
| 1 | Introduction | 5 |
| 2 | Definitions and Abbreviations..... | 6 |
| 2.1 | Definitions | 6 |
| 2.2 | Abbreviations | 7 |
| 2.3 | Terminology..... | 9 |
| 2.3.1 | Subcategories | 9 |
| 3 | Relevant Rules, Regulations, Standards and Codes | 10 |
| 3.1 | Standards and Codes | 10 |
| 3.2 | Legislation and Regulation | 12 |
| 4 | Technical Requirements..... | 13 |
| 4.1 | Labelling and Signage | 13 |
| 4.2 | Maximum System Capacity | 13 |
| 4.3 | Generation Control | 13 |
| 4.3.1 | Export Limits at Connection Point..... | 13 |
| 4.3.2 | Site Generation Limit Downstream of Connection Point..... | 14 |
| 4.4 | Inverter Energy System | 15 |
| 4.5 | Network Connection and Isolation | 15 |
| 4.6 | Earthing..... | 15 |
| 4.7 | Protection | 15 |
| 4.7.1 | Inverter Integrated Protection..... | 15 |
| 4.7.2 | Central Protection..... | 16 |
| 4.7.3 | Interlocking..... | 19 |
| 4.7.4 | Power Factor Control..... | 19 |
| 4.7.5 | Synchronisation | 19 |
| 4.7.6 | Additional Requirements for LV EG Non-IES | 19 |
| 4.8 | Operating Voltage and Frequency | 19 |

CitiPower and Powercor
Technical Guidelines for Low Voltage Embedded Generation Connections

| | | |
|--------|--|----|
| 4.9 | Metering | 20 |
| 4.10 | Power Quality | 20 |
| 4.10.1 | Quality of Supply | 20 |
| 4.10.2 | IES Power Quality Response Modes | 20 |
| 4.10.3 | LV EG Non-IES Synchronous Power Quality Response | 21 |
| 4.11 | Communications Systems | 21 |
| 4.11.1 | LV EG IES (excluding ESS) up to 200kVA Communications Systems | 21 |
| 4.11.2 | LV EG IES (excluding ESS) greater than 200kVA Communications Systems | 21 |
| 4.11.3 | LV EG Non-IES (excluding ESS) Communications Systems | 22 |
| 4.12 | Data and Information | 22 |
| 4.12.1 | Static Data and Information | 22 |
| 4.12.2 | Dynamic Data and Information | 22 |
| 4.13 | Cybersecurity | 22 |
| 4.14 | Technical Studies | 22 |
| 5 | Fees and Charges | 23 |
| 6 | Testing and Commissioning | 24 |
| 7 | Operations and Maintenance | 25 |
| | Appendix A: Deviations from the National DER Connection Guidelines | 26 |
| | Appendix B: Connection Arrangement Requirements | 27 |
| | Appendix C: Model Standing Offer | 30 |
| | Appendix D: Static Data and Information | 31 |

1 Introduction

This guideline covers the technical requirements for a proponent to connect a low voltage embedded generation system to the CitiPower and Powercor low voltage networks.

1. Definition

A low voltage embedded generation connection in CitiPower and Powercor is defined as “an LV EG system with a total system capacity greater than 30kVA for a three-phase IES or non-IES (excluding ESS) network connection that is:

- (a) intended to be connected to and capable of operating in parallel with any part of the LV distribution network;
- (b) meeting all other technical requirements set out in this document.

2. Purpose

The purpose of this technical requirements document is to provide proponents of LV EG connections recommendations and information about their obligations for connection to and interfacing with the LV distribution network.

3. Scope

The scope of connections to which this technical requirements document applies, is for new connections of LV EG systems or modifications to existing LV EG systems, where the LV EG system consists of IES, ESS or a combination of both.

4. Not in Scope

The scope of systems to which this technical requirements document does NOT apply, are:

- (c) EG units covered by CitiPower and Powercor’s Basic Micro EG Connection Technical Requirements (up to 5kVA single phase and 30kVA three phase);
- (d) EG units covered by CitiPower and Powercor’s MV/HV EG Connection Technical Requirements (above 1MVA HV);
- (e) Electric vehicles, unless the on-board battery storage system is capable of exporting to the LV network (in which case the requirements shall apply);
- (f) DER systems that do not generate electricity, including demand response/demand management systems, unless they impact on the ability of the LV EG system to meet the technical requirements.

5. The general obligations of proponents are:

- (g) The obligation to comply with the technical requirements as well as relevant national standards, industry codes, legislation and regulations. In the event of inconsistency, an indication of which instrument shall prevail, being legislation and regulations, followed by the technical requirements, followed by national standards and industry codes;
- (h) The obligation to not connect additional inverters, make modifications or install additional LV EG units, including ESS, without prior written agreement from CitiPower and Powercor;
- (i) The obligation to comply with CitiPower and Powercor’s generator deed;
- (j) The obligation to meet the requirements in the design, installation and operation of the LV EG system.

6. Safety

CitiPower and Powercor are obligated to ensure the safe and reliable operation of the distribution system for operating personnel, customers and the general public.

7. Compliance to ENA National DER Connection Guidelines

The technical requirements comply with the ENA National DER Connection Guidelines for LV EG Connections, with the exception of the deviations presented in Appendix A: Deviations from the National DER Connection Guidelines.

2 Definitions and Abbreviations

2.1 Definitions

This section provides a tabulated list of definitions for any technical or industry terms used throughout the technical requirements document. The definitions are consistent with the definitions provided within the National DER Connections Guidelines (and the Framework and Principles guideline) as relevant.

| | |
|---|--|
| <i>Basic micro embedded generation connection</i> | <i>A connection between a distribution network and a retail customer's premises for a micro embedded generating unit, for which a model standing offer is in place or an equivalent model offer is in place in jurisdictions not subject to Chapter 5A of the National Electricity Rules</i> |
| Central protection | Central protection is the protection contemplated by AS/NZS 4777 (grid connection of energy systems via inverters) installed to perform the functions of: coordinating multiple inverter energy system installations at one site, providing protection for the entire inverter energy system installation and islanding protection to the connected grid as well as preserving safety of grid personnel and the general public |
| <i>Embedded generating unit</i> | <i>A generating unit connected within a distribution network and not having direct access to the transmission network</i> |
| Embedded generating system | A system comprising of multiple embedded generating units |
| Distributed Energy Resources | Power generation or storage units that are connected directly to the distribution network |
| Energy storage system | A system comprising one or more batteries that store electricity generated by distributed energy resources or directly from the grid, and that can discharge the electricity to loads |
| <i>Generating unit</i> | <i>The plant used in the production of electricity and all related equipment essential to its functioning as a single entity.</i> |
| <i>Generation</i> | <i>The production of electrical power by converting another form of energy in a generating unit</i> |
| <i>Generator</i> | <i>A person who owns, operates or controls a generating unit</i> |
| Generator Deed | A contract that sets out the terms and conditions by which a customer must comply with in order to synchronise and parallel an embedded generating unit with the Distributer's network. This is a more specific document than a model EG standing offer due to the need to specify different settings for large LV EG |
| Inverter energy system | A system comprising one or more inverters that convert direct current to alternating current |
| Low voltage | The mains voltages as most commonly used in any given network by domestic and light industrial and commercial consumers (typically 230V) |
| Medium voltage/ High voltage | Any voltage greater than 1kVAC |

