Sub 5MW Generator Commissioning and Compliance Testing Guideline

CitiPower Pty Ltd and Powercor Australia Ltd
Generation and Major Augmentation Manager
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Contents

Introduction

These guidelines are intended to cover the commissioning of generating systems typically between 2 MW and 5MW connecting to a CitiPower/Powercor distribution network. This guideline applies to both Customers seeking to connect new generating system to the network or to alter existing generating system.

The guidelines have been prepared to provide guidance on the generator commissioning procedure and requirement as part of the connection process.

The aim of these Guidelines is to ensure that:

- Reliability and quality of the grid supply to other Customers is not to be adversely affected by operation of the Customer's generating system.
- The safety of other Customers, CitiPower/Powercor employees and contractors is not compromised.
- The Customer's generating system is of an accepted design and capable of operating as per the design reliably for extended periods.
- The connection complies with the requirements of CitiPower/Powercor.

These Guidelines will cover:

- Commissioning and compliance testing process
- Communication protocol
- Compliance testing
- Pre-commissioning testing and requirements
- Generation commissioning and approval
- Metering / real-time data requirement during commissioning

The installation of a private generating system must comply with the Electricity Safety Act and its Regulations and it is the responsibility of the Customer intending to ensure the commissioning and operation of the generating system conforms to the requirement of all other Government and statutory authorities.

1. Commissioning and Compliance Testing Process

Following the execution of the connection agreement for the generator connection, commissioning and compliance testing are required to ensure the connection is compliant with CitiPower/Powercor technical performance standard requirement.

As part of the generator commissioning process, CitiPower/Powercor requires the Customer to perform compliance testing in two stages: pre-commissioning tests and commissioning tests.

As a prerequisite to commissioning tests, the Customer is required to perform the pre-commissioning tests and prepare all the required documentation (commissioning test request notice, pre-test simulation studies and voltage variation spreadsheet of the proposed commissioning tests). The detail of the pre-commissioning tests and requirements are available in Section 3 of this document.

The pre-commissioning test results along with all the required documentation for commissioning tests such as commissioning test request notice, commissioning test plan, and voltage variation spreadsheet of the proposed commissioning tests must be received by CitiPower/Powercor 10 business days prior to the proposed testing and commissioning date.

CitiPower/Powercor will review the commissioning test plan, pre-test simulation studies and provide an approval for the Customer to perform commissioning tests once it is satisfied that the proposed testings do not pose any risk to its network.

At the completion of commissioning test activities, the Customer is required to prepare a commissioning test report including all the test results and submit it to CitiPower/Powercor for review. CitiPower/Powercor will provide the approval for the completion of the commissioning process once they are satisfied with the commissioning report.

Within 2 months from the completion of commissioning process, the Customer is required to submit a post-commissioning model validation report which shows the final model parameters and the overlays between model simulation results and commissioning test results. The report is required to validate the generating system performance with PSS®E and/or PSCAD model simulation results. Once the post-commissioning model validation report is approved by CitiPower/Powercor, the connection process of the generating system is complete.

Refer to Figure 1 for a high level flowchart of the commissioning process, from pre-commissioning to commissioning test and the completion of generator connection process.