CitiPower and Powercor
 Technical Guidelines for Low Voltage Embedded Generation Connections

| | |
|---|--|
| <i>Micro embedded generation connection</i> | <i>Means a connection between an embedded generating unit and a distribution network of the kind contemplated by Australian Standard AS 4777 (Grid connection of energy systems via inverters) currently up to 200kVA</i> |
| <i>Market generating unit</i> | <i>A generating unit whose generation is not purchased in its entirety by a retailer (and receives payment for generation through the National Electricity Market or Wholesale Electricity Market)</i> |
| <i>Model standing offer</i> | <i>A document approved by the Australian Energy Regulator as a model standing offer to provide basic micro embedded generation connection services or standard connection services which contains (amongst other things) the safety and technical requirements to be complied with by the proponent. This definition also applies to an equivalent model offer for jurisdictions not subject to Chapter 5A of the National Electricity Rules</i> |
| Model connection agreement | A document that is a model standing offer or a document used to provide low voltage embedded generation connection services which contains (amongst other things) the safety and technical requirements to be complied with by the proponent |
| <i>Negotiated connection</i> | <i>A connection of an embedded generating unit which is neither a basic micro embedded generation connection nor a standard connection for which technical requirements are negotiated between the Distribution Network Service Provider and the proponent</i> |
| Non-inverter energy system | A system consisting of one or more synchronous or asynchronous generators |
| Proponent | A person proposing to become a generator (the relevant owner, operator or controller of the generating unit (or their agent)) |
| <i>Registered generator</i> | <i>A person who owns, operates or controls a generating unit that is connected to, or who otherwise supplies electricity to, a transmission or distribution system and who is registered by the Australian Energy Market Operator as a Generator under Chapter 2 of the National Electricity Rules</i> |
| Site generation limit | The generation threshold that the embedded generation system cannot exceed, measured downstream of the connection point |
| <i>Small generation aggregator</i> | <i>A person who has classified one or more small generating units as a market generating unit</i> |
| <i>Small registered generator</i> | <i>A generator who elects to register a generator with the Australian Energy Market Operator as a market generating unit who would otherwise be entitled to an exemption to register based on size</i> |
| <i>Standard connection</i> | <i>A connection service (other than a basic micro embedded generation connection service) for a particular class (or sub-class) of connection applicant and for which an Australian Energy Regulator approved model standing offer is in place or for which an equivalent model offer is in place in jurisdictions not subject to Chapter 5A of the National Electricity Rules</i> |
| Technical requirements document | The document produced by each Distribution Network Service Provider (e.g. CitiPower and Powercor) setting out their requirements for proponents to enable a grid connection, to which these guidelines apply |

Table 1: Definitions

¹ Definitions in italics are consistent with the definitions under the National Electricity Rules

2.2 Abbreviations

This section shall provide a tabulated list of all abbreviations used throughout the technical requirements document. The abbreviations are consistent with the abbreviations provided within

CitiPower and Powercor
 Technical Guidelines for Low Voltage Embedded Generation Connections

the National DER Connections Guidelines (and the Framework and Principles guideline) as relevant.

| | |
|--------|---|
| AEMC | Australian Energy Market Commission |
| AEMO | Australian Energy Market Operator |
| AER | Australian Energy Regulator |
| AS/NZS | A jointly developed Australian and New Zealand Standard |
| AS | Australian Standard |
| CEC | Clean Energy Council |
| CPEng | Chartered Professional Engineer of Engineers Australia |
| DC | Direct Current |
| DER | Distributed Energy Resources |
| DNSP | Distribution Network Service Provider |
| EG | Embedded Generation or Embedded Generating |
| ESS | Energy Storage System |
| GDL | Generation Dispatch Limiter |
| HV | High Voltage |
| IEC | International Electrotechnical Commission |
| IES | Inverter Energy System |
| LV | Low Voltage |
| MV | Medium Voltage |
| MBN | National Broadband Network |
| NEM | National Electricity Market |
| NER | National Electricity Rules |
| NMI | National Metering Identifier |

| | |
|------|---|
| RPEQ | Registered Professional Engineer of Professionals Australia |
| SWIS | South West Interconnected System |
| WEM | Wholesale Electricity Market servicing the SWIS |
| xDSL | X Digital Subscriber Line |

Table 2: Abbreviations

2.3 Terminology

In these guidelines the following terminology is used:

1. The word 'shall' indicates a mandatory requirement;
2. The word 'may' indicates a requirement that may be mandatorily imposed on the proponent;
3. The word 'should' indicates a recommendation that will not be mandatorily imposed on the proponent.

2.3.1 Subcategories

The subcategories, for which different technical settings may apply, are:

1. LV EG IES (excluding ESS) connection ≤ 200 kVA – Any LV EG system, that is not a basic micro EG system, with a total system capacity less than or equal to 200 kVA for a single-phase or three-phase IES (excluding ESS) network connection, meeting all relevant technical requirements for LV EG connections set out in the DNSP's technical requirements document. Further subcategorised by:
 - a. Exporting
 - b. Non-exporting
2. LV EG IES (excluding ESS) connection > 200 kVA – Any LV EG system, with a total system capacity greater than 200 kVA and less than or equal to 2000 kVA for a three-phase IES (excluding ESS) network connection, meeting all relevant technical requirements for LV EG connections set out in the DNSP's technical requirements document. Further subcategorised by:
 - a. Exporting
 - b. Non-exporting
3. LV EG non-IES connection – Any LV EG system, that is synchronous or asynchronous, with a total system capacity greater than 0 kVA and less than or equal to 2000 kVA for a single- phase or three-phase network connection, meeting all relevant technical requirements for LV EG connections set out in the DNSP's technical requirements document. Further subcategorised by:
 - a. Exporting
 - b. Non-exporting.

Where:

1. The maximum LV system capacity allowed for connection to the LV network may be specified as an indicative level or range above which the proponent would likely require a connection to the MV/HV networks. Where this is the case, this section shall state that proponents wishing to connect a system at or near this size contact the DNSP to determine whether an LV EG connection is appropriate

2. Exporting systems shall be considered to be LV EG systems operating in parallel with the LV distribution network and exporting electricity either via partial-export or full-export into the LV distribution network, where:
 - a. Partial-export LV EG systems limit the amount of export into the LV distribution network to an agreed export threshold defined in the connection agreement
 - b. Full-export LV EG systems can export into the LV distribution network to the full LV EG nameplate capacity (full AC rating).
3. Non-exporting systems shall be considered to be LV EG systems operating in parallel with the LV distribution network that are not approved to and limited to ensure they cannot export electricity into the LV distribution network.

The hyperlink or website reference to a map to geographically identify the distribution business supplying a customer is at:

<https://www.powercor.com.au/what-we-do/the-network/citipower-and-powercor-networks/>

Contact details in case there is any doubt as to which subcategory applies:

Contact CitiPower on 13 12 80 and Powercor on 13 24 12.

<https://www.powercor.com.au/contact-us/general-enquiry/>

The technical requirements set out in these guidelines should be interpreted as applying to all subcategories of LV EG connections unless otherwise specified.

3 Relevant Rules, Regulations, Standards and Codes

3.1 Standards and Codes

This section contains a list of all the Australian and international standards and industry codes which shall apply to the design, manufacture, installation, testing and commissioning, and operation and maintenance of all plant and equipment for LV EG connections to the distribution network.

In the event of any inconsistency between Australian and international standards and industry codes and the CitiPower and Powercor technical requirements, the CitiPower and Powercor technical requirements shall prevail.

| Victorian industry codes applicable to DNSPs | | | |
|---|--|------------------------|---|
| Document Title | Includes technical requirements | Legally binding | Description |
| Electricity Distribution Code (Version 9) | Yes | Yes | Regulates the distribution of electricity, connections to distribution networks, and the transfer of electricity between distribution systems so that they are undertaken in a safe, efficient, and reliable manner |

Table 3: Industry codes

| Australian Standards | Standard Title |
|-----------------------------|---|
| AS 1319 | Safety signs for occupational environment |
| AS 1359 | General Requirements for Rotating Electrical Machines |
| AS 2006 | Diesel Generators/internal combustion engines |

CitiPower and Powercor
 Technical Guidelines for Low Voltage Embedded Generation Connections

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| AS 2184 | Low voltage switchgear |
| AS 2344 | Limits of electromagnetic interference from overhead a.c. power lines and high voltage equipment installations in the frequency range 0.15 to 1000 MHz |
| AS 2373 | Electric Cables |
| AS 2374 | Power Transformers |
| AS 2915 | Solar Photovoltaic Modules – Performance Requirements |
| AS/NZS 3000 | Electrical Installations (Wiring Rules), 3010 – Electrical Installations – Generating Sets, 3017 – Testing Guidelines |
| AS/NZS 3008 | Electrical installations - Selection of cables - Cables for alternating voltages up to and including 0.6/1 kV |
| AS 3010 | Electrical Installations |
| AS/NZS 3017 | Electrical installations – Testing Guidelines |
| AS/NZS 3100 | Approval and test specification – General requirements for electrical equipment |
| AS/NZS 3439.1:2002 | Low Voltage Switchgear and control gear assemblies |
| AS 4509 | Stand-alone power systems, Parts 1,2,3 |
| AS 4777 | Grid Connection of Energy Systems via Inverters, Parts 1 & 2 |
| AS/NZS 5033 | Installation of photovoltaic (PV) arrays |
| AS 60034.1 | Rotating electrical machines, Part 1: Rating and performance |
| AS 60034.22 | Rotating electrical machines, Part 22: AC generators for reciprocating internal combustion (RIC) engine driven generating sets |
| AS 60038 | Standard Voltages |
| AS 60044 | Instrument transformers (multiple parts) |
| AS/NZS IEC 60947.6-1 | Low-voltage switchgear and control gear - Multiple function equipment - Automatic transfer switching equipment |
| AN/NZS TR 61000.3.14 | Electromagnetic compatibility (EMC), Part 3.14: Limits—Assessment of emission limits for harmonics, inter-harmonics, voltage fluctuations and unbalance for the connection of disturbing installations to LV power systems |
| AN/NZS TR 61000.3.15 | Electromagnetic compatibility (EMC), Part 3.15: Limits— Assessment of low frequency electromagnetic immunity and emission requirements for dispersed generation systems in LV network |

Table 4: Australian Standards

| International Standards | Document Title |
|--------------------------------|---|
| IEEE PSRC | Intertie protection of consumer-owned sources of generation, 3MVA or less |
| IEEE 519 | Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems |
| IEEE 1547 | IEEE Standard for interconnecting Distributed Resources with Electric Power systems |

CitiPower and Powercor
 Technical Guidelines for Low Voltage Embedded Generation Connections

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|---------------|--|
| IEC 60255-12 | Electrical relays - Part 12: Directional relays and power relays with two input energizing quantities |
| IEC 60255-26 | Electrical relays - Part 26: Electromagnetic compatibility requirements |
| IEC 60255-27 | Electrical relays - Part 27: Product safety requirements |
| IEC 60255-127 | Measuring relays and protection equipment - Part 127: Functional requirements for over/under voltage protection |
| IEC 62109 | Safety of power converters for use in photovoltaic power systems |
| IEC 62116 | Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures |
| IEC 62786 | Distributed energy resources connection with the grid |
| G59/2* | Recommendations for the connection of embedded generating plant to the DNSP's distribution systems and the provision of standby generators |
| G75* | Recommendations for the connection of embedded generating plant to Public distribution systems above 20kV or with outputs over 5MW |
| G83/18* | Recommendations for the Connection of Small-scale Embedded Generators (Up to 16A per Phase) in Parallel with Public Low-voltage Distribution Networks. |
| ETR 113* | Engineering Technical Report No ETR 113 |

Table 5: International Standards

* Energy Networks Association UK

3.2 Legislation and Regulation

This section provides a list of all the relevant legislation and regulations which shall apply to the design, manufacture, installation, testing and commissioning, and operations and maintenance of all plant and equipment for LV EG connections to the distribution network.

In the event of any inconsistency between legislation and regulations and the CitiPower and Powercor technical requirements, the legislation and regulation shall prevail.

| Victorian legislation and regulation applicable to DNSPs | | | |
|---|--|------------------------|--|
| Document Title | Includes technical requirements | Legally binding | Description |
| Electricity Industry Guideline 15 – Connection of Embedded Generation | No | Yes | Provides arrangements for connecting embedded generating units to distribution systems |
| Victorian Service and Installation Rules | Yes | Yes | Provides industry agreed technical requirements that meet all legislative and code requirements for the supply and metering related aspects of any connection to the Victorian electricity supply networks |

Table 6: Legislation and Regulation

4 Technical Requirements

4.1 Labelling and Signage

All labels and signs on the installation, including cables, shall be as per AS/NZS 4777.1, AS/NZS 3000 and AS/NZS 5033.

Additional signage and labelling may be required above 200kVA of LV EG. Refer to the CitiPower/Powercor 'Customer GL for LV connection EG V8 Final 22112018.pdf' in the link below:

<https://media.powercor.com.au/wp-content/uploads/2018/11/30122510/customer-gl-for-lv-connected-eg-v8-final-22112018.pdf>

4.2 Maximum System Capacity

This section specifies the maximum system capacity of LV EG connections for each subcategory consistent with the below:

1. LV EG IES (excluding ESS) connection ≤ 200 kVA – For LV EG connections of IES (excluding ESS), the maximum system capacity at the same connection point shall be set to less than or equal to 200 kVA
2. LV EG IES (excluding ESS) connection > 200 kVA – For LV EG connections of IES (excluding ESS), the maximum system capacity at the same connection point shall be determined at the time of application but shall typically be greater than 200 kVA and less than or equal to 2000 kVA
3. LV EG non-IES connection – For LV EG connections of non-IES, the maximum system capacity shall be determined at the time of application but shall typically be greater than 0 kVA and less than or equal to 2000 kVA.

4.3 Generation Control

LV EG connections require generation control.

4.3.1 Export Limits at Connection Point

The export limits of LV EG connections for each subcategory are as per below:

1. LV EG IES (excluding ESS) connection ≤ 200 kVA – For LV EG connections of IES (excluding ESS), the export limit at the same connection point shall be determined at the time of application and less than or equal to 200 kVA
2. LV EG IES (excluding ESS) connection > 200 kVA – For LV EG connections of IES (excluding ESS), the export limit at the same connection point shall be determined at the time of application and less than or equal to 2000 kVA
3. LV EG non-IES connection – For LV EG connections of non-IES, the export limit shall be determined at the time of application and less than or equal to 2000 kVA.

The export limit is to be interpreted as “soft”, consistent with the definition of soft export limits within AS/NZS 4777.1.

The export limit is also to be interpreted by the proponent as a maximum. The ability of the proponent's LV EG system to export at the export limit is not guaranteed, but rather, it will depend upon network characteristics which change over time. There are circumstances where output may need to be constrained including, but not limited to inverter power output where power quality response modes are in operation.