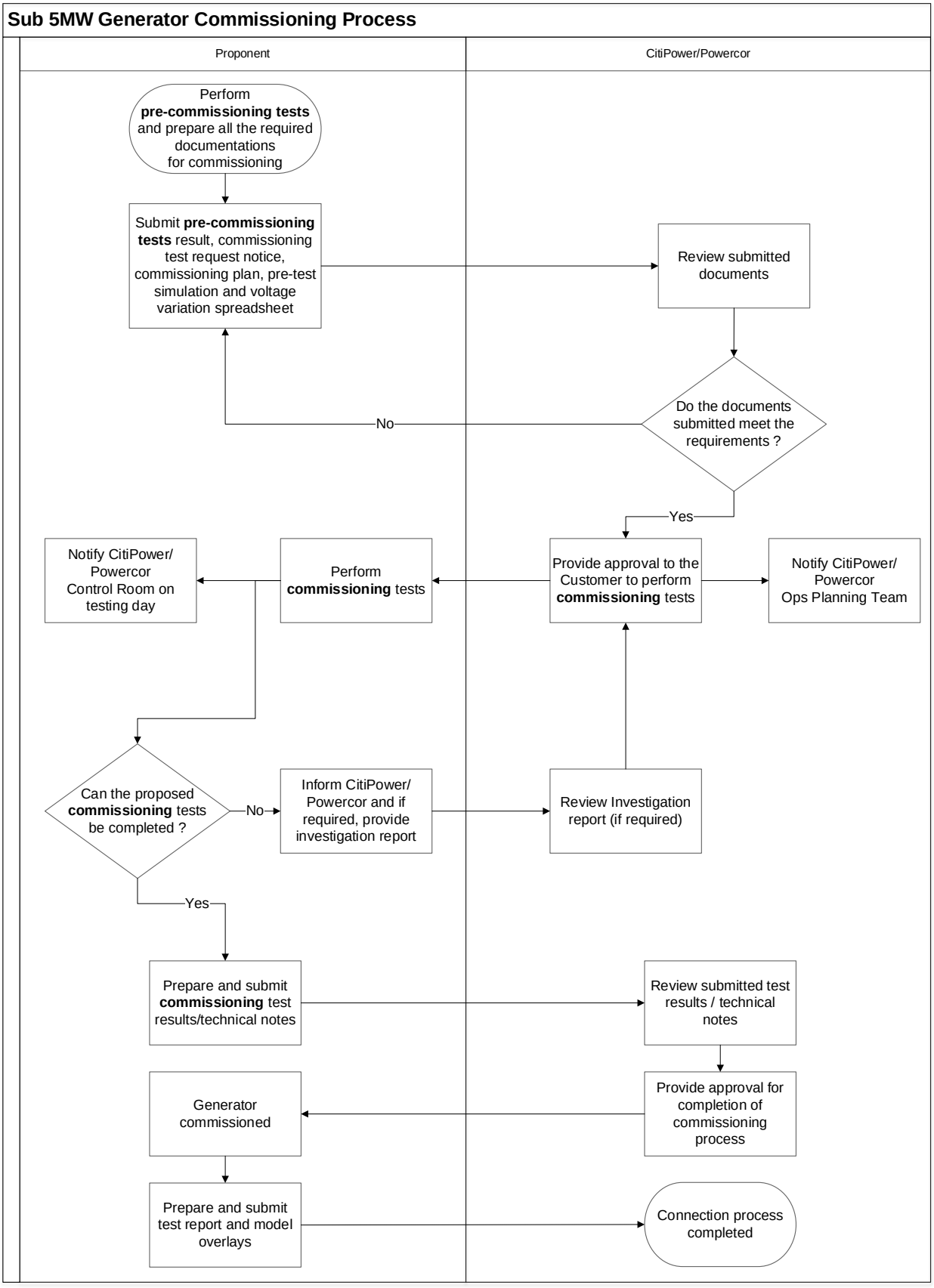

Figure 1 Flowchart Diagram of Sub 5 MW HV Generator commissioning process

2. Communication Protocol

The Customer is required to notify CitiPower/Powercor of its intention to perform commissioning and compliance testing of its generating system via the Customer Development Manager (CDM) and the Network Solutions Engineer(s) involved with the generation connection application. CitiPower/Powercor require minimum of 10 business days for the submission of all the required commissioning documents as described in Section 3 of this document.

The Customer is required to update the operational contacts in the commissioning test plan. The operational contacts shall include the CitiPower/Powercor Control Room number and the contact details of CitiPower/Powercor's commissioning support engineers.

As the Customer is required to perform compliance testing in two stages: pre-commissioning tests and commissioning tests, the Customer shall inform CitiPower/Powercor Control Room prior to commencement and at the completion of commissioning tests on the day of testing.