For example, when the voltage is above or below certain thresholds, the generator will need to operate in a power quality mode that controls voltage firstly using reactive power control to

CitiPower and Powercor
 Technical Guidelines for Low Voltage Embedded Generation Connections

contain connection point voltage within code limits i.e. 206V to 253V. Secondly, if the voltage is above the steady state code limit of 253V, output power is constrained to bring voltage back to code limits.

Also there may be other assets e.g. LV conductors and distribution transformers, upstream of the connection point that may constrain export by the proponent due to the existing amount of connected EG. The following table shows the asset limitations based on transformer capacity for a typical LV network:

| Network type | Maximum inverter size (solar and hybrid~) | Maximum export to the grid** | Maximum Battery discharge size | EG proportion of asset rating capacity limits** |
|--------------|---|------------------------------|--------------------------------|--|
| Three phase | 2000kVA | 2000kVA | 200kVA | 30% of rural and 50% of urban transformer nameplate rating |

Table 7: EG sizes and asset rating limits

~A hybrid inverter is a multi-mode inverter that can control both solar PV and battery installations. It is recommended that battery storage systems should be normally set up to charge when there is excess generation and discharge only when there is a shortage of generation i.e. supply is taken from the network. An export meter and IES controller is required to detect point of supply import/export condition to assist controlling a battery storage system.

**The allowable export may be less depending on asset capacity. An export meter and IES Controller is required to be set to control grid export where inverter size is greater than the export limit. Network LV overhead lines and underground cables may not be able to be loaded to the maximum continuous rating due to excessive voltage drop, hence the above limitations have been applied on the basis of transformer rating. Location specific technical assessments will be required where a proponent’s application for export results in the total connected EG exceeding the limits in the above table.

4.3.2 Site Generation Limit Downstream of Connection Point

The generation limits of LV EG connections for each subcategory are as per below:

1. LV EG IES (excluding ESS) connection ≤ 200 kVA – For LV EG connections of IES (excluding ESS), the site generation limit shall be determined at the time of application and less than or equal to 200 kVA
2. LV EG IES (excluding ESS) connection > 200 kVA – For LV EG connections of IES (excluding ESS), the site generation limit shall be determined at the time of application and less than or equal to 2000 kVA
3. LV EG non-IES connection – For LV EG connections of non-IES, the site generation limit shall be determined at the time of application and less than or equal to 2000 kVA.

The suite generation limit may be dependent on the following factors:

1. Retail and market operations
2. Existing asset ratings
3. Existing power quality at the relevant network location
4. Existing and forecast DER penetration at the relevant network location.

Also as per the above Table 7, ESS size is limited to 200kVA discharge for three phase installations.

As described in section 4.3.1, generation control will be required to maintain voltage within code requirements.

4.4 Inverter Energy System

The requirements that apply to IES are:

1. IES shall be tested by an authorised testing laboratory and be certified as being compliant with AS/NZS 4777.2 with an accreditation number;
2. IES shall comprise of inverters that are registered with CEC as approved grid connect inverters;
3. IES shall comprise of inverters that are tested by an authorised testing laboratory and certified as being compliant with IEC 62116 for active anti- islanding protection as per AS/NZS4777.2;
4. IES shall comprise of inverters installed in compliance with AS/NZS 4777.1;
5. IES shall comprise of inverters that have both volt-var and volt-watt response modes available.

4.5 Network Connection and Isolation

The network connection and isolation requirements for IES shall be as per AS/NZS4777.1.

In addition:

1. For all IES (above and below 200kVA), earthing requirements shall be as per AS/NZS 4777.1 and AS/NZS 3000
2. As a minimum, mechanical isolation shall be as per AS/NZS 3000 in that the isolator must always be readily accessible
3. Any means of isolation (where lockable) shall be able to be locked in the open position only
4. The requirements for multiple mode IES are as per for single mode IES.

The network connection and isolation requirements for non-IES shall be determined by CitiPower/Powercor in the connection application stage and may be similar to that required for IES.

4.6 Earthing

The earthing of the installation shall include:

1. For all IES < 200kVA, earthing requirements shall be as per AS/NZS 4777.1 and AS/NZS 3000
2. For all IES > 200kVA), earthing requirements shall be as per AS/NZS 4777.1 and AS/NZS 3000
3. For all non-IES, earthing requirements shall be as per AS/NZS 3000 and AS/NZS 3010
4. For ESS, earthing requirements shall be as per AS 3011.

4.7 Protection

4.7.1 Inverter Integrated Protection

The inverter integrated protection requirements shall be as per AS/NZS 4777.1 and AS/NZS 4777.2 for LV EG IES connections less than or equal to 200kVA or greater than 200kVA.

The passive anti-islanding requirements using voltage and frequency limits required are as per

Table 13 of AS/NZS 4777.2 reproduced below:

| Table 13 of AS/NZS 4777.2 | Protective function | Protective function limit | Trip delay time | Maximum disconnection time |
|--|----------------------|---------------------------|-----------------|----------------------------|
| Passive anti-islanding protection (default and not able to be changed) | Undervoltage (V<) | 180V | 1s | 2s |
| | Overvoltage 1 (V>) | 260V | 1s | 2s |
| | Overvoltage 2 (V>>) | 265V | - | 0.2s |
| | Under-frequency (F<) | 47Hz | 1s | 2s |
| | Over-frequency (F>) | 52Hz | - | 0.2s |

Table 8: Passive anti-islanding protection settings

Active anti-islanding protection and its requirements shall be per AS/NZS 4777.2.

The Frequency Disturbance Control Protection Settings are the default settings in sections 7.5.3.1-2 of AS4777.2 as shown below:

| Frequency disturbance control protection settings | Quantity | Range | Default setting | Required setting |
|---|----------|---------|-----------------|------------------|
| Increase in frequency | Fstop | 51-52Hz | 52Hz | 52Hz |
| Decrease in frequency | Fstop-CH | 47-49Hz | 49Hz | 49Hz |

Table 9: Frequency disturbance control protection settings

4.7.2 Central Protection

Central protection is required for a number of reasons as explained in section 3.4.4 of AS4777.1. One of the main reasons is to provide protection for the entire IES installation including (where installed) multiple IES on site, and consequently Central Protection shall be installed as close as practicable to the main switch of the installation.

Central Protection shall be installed as per Table 1 of AS/NZS 4777.1 and have voltage and frequency set points as per Table 2 of AS/NZS 4777.1 (see tables 10 & 11 below) and be applicable for IES greater than 200kVA. Phase balance protection is only required for non-integrated three phase inverters however under and over voltage and under and over frequency protection is required as the minimum central protection required.

| | IES ≤ 5kVA/phase | 15kVA < IES ≤ 30kVA | 30kVA < IES ≤ 200kVA |
|-------------------------------------|---|--|--|
| Connection type | Single-phase, two-phase or three-phase | Three-phase | Three-phase |
| Protection required for all systems | Inverter integrated protection according to AS/NZS 4777.2 | Inverter integrated protection according to AS/NZS 4777.2 | Inverter integrated protection according to AS/NZS 4777.2 |
| Additional central protection | None | Phase balance protection (refer to clause 3.4.4.2 of AS/NZS 4777.1) where not inverter integrated according to AS/NZS 4777.2 | Phase balance protection (refer to clause 3.4.4.2 of AS/NZS 4777.1) where not inverter integrated according to AS/NZS 4777.2 AND Under and over voltage and under and over frequency protection (refer to clause 3.4.4.3 of AS/NZS 4777.1) |

Table 10: Requirements for inverter integrated protection and central protection functions (Table 1 of AS/NZS 4777.1)

| Setting parameter | Disconnection time | Protective function limit |
|--|--------------------|---------------------------|
| Sustained over voltage (V>) (based on average value over a period of 10 min) | 15s | 258V |
| Over voltage 2 (V>>) | 2s | 260V |
| Under voltage (V<) | 2s | 180V |
| Over-frequency (F>) | 2s | 52Hz |
| Under-frequency (F<) | 2s | 47Hz |

Table 11: Central Voltage and Frequency Protection set points (Table 2 of AS/NZS 4777.1)

Additional central protection may also be required as per Table 12 below.

| Protection Requirements | LV EG IES | | | | LV EG Non-IES | |
|---|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| | ≤200kVA | | >200kVA | | Exporting | Non-exporting |
| | Exporting | Non-exporting | Exporting | Non-exporting | | |
| Grid reverse power (32R) | Required | May be required | Required | May be required | May be required | May be required |
| Generator circuit phase balance protection (46/47) | May be required | May be required | May be required | May be required | Required | Required |
| Overcurrent facility fault, grid fault and earth fault protection (50/51) | Required | Required | Required | Required | Required | Required |
| Passive anti-islanding protection (27U/O, 59U/O, 81U/O, 81R) | Required | Required | Required | Required | Required | Required |
| Inter-tripping | N/A | N/A | May be required | N/A | May be required | May be required |

Table 12: Central protection requirements other than specified by AS/NZS 4777.1 & 4777.2

Additional grid protection is required by CitiPower/Powercor as per the following customer guideline for LV connected EG document:

<https://media.powercor.com.au/wp-content/uploads/2018/11/30122510/customer-gl-for-lv-connected-eg-v8-final-22112018.pdf>

4.7.2.1 Grid Reverse Power Protection

Grid reverse power protection requirements shall include:

1. That reverse power protection shall be set as low as practicable with consideration of protection relay, CT accuracy and generating system synchronisation characteristics

2. That design of control systems shall minimise reverse power flow immediately following synchronisation.

The specific settings for grid reverse power protection shall be determined via a connection specific technical assessment as part of the connection application process.

4.7.2.2 Phase Balance Protection

All LV EG connections shall have phase balance protection in place where not inverter integrated. Three-phase IES are exempt from this requirement.

All Non-IES shall require both current unbalance and voltage unbalance protection.

4.7.2.2.1 Current Unbalance Protection

There are no current unbalance protection requirements.

4.7.2.2.2 Voltage Unbalance Protection

The specific settings for voltage unbalance protection shall be determined via a connection specific technical assessment as part of the connection application process. The settings shall include but are not limited to:

1. Threshold of voltage unbalance, i.e. amplitude asymmetry (%)
2. Undervoltage limit of the positive sequence (%)
3. Overvoltage limit of the negative sequence (%)
4. Delay of the voltage unbalance (amplitude asymmetry) protection (sec)
5. Direction of correct phase rotation (clockwise, counter-clockwise, any).

CitiPower and Powercor require embedded generators are as per the Distribution Code and require the contribution to the negative sequence voltage at the point of connection between the EG and the network is less than 1%.

4.7.2.3 Overcurrent Facility Fault, Overcurrent Grid Fault and Earth Fault Protection

The requirements for overcurrent facility fault, overcurrent grid fault and earth fault protection shall be determined via a connection- specific technical assessment as part of the Connection Application process. Refer to the CitiPower/Powercor 'Customer GL for LV connection EG V8 Final 22112018.pdf' in the link below:

<https://media.powercor.com.au/wp-content/uploads/2018/11/30122510/customer-gl-for-lv-connected-eg-v8-final-22112018.pdf>

4.7.2.4 Passive Anti-Islanding Protection

The passive anti-islanding requirements for LV IES and non-IES are as per Table 2 of AS/NZS 4777.1 using voltage and frequency limits for LV EG IES connections greater than 30 kVA. See Table 11 above.

4.7.2.5 Inter-tripping

Inter-tripping is generally not required for most LV EG, however:

1. For LV EG connections inter-tripping may be required depending on the outcomes of technical studies
2. For LV EG Non-IES non-exporting connections, inter-tripping may not be required provided that minimum import protection is installed
3. Where there is an inter-trip, reverse power protection may not be required.

Where inter-tripping is required, the following protection functions and requirements may include

but are not limited to:

1. Inter-trip protection is to be applied in addition to the distribution network protection requirements set out in the DNSP's technical requirements document
2. Responsibilities for the set-up and monitoring of the communication link between an EG system (specifically connecting to an interface panel on the customer's site) and the CitiPower/Powercor's data collection system
3. Interface requirements
4. Responsibilities for tripping the circuit breaker upon receiving the inter-trip signal
5. Actions that shall be taken by the CitiPower/Powercor should the communication link fail until such time when the link is restored
6. Responsibilities for including a tripping function of the generating system in the case where the DC supply to the protection scheme is lost.

4.7.3 Interlocking

Where multiple single-phase inverters are connected to more than one phase, either of the following requirements will apply:

1. Single-phase inverters are to be interlocked and configured to operate as an integrated multi-phase inverter providing a balanced output that is no more than 5 kVA between any phases as per AS/NZS 4777.1;
- OR
2. Phase balance protection as per Clause 3.4.4 of AS/NZS 4777.1 is required, with exceptions outlined within Clause 5.4.4 in AS/NZS 4777.1. Refer also to section 4.7.2.2 above.

4.7.4 Power Factor Control

Generally powerfactor control is not the preferred method of control of LV IES EG. For non-IES EG, powerfactor settings may be applicable depending on the generator control capability and the network voltage conditions and operating characteristics. Where power factor control is specified as being required for all LV IES and non-IES EG, a technical assessment by the proponent as part of the connection application process will be required and following checking and acceptance or specification of alternate settings by CitiPower/Powercor, a suitable setting shall be agreed.

4.7.5 Synchronisation

Automatic synchronising and synchronisation check are required for all LV EG connections above 30kVA where it is intended that parallel operation of a generating unit will occur.

4.7.6 Additional Requirements for LV EG Non-IES

Additional protection functions may be required for EG Non-IES beyond those specified within Table 12 to allow for the differences between synchronous and asynchronous generator technology and applications on the LV network.

For further information regarding additional requirements above table 12, refer to CitiPower/Powercor 'Customer GL for LV connection EG V8 Final 22112018.pdf' in the link below:

<https://media.powercor.com.au/wp-content/uploads/2018/11/30122510/customer-gl-for-lv-connected-eg-v8-final-22112018.pdf>

4.8 Operating Voltage and Frequency

The operating voltage and frequency requirements can be found in above section 4.7 above containing the Inverter Integrated Protection requirements.

The nominated maximum voltage set point, V_{nom_max} as per AS/NZS 4777.2 is 255V.

The voltage rise of the installation is to be no greater than the requirement in Appendix F.2 (i) of AS/NZS 4777.1.

4.9 Metering

This section is noted as intentionally blank for Citipower and Powercor as being subject to Chapter 7 'Metering' of the NER.

4.10 Power Quality

4.10.1 Quality of Supply

All LV EG connections shall comply with the applicable power quality requirements of the AS/NZS 61000 series as well as relevant state-based regulations and licence conditions, including but not limited to:

1. Network voltage control
2. Voltage fluctuations
3. Harmonics
4. Voltage balance.

4.10.2 IES Power Quality Response Modes

Volt-watt and volt-var response modes specified in Clause 6.3.2.2 and Clause 6.3.2.3 of AS/NZS 4777.2 shall be enabled.