However, the pre-commissioning tests can be performed by the Customer without informing CitiPower/Powercor Control Room as the pre-commissioning tests are internal plant testings and do not have direct impact to CitiPower/Powercor network.

Once the Customer's generating system is fully commissioned, CitiPower/Powercor require the Customer to submit the full commissioning report of the testing performed and the overlays of test results with PSS®E and/or PSCAD model simulation results.

3. Pre-Commissioning Testing and Requirements

3.1 Pre-Commissioning Testing

At pre-commissioning testing stage, the generating system is still disconnected from the network and the following pre-commissioning compliance tests are to be performed:

- Power quality background measurement with generating system disconnected from the network (Refer to Appendix A for details)
- Protection system tests, and
- Communication system tests

When the compliance tests are completed at pre-commissioning test stage, test results and/or technical notes are to be submitted along with the notice of commissioning test, commissioning Plan, pre-test simulation studies to CitiPower/Powercor for its review and approval to progress to commissioning tests stage.

3.2 Notice of Commissioning and Testing

The Customer is required to inform CitiPower/Powercor of the intended date for the testing and commissioning of its generating system by submitting the notice of the testing at least 10 business days prior to commencing commissioning tests.

The Customer can submit the notice of testing via email to CitiPower/Powercor Customer Development Manager (CDM) assigned to the project and the Planning Engineer involved in the project. The email's subject shall be in the following format: "{Generator Name} Request to perform system testing - dd/mm/yy".

The notice of commissioning and testing submitted by the Customer requires to have at least the following information:

- Location
- Date of commissioning tests
- Summary of testing to be done
- System requirement or any relevant notes
- Contact Details of the personnel on the testing day

Table 1 shows a sample of test request notice for commissioning tests to be provided in the pre-commissioning stage.

NOTICE OF TESTING	
Location:	
From:	
To:	
Work to be done:	
System Requirements:	
Notes:	
Reference No:	
Contact Details on the day:	

Table 1. Sample of commissioning tests request notice

3.3 Commissioning Test Plan

The commissioning test plan submitted by the Customer shall provide at least the details of the generating system, metering recording device, the proposed commissioning tests and the methodology of the tests to be performed.

The commissioning test plan shall include the risk assessment on each of the tests to be performed and the mitigation control of any risk identified. CitiPower/Powercor will review the commissioning test plan and provide approval for the Customer to proceed with the proposed commissioning tests.

3.4 Pre-test Simulation Studies

The Customer who intends to connect its embedded generator to CitiPower/Powercor network must perform the pre-test simulation studies prior to the proposed commissioning tests for CitiPower/Powercor review and approval.

The Customer shall contact CitiPower/Powercor for the network data and criteria that are suitable for its generating system operation prior to submission of the pre-test simulation studies.

The pre-test simulation studies need to provide an evidence that the proposed commissioning tests will not cause any detrimental impact / adverse impact to the CitiPower/Powercor network by verifying the extend of network voltage and reactive power during the commissioning tests. The acceptable voltage range on the high

voltage distribution network to minimise impact of the proposed commissioning tests is 22kV to 23kV (for 22kV connection voltage) and 11kV to 11.5kV (for 11kV connection voltage). The pre-test simulation studies are required to show the network voltage at point of connection as a result of the Commissioning tests are within the above specified range.

The pre-test simulation studies for the proposed commissioning tests are to be performed with:

- Static voltage change studies with transformer tap in locked position on High Voltage (HV) distribution network to minimise impact to customers along the feeder with the proposed commissioning tests.
- Dynamic simulation studies using Single Machine Infinite Bus (SMIB) model for the proposed commissioning tests. These studies are optional in most cases, however CitiPower/Powercor will advise the Customer when these studies are required as part of the review of the pre-test simulation studies.

3.5 Voltage Variation Spreadsheet and test schedule

The Customer shall provide a summary of the voltage step changes of the proposed commissioning tests in a spreadsheet format to CitiPower/Powercor for review. The summary document shall contain at least the proposed date and time, the procedure of commissioning tests to be performed, the expected voltage at point of connection and the expected voltage changes as a result of proposed commissioning tests.

4. Compliance Testing

The compliance testing is required to be performed by the Customer on the proposed generating system prior to being fully commissioned or operating commercially. The compliance testing is to ensure that the proposed generating system can meet the technical performance standards set out by CitiPower/Powercor during commissioning and ongoing basis. The generation system is required to be able to generate at least 80% of the maximum generation output to the network during commissioning tests for the testing results to be accepted.

The following sections describe the typical tests required to be performed during commissioning process noting that CitiPower/Powercor may request additional tests based on the type and size of proposed plant or generation system and the location where the proposed generating system is installed:

4.1 Power Quality Testing

The power quality test is to measure background power quality at the connection point before and after the commissioning of the generation system.

CitiPower/Powercor recommends that the power quality tests to be commenced by the Customer as soon as the Point of Connection of its generating system is energised. This is due to the Power Quality tests in the pre-commissioning tests requires minimum of 30 days of measurement to satisfy the requirement of this test.

The power quality test is required in both pre-commissioning tests and commissioning tests.

Refer to Appendix A for details of CitiPower/Powercor power quality test requirement.

4.2 Protection System Testing

The protection system testing is to confirm the generating system protection relay, voltage and frequency protection settings have been set and tested in accordance with agreed protection setting and CitiPower/Powercor technical requirements.

The tests are performed and done via secondary injection testing.

The protection system test is performed as part of pre-commissioning tests.

4.3 Communications Testing

The communications testing is to confirm SCADA functionality and operation including the communication equipment operation and feedback signals.

The test shall be performed on the communication system and PQM for Power Plant Controller (PPC) by validating whether the PPC transmits signals to the generating units correctly via SCADA.

The communications failure test shall be performed as part of pre-commissioning tests.

4.4 Power Factor Reference Step Testing

The power factor reference step test is to assess the generating system reactive power capability and to validate the PPC power factor control model and parameters.

The test shall be performed over a range of power factor setpoints at the connection point from 0.95 capacitive operating power factor (exporting var) to 0.90 inductive operating power factor (absorbing vars) in suitable step change. A minimum of 1 minute delay between each step change is required to reduce unnecessary tap changes of the transformers at the CitiPower/Powercor zone substations. The extent of the power factor setpoints and the associated step changes for the test are determined based on the pre-test simulation studies and they may vary depending on size of generation and the area / network location / season etc.

The power factor reference test shall be performed as part of commissioning tests.

4.5 Active Power Control Testing

The active power control test is to assess the generating system response to different active power setpoints set by the generating system's Power Plant Controller (PPC).

The test shall be performed over a range of different active power setpoints with agreed generating system control mode (i.e. power factor control/voltage control) as per the connection deed. The typical active power setpoints performed for the test is ranging from 100% to 25% of the generating system maximum output in steps (100% – 50% - 25% - 50% - 100%).

The active power control test shall be performed as part of commissioning tests.

4.6 Generation Run Back Testing

The generation run back testing is to assess the generating system capability to comply with the trip or runback scheme operation required as part proposed generating system connection to the network.

The test shall be performed by initiating a trip or runback signal at the generating system receiving ends. The test will determine whether the generating system can trip or decrease generation output to zero from maximum output within required timeframe in the trip or runback scheme.

The generation run back test shall be performed as part of commissioning tests.

4.7 Partial Trip Testing

The partial trip testing is to access the generating system stability when part of the generating units is tripped.

The test shall be performed with the generating system is operating at agreed control mode and setpoint. The trip signal will then be initiated at the generating system to determine whether it can maintain continuous uninterrupted operation on the remaining generating units after partial tripping concludes.

The partial trip testing shall be performed as part of commissioning tests.