The following table specifies the volt response reference values, the volt-watt response set-point values and the volt-var response set-point values. These settings apply to ESS and hybrid (multimode) inverters.

| Voltage reference point | Volt-Watt | | Volt-Var | |
|-------------------------|-------------------|----------------------------------|-------------------|-------------------------------|
| | Voltage set point | Setting value (% of rated power) | Voltage set point | Setting value (% of rated VA) |
| V1 | 207V | 100% | 208V | +44% leading |
| V2 | 220V | 100% | 220V | 0 |
| V3 | 253V | 100% | 241V | 0 |
| V4 | 259V | 20% | 253V | -44% lagging |

Table 13: Power quality settings

Above table is current for Victoria wide settings. The setting points and values are consistent with the Model Standing Offer for CitiPower and Powercor.

Note that leading is sourcing vars to the grid (also known as 'exporting' or 'capacitive') and lagging is sinking vars from the grid (also known as 'importing' or 'inductive').

Where an additional LV EG unit is being added to a site with an existing LV EG connection that has legacy power quality settings, the above voltage response mode settings will be required for both the new and existing installation.

The power rate ramping requirements for the IES (and ESS for multimode inverters) shall be as per AS/NZS 4777.2 default settings.

Volt-Watt charging of energy storage devices shall be as per the default settings in AS 4777.2.

4.10.3 LV EG Non-IES Synchronous Power Quality Response

All synchronous LV EG Non-IES connections shall be designed and operated to adequately control real and reactive power output through either of the following power quality response modes:

1. Voltage control mode; OR
2. Fixed power factor mode that shall require achieving a power factor operating window at the connection point of typically 0.90 to 0.95 lagging and not leading unless otherwise agreed to or specified by CitiPower/Powercor.

The power quality response mode and settings shall be determined depending on the outcomes of technical studies carried out by the proponent to criteria specified by CitiPower/Powercor and approved by CitiPower/Powercor as part of the connection application process

4.11 Communications Systems

4.11.1 LV EG IES (excluding ESS) up to 200kVA Communications Systems

There are no communications systems for LV EG <200kVA and therefore this section has been left intentionally blank.

4.11.2 LV EG IES (excluding ESS) greater than 200kVA Communications Systems

For LV EG IES (excluding ESS) systems greater than 200 kVA, monitoring and control is required:

1. For safety reasons, all non-exporting systems shall have the same generator monitoring and control requirements as for exporting systems
2. For exporting systems:
 - a) Continuous monitoring of current per phase, active power flow and reactive power flow shall be required
 - b) The CitiPower/Powercor private communications network (e.g. radio, optical fibre or third-party networks such as mobile cellular carrier, xDSL, broadband, NBN, etc.) will be used unless otherwise specified
 - c) The proponent will be responsible for the set-up and monitoring of the communication link between the EG system and the CitiPower/Powercor data collection system
 - d) A scope specifying interface signal requirements for digital outputs/inputs and analogue outputs/inputs between CitiPower/Powercor and the EG system will need to be required to be prepared by CitiPower/Powercor
 - e) There may be communication signal fail-safe scheme requirements for remote monitoring (telemetry) and control functionality. Details shall include timing and expected outcome (e.g. reduce GDL or cease exporting)
 - f) The communications equipment DC supply requirements and associated fail-safe schemes will be specified in any scope prepared for the LV EG connection
 - g) Any inter-trip communications requirements (if applicable) and the

associated signal fail-safe scheme requirements may be specified in any scope prepared for the LV EG connection. These requirements may include details such as availability, integrity monitoring and maximum latency.

Refer to the CitiPower/Powercor 'Customer GL for LV connection EG V8 Final 22112018.pdf' in the link below for further details regarding remote generator monitoring and control of LV EG systems:

<https://media.powercor.com.au/wp-content/uploads/2018/11/30122510/customer-gl-for-lv-connected-eg-v8-final-22112018.pdf>

4.11.3 LV EG Non-IES (excluding ESS) Communications Systems

For LV EG Non-IES systems, the remote monitoring and control is the same as for all IES. Refer to sections 4.11.1 and 4.11.2 above for detailed requirements.

4.12 Data and Information

4.12.1 Static Data and Information

The proponent is to supply the static data and information to CitiPower/Powercor as per Appendix D: Static Data and Information. The data is to be provided to the CitiPower/Powercor contact person/email address used for the connection and approval of the IES.

4.12.2 Dynamic Data and Information

CitiPower and Powercor does not yet have any communications systems for LV EG connections to transmit dynamic data and information to us and/or any other bodies, and this section has been retained, and noted as intentionally blank.

4.13 Cybersecurity

CitiPower and Powercor does not yet have any communications systems requirements for LV EG connections other than contained in the document at the link below in relation to the generator monitor and generator input and output analogue and digital contacts, hence, this section shall be retained, but noted as intentionally blank.

<https://media.powercor.com.au/wp-content/uploads/2018/11/30122510/customer-gl-for-lv-connected-eg-v8-final-22112018.pdf>

4.14 Technical Studies

The following technical studies as shown in Table 14 are required to be carried out by the proponent or at the proponent's expense to enable connection to the distribution network. The studies will be checked by CitiPower/Powercor to confirm settings and suitability to connection to the network within the parameters allowed in the Distribution Code i.e. voltage, fault level, voltage fluctuations etc.

| Technical Studies | LV EG IES | | | | LV EG Non-IES | |
|------------------------------------|--------------|---------------|-----------|---------------|-----------------|-----------------|
| | ≤200kVA | | >200kVA | | Exporting | Non-exporting |
| | Exporting | Non-exporting | Exporting | Non-exporting | | |
| Voltage level (incl. power factor) | Not required | Not required | Required | Not required | May be required | May be required |
| Power flow | Not required | Not required | Required | Not required | Required | Required |
| Fault level | Not required | Not required | Required | Not required | Required | Required |
| Protection grading | Not required | Not required | Required | Not required | Required | Required |

Table 14: Technical Studies Required for LV EG Connections

CitiPower/Powercor will provide the necessary study parameters for the proponent to carry out the above studies as part of the connection application process.

The outputs required will be to demonstrate compliance to the Distribution Code requirements that CitiPower/Powercor is respondent to.

1. Fault level: not to increase the low voltage limit above plant ratings and Distribution Code requirements
2. Voltage fluctuations: loss of generation not to change voltage at the point of connection by more than 5%
3. Protection grading: to good practice as per requirements in the following document: <https://media.powercor.com.au/wp-content/uploads/2018/11/30122510/customer-gl-for-lv-connected-eg-v8-final-22112018.pdf>
4. Steady state voltage rise: no more than 2% at the point of connection (AS/NZS 4777.1 clause 3.3.3)
5. Recommended power factor or voltage control settings for non-IES LV EG

Where one or more of the technical studies do not meet the assessment criteria, CitiPower/Powercor shall provide the proponent with an alternative option which may include:

1. Alternative configurations and or settings for the generating systems
2. Network augmentation (and associated cost of network augmentation).

5 Fees and Charges

Fees and charges are applicable for LV EG connection application and/or technical review.