5. Generation Commissioning and Approval

At commissioning testing stage, the generator is no longer constrained and can perform the required commissioning compliance tests at full output/export of its generation system. CitiPower/Powercor requires the compliance tests performed under commissioning stage to be at least 80% of the maximum output of the generation system.

The following commissioning compliance tests are required to be performed:

- Power quality test
- Power factor reference step test
- Active power control test
- Generation run back testing
- Partial trip testing

Note that the list of compliance tests mentioned in this section is not exhaustive and different type of tests may be requested by CitiPower/Powercor if they are deemed necessary to assess the generation technical performance requirements.

When the compliance tests are completed with the test results or technical note provided by the Customer reviewed and accepted by CitiPower/Powercor, the generating system will be allowed to start generating to CitiPower/Powercor network.

For the completion of connection process, CitiPower/Powercor require the Customer to submit the post-commissioning model validation report which shows the final model parameters and the overlays between commissioning test results and PSS®E and PSCAD simulation results within two months from the completion of commissioning tests.

6. Metering / real-time data requirement during commissioning

CitiPower/Powercor require Customer to install high-speed measurement device to measure instantaneous and RMS voltage (V), current (I) for each phase, as well as RMS voltage, current, frequency (f), active power (P), reactive power (Q) and power factor (PF) at the point of connection. The high-speed measurement device shall have capability to measure the data with a sampling rate of 10ms or less.

The detail of the metering / measurement devices is available from the interface document between CitiPower/Powercor and the Customer during design stage and/or as part of generation connection deed.

The high-speed measurement device shall be used to obtain the testing data during commissioning in order to provide accurate data of the generating system performance.

7. Safety

Embedded generators should ensure that safety legislation and standards are complied with including any additional conditions that may be applied by the DNSP. These should include consideration of the connection assets and site security.

Where an embedded generator operator is required to undertake works in the vicinity of DNSP assets, the embedded generator is required to use appropriate practices as per the requirements of 'the green book' code of practice and in consultation with the DNSP.

No tests should be undertaken if the Customer identifies potential consequential damage to the generating system. If there are any risks identified, they should be discussed internally and the required variations to the test procedure must be agreed with CitiPower/Powercor and documented as part of the compliance reporting.

For safety and work efficiency, roles and responsibilities of different parties must be clearly defined and accepted. It will be important that everyone involved is aware of the safety risks, of issues that may endanger the generating system, and of the test procedures, and that the risks would be minimised by proper coordination and communication between the parties involved.

8. Contact

Refer to the '*Connecting generation*' section of the CitiPower/Powercor website (www.powercor.com.au) for contact details.

Appendix A

Embedded Generator Connection Guidance
Power Quality Allocations and Compliance Testing

Purpose

The purpose of this guidance note is to inform parties seeking connection to the CitiPower/Powercor network on their obligations regarding power quality. This includes the high-level processes for the definition of power quality allocations and CitiPower/Powercor's requirements for embedded generators undertaking commissioning.

Introduction

The National Electricity Rules (Rules) apply specific obligations for power quality onto both CitiPower/Powercor, as a distribution network service provider, and any parties seeking to connect generation to the Powercor network within the Rules framework.

The key obligations within the Rules, with their associated technical standards are as follows:

- CitiPower/Powercor's obligations under S5.1a.6 and specifically Australian Standard AS 61000.3.6:2001. It should be noted that the successor standard (AS/NZS TR IEC 61000.3.6:2012) is not explicitly referenced in the Rules and therefore cannot be applied;
- CitiPower/Powercor's obligations under S5.1a.5 and specifically Australian Standard AS 61000.3.7: 2001. It should be noted that the successor standard (AS/NZS TR IEC 61000.3.7.2012) is not explicitly referenced in the Rules and therefore cannot be applied; and
- A generator's obligations under power quality performance standard in the connection agreement

CitiPower/Powercor undertake to apply these rules and standards in defining an acceptable power quality allocation for any proposed new or modified connection on the CitiPower/Powercor network.

Power Quality Allocations

CitiPower/Powercor provide power quality allocations to all generators connecting to its network. These allocations are provided on a shared basis across all Customers, with allocations based upon relative use of network capacity within the relevant terminal station supply area. These allocations are based upon CitiPower/Powercor's own obligations to the Australia Energy Market Operator (AEMO), at our points of connection to the shared transmission network. As a result, CitiPower/Powercor is not able to provide our entire allocation from AEMO to any single embedded generator or large Customer without breeching our own connection obligations to AEMO.

Power quality allocations imposed by AEMO onto CitiPower/Powercor, and shared by CitiPower/Powercor across our Customers consist of the following elements:

- Voltage harmonic emission limits, specified from the 2nd order through to the 50th order, with an associated Total Harmonic Distortion (THD) in addition to 'Non-Integral Distortion' limits;
- Flicker (voltage fluctuation) emission limits, provided as both short term and long term allocations; and
- A 'Negative Sequence Voltage' limit (i.e. voltage unbalance).

CitiPower/Powercor require all generators to demonstrate and maintain compliance to the level of performance that has been agreed as part of the connection process. These generator performance standards, once agreed, will be documented within the connection contract.

Harmonic Mitigation & Filtering

In many areas of the CitiPower/Powercor network, our obligations to AEMO who is the Victorian Transmission Planner, at our connection to the transmission network dictate that only very limited power quality allocations can be provided to any prospective generator who is seeking a connection to the network. In these cases, recent experience has shown that large scale generating systems comprised of inverter connected generators will likely require harmonic filtering in order to achieve compliance.

Any harmonic filter or filters must be appropriately design and sized in order to ensure compliance with the agreed performance standards at the point of connection for all foreseeable network conditions and operating states, including when the generating system is exporting no or low active power.

Power Quality Compliance Testing

CitiPower/Powercor require all generators connecting to CitiPower/Powercor network to demonstrate their ability to meet their agreed performance standards at the time of commissioning and on an ongoing basis where required. This evaluation must be in accordance with the standards and processes applicable under CitiPower/Powercor requirement.

Specifically, for commissioning tests, CitiPower/Powercor require that any generator connecting to CitiPower/Powercor network to be able to demonstrate their performance against the existing network conditions at their connection point prior to the connection of their generating system. This 'background' power quality measurement must be taken as close as practically possible to the commencement of commissioning testing and be measured for a duration of no less than thirty (30) consecutive days*. If this may not be possible due to construction timing for a new connection point dispensation can be provided to record the background harmonic data at an existing network point which is closer to the connection point. These data can be verified with a short background validation taken once the connection point is constructed.

The power quality performance of the generating system that is recorded as part of any commissioning process or 'hold point' testing must be compared against the background level in order to demonstrate compliance with generator performance standards. As network harmonics and potential network resonances can vary substantially with network loading, it may be required to repeat background testing during the commissioning process if power quality at the connection point is shown to have changed substantially from the initial background power quality measurement.

Where it is practically possible to do so, all comparisons for the purposes of demonstrating compliance with power quality performance standards should be made against periods of stable generation.

The table below specifies the test periods required to demonstrate compliance to the GPS.

Hold Point	**Test requirements for the maximum of the average (rms) individual voltage harmonics in each phase sampled at 10 minute intervals**	**Test requirements for 1, 10- and 30-minute average (rms) negative sequence (unbalance) voltage**	**Test requirements for the 99th percentile of the measured P_{lt} (2 hours) and P_{st} (10 minutes)**
HP0 (no generation) with the generation system fully disconnected (Pre-Commissioning Testing)	Minimum 30 day background test	Minimum 30 day background test	Minimum 30 day background test
HP1 with generating system maximum output (Commissioning Testing)	Minimum 14 days to compare against 30 day background test for compliance to emission limits Within 30 days of Final Hold Point testing, a power quality assessment report to be produced with assessment on measurements at Hold Points to compare against 30 day background test for compliance to emission limits.	Minimum 14 days to compare against 30 day background test for compliance to emission limits Within 30 days of Final Hold Point testing, a power quality assessment report to be produced with assessment on measurements at Hold Points to compare against 30 day background test for compliance to emission limits.	Minimum 14 days to compare against 30 day background test for compliance to emission limits Within 30 days of Final Hold Point testing, a power quality assessment report to be produced with assessment on measurements at Hold Points to compare against 30 day background test for compliance to emission limits.
Post Commissioning	Minimum of 30 consecutive days to show compliance with both planning and emission limits (against the 30 day background).	Minimum of 30 consecutive days to show compliance with emission limits (against the 30 day background).	Minimum of 30 consecutive days to show compliance with both planning and emission limits (against the 30 day background).