Refer to the following link for information about the solar connection process:

<https://www.powercor.com.au/customers/electricity-connections/solar-and-other-generation/>

Some of these fees and charges may be for meter reconfiguration and or replacement to facilitate the registration of solar generation. Refer to the following link:

<https://www.powercor.com.au/customers/electricity-connections/solar-and-other-generation/solar-meter-set-up-and-associated-charges/>

Refer to the link below for the latest CitiPower or Powercor Pricing Proposal:

<https://www.powercor.com.au/industry/retailer-resources/network-tariffs-and-charges/>

6 Testing and Commissioning

The testing and commissioning requirements for LV EG connections are as per Table 15 and include the following requirements:

1. Testing and commissioning plans shall be produced by the proponent and may be required to be signed off by CitiPower/Powercor prior to finalising the connection agreement
2. Testing and commissioning acceptance shall be signed off either by a CPEng, RPEQ (only in Queensland) or by a CitiPower/Powercor approved suitably qualified person
3. Testing and commissioning acceptance may require the CitiPower/Powercor to carry out witnessing at the CitiPower/Powercor's expense
4. For IES, testing and commissioning requirements shall be in accordance with AS/NZS 4777.1, AS/NZS 3000 and AS/NZS 5033 (where applicable), the equipment manufacturer's specifications and the CitiPower/Powercor's technical requirements to demonstrate that the LV EG IES system meets the requirements of the connection agreement. Compliance to AS/NZS 3000 and AS/NZS 5033 (where applicable) may be tested by suitably qualified local electrical authorities
5. For Non-IES, testing and commissioning requirements shall be in accordance with the equipment manufacturer's specifications and the CitiPower/Powercor's technical requirements to demonstrate that the LV EG non-IES system meets the requirements of the connection agreement. The technical settings that will be required to be tested, include protection settings, power quality settings, export limits, communications settings and shutdown procedures.

| Technical Studies | LV EG IES | | | | LV EG Non-IES | |
|---|-----------------|-----------------|-----------|-----------------|---------------|---------------|
| | ≤200kVA | | >200kVA | | Exporting | Non-exporting |
| | Exporting | Non-exporting | Exporting | Non-exporting | | |
| Protection settings and performance | Required | Required | Required | Required | Required | Required |
| Power quality settings and performance | Required | Required | Required | Required | Required | Required |
| Export limits settings and performance | Required | Required | Required | Required | Required | Required |
| Communications settings and performance | May be required | May be required | Required | May be required | Required | Required |
| Shutdown Procedures | Not required | Not required | Required | May be required | Required | Required |
| Confirm system is as per specifications | Required | Required | Required | Required | Required | Required |
| Confirm SLD is located on site | Required | Required | Required | Required | Required | Required |

Table 15: Testing and Commissioning Requirements for LV EG Connections

7 Operations and Maintenance

The operations and maintenance requirements for LV EG connections, including the following:

1. An operation and maintenance plan shall be produced and CitiPower/Powercor may require for it to be signed off prior to forming a connection agreement
2. The LV EG system shall be operated and maintained to ensure compliance with the connection agreement and all legislation, codes, and/or other regulatory instruments at all times
3. Operation and maintenance reports may be submitted to the CitiPower/Powercor at a specified interval no more frequently than annually
4. CitiPower/Powercor may inspect the LV EG system at any time at the DNSP's expense.

The general expectations for operating and maintaining LV EG systems are:

1. Maintaining the electrical installation at the supply address in a safe condition
2. Ensuring that any changes to the electrical installation at the supply address are performed by an electrician lawfully permitted to do the work and that the customer holds a Certificate of Compliance issued in respect of any of the changes
3. Seeking CitiPower/Powercor approval prior to altering the connection in terms of an addition, upgrade, extension, expansion, augmentation or any other kind of alteration, including changing inverter settings
4. CitiPower/Powercor does not allow connection of non-complying LV EG systems to the network. Further, if connection and energization of a LV EG has occurred without approval, any generation credits will not be registered at the installation meter. Post installation, consumers with non-complying LV EG systems will need to negotiate with CitiPower/Powercor over rectification actions required. CitiPower/Powercor has a number of actions that could be taken in response to the severity of the non-compliance that include disconnection for immediate safety issues.

Appendix A: Deviations from the National DER Connection Guidelines

This appendix shall include a register of all deviations from this technical guideline in the format provided in Table 16.

| Section | Description of deviation | Type of deviation | Justification |
|---------|--------------------------|-------------------|---------------|
| | | | |
| | | | |

Table 16: Table of Deviations from National DER Connection Guidelines

Appendix B: Connection Arrangement Requirements

This appendix includes:

1. Basic single line diagrams of CitiPower/Powercor's preferred connection arrangements, and a range of other possible connection arrangements for integration of an LV EG connection, showing:
 - a) the connection point
 - b) the point of common coupling
 - c) the EG unit(s)
 - d) load(s)
 - e) meter(s)
 - f) circuit breaker(s)
 - g) Isolator(s).

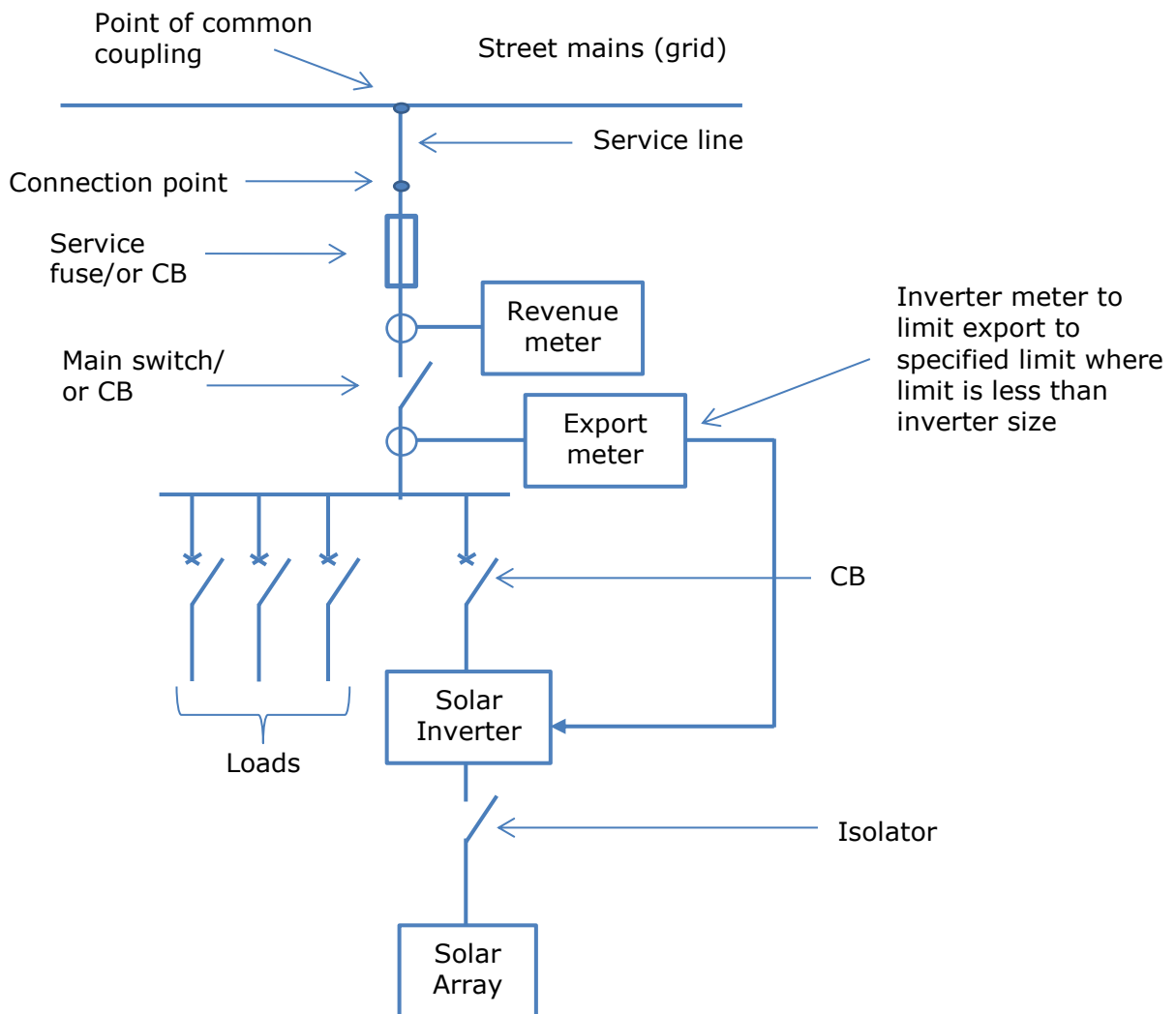


Figure 1: Basic solar Inverter only

CitiPower and Powercor
 Technical Guidelines for Low Voltage Embedded Generation Connections