*Minimum 30 days background required for all inverter based connections (Wind, Solar, Battery). Shorter time period can be negotiated for synchronous or load connections.

Definitions

Term	Definition
AEMO	Australian Energy Market Operator.
DNSP	Distribution Network Service Provider.
Active Power	The component of an AC electric current which is converted to mechanical power or to heat.
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.
Point of Connection	The point on a distribution feeder at which an embedded generator is connected to the distributor's network.
Distribution Network	A network which is not a transmission network.
Power Factor	A measure of the relative proportions of active power and reactive power in an AC load current; if power factor = 1, all current is used in producing heat or mechanical power; if power factor = 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.
High Voltage	In this document High Voltage refers to voltages between 1kV and 66kV. Typically in the CitiPower and Powercor networks this will be the voltages that the Distribution Feeders operate at, 6.6kV, 11kV or 22kV phase to phase.
PQM	Power Quality Metering
PPC	Plant Power Controller
CDM	Customer Development Manager who is the customer interface for the associated generation connection application

Standards and Guidelines

The following lists are not necessarily updated and not exhaustive. They are intended as a guide to prospective Embedded Generators. It is incumbent on the proponent and proponents' consultant to ensure that the project complies with appropriate standards, guidelines and rules.

Australian Standards

Australian Standards are employed by the DNSP's to provide a standard approach for technical requirements. Below is a table that provides a list of relevant Australian Standards.

Australian Standard	Standard Title
AS 1319	Safety signs for occupational environment
AS 1359	General Requirements for Rotating Electrical Machines
AS 1931	High Voltage Test Techniques
AS 2006	Diesel Generators/internal combustion engines
AS 2067	Substations and high voltage installations exceeding 1 kV a.c.
AS 2344	Limits of electromagnetic interference from overhead a.c. powerlines and HV equipment installations in 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/NZS3100	Approval and test specification – General requirements for electrical equipment

AS 4509	Stand-alone power systems, Parts 1,2,3
AS 4777	Grid Connection of Energy Systems via Inverters, Parts1, 2, 3
AS/NZS 5033	Installation of photovoltaic (PV) arrays
AS 60038	Standard Voltages
AS/NZS 60265.1	High-voltage switches - Switches for rated voltages above 1 kV and less than 52 kV
AN/NZS 61000 Series	Electromagnetic Compatibility
AS 62271 Series	High-voltage switchgear and control gear
AS/NZS 7000	Overhead line design standard

Other International Standards

To assist in providing a standard approach for technical requirements below is a table of International standards and guidelines which may be referred to.

The following list is not necessarily updated and not exhaustive. It is intended as a guide to prospective Embedded Generators. It is incumbent on the proponent and proponents' consultant to ensure that the project complies with appropriate standards, guidelines and rules.

Standard	Document Title
IEEE 519	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
G59[1]	Recommendations for the connection of embedded generating system to the DNO's distribution systems and the provision of standby generators
ETR 113[2]	Engineering Technical Report No ETR 113

[1] Energy Networks Association (UK)

[2] Energy Networks Association (UK)

Other CitiPower/Powercor Guidelines

This document shall be read in conjunction with other relevant CitiPower/Powercor Guidelines such as:

- Customer Guideline – HV Distribution Connected Embedded Generation
- HV Generator Performance Standard Guideline for Sub 5MW Generators