2. A sample schematic diagram of the protection system and control system relevant to the connection of an LV EG unit to the distribution network, showing the protection system and control system, and including:
 - a) All relevant current circuits
 - b) Relay potential circuits
 - c) Alarm and monitoring circuits
 - d) Back-up systems
 - e) Parameters of protection and control system elements.

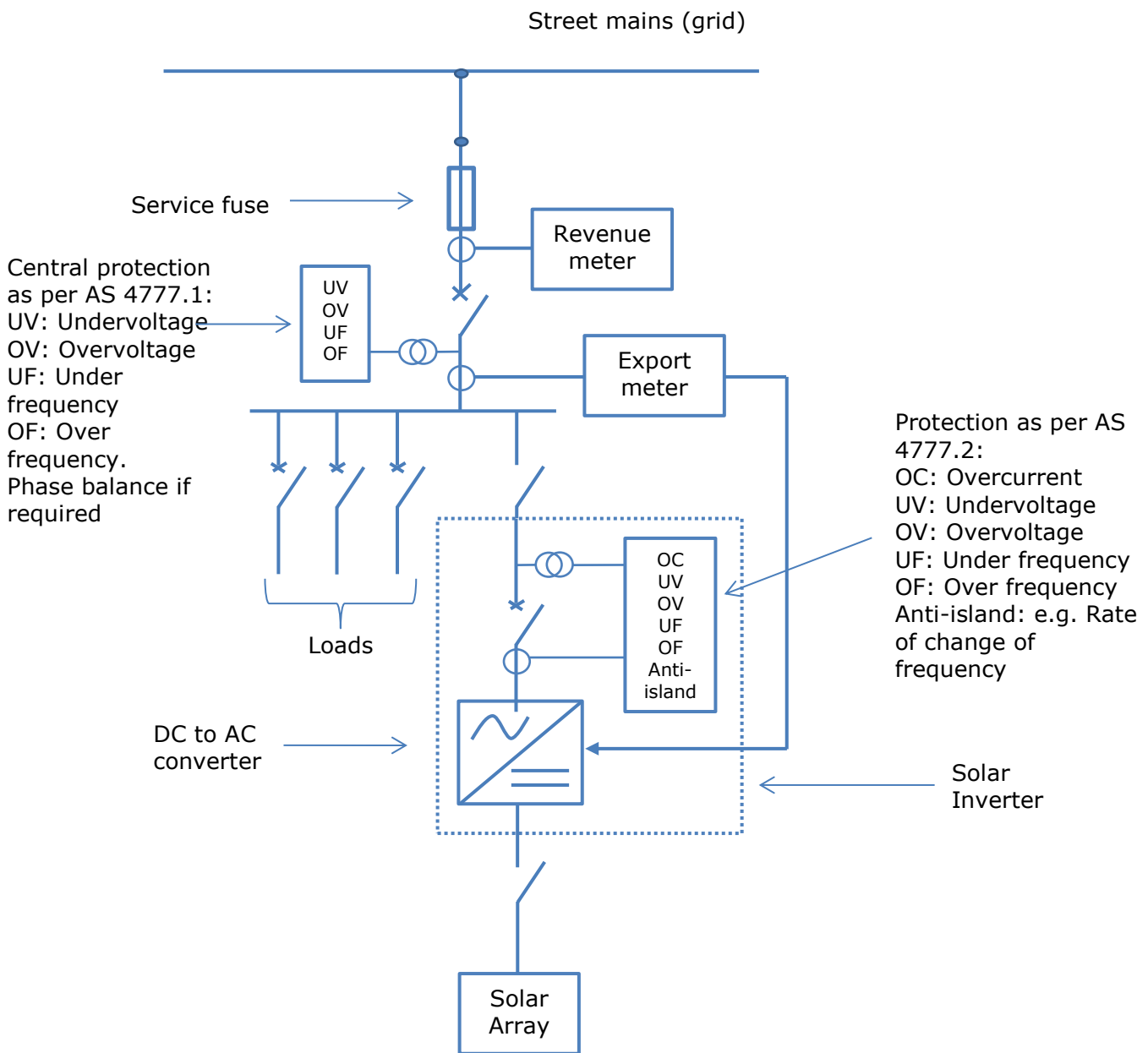


Figure 2: LV IES EG 30kVA-200kVA basic protection arrangement

Refer to the CitiPower/Powercor 'Customer GL for LV connection EG V8 Final 22112018.pdf' in

CitiPower and Powercor
Technical Guidelines for Low Voltage Embedded Generation Connections

the link below for further details regarding remote generator monitoring and non-IES LV EG systems:

<https://media.powercor.com.au/wp-content/uploads/2018/11/30122510/customer-gl-for-lv-connected-eg-v8-final-22112018.pdf>

Appendix C: Model Standing Offer

The deed for non-registered embedded generators (applicable for all LV generators not micro basic) for CitiPower and Powercor is available on the CitiPower/Powercor website at the following link:

<https://media.powercor.com.au/wp-content/uploads/2018/12/03134252/powercor-generator-deed-non-registered-market-participant-2017.pdf>

Appendix D: Static Data and Information

The following static data and information is required to be provided by the proponent to CitiPower/Powercor, as a minimum:

1. NMI meter numbers (10 digit)
2. DER Devices
 - a) Fuel source – primary {renewable/biomass/waste; fossil; hydro; geothermal; solar; wave; wind; tidal; storage}
 - b) Fuel source – descriptor {as per appendix 8 of the NEM Generator registration guide}
 - c) Make, model and manufacturer
 - d) Maximum capacity (kW or MW)
 - e) Storage capacity (kWh/MWh of available storage)
 - f) Installer
 - g) Whether the device is registered for ancillary service provision (Y/N)
 - h) Whether the device is part of an aggregated control (Y/N)
 - i) Whether the device is remotely controllable (Y/N)
 - j) Compliance with Australian Standards
3. Inverter
 - a) Make, model and manufacture
 - b) Whether the installer has changed the inverter default manufacturer settings (Y/N)
 - c) Maximum capacity (kW and kVA)
 - d) Date of installation
 - e) Compliance with Australian Standards
4. Inverter enabled modes of operation
 - a) Demand response modes enabled and enablement method
 - b) Power quality modes {power response (frequency control); voltage response (voltage-watt or voltage-var); Q (reactive power), PF (power factor); standalone}
5. Trip settings
 - a) Frequency trip settings {none, over-frequency, under frequency}
 - b) Voltage trip settings {none, over-voltage, under-voltage}