



Part of Energy Queensland

# **Power Quality Reporting Guideline for Embedded Generators (30kVA – 1,500kVA)**

# Power Quality Reporting Guideline for Embedded Generators (30kVA - 1,500kVA)



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## 1. PURPOSE AND SCOPE

The purpose of this document is to provide details on how the Power Quality (PQ) parameters are to be presented as part of the Compliance Report (CR).

This document provides the time requirements for data collection from the relevant standards to be met. At the same time, it does not intend to set out how the testing is to be undertaken.

## 2. DEFINITIONS, ABBREVIATIONS AND ACRONYMS

| Term  | Definitions  |
|-------|--|
| CR    | Compliance Report  |
| DNISP | Distribution Network Service Provider (Ergon Energy and Energex) |
| EG    | Embedded Generation  |
| IES   | Inverter Energy System   |
| LV    | Low Voltage, voltage less than 1,000Vac                          |
| PQ    | Power Quality  |
| RPEQ  | Registered Professional Engineer Queensland                      |
| TDD   | Total Demand Distortion  |
| THD   | Total Harmonic Distortion  |

## 3. REFERENCES

### 3.1. Energex and Ergon Energy controlled documents

A copy of the latest version of these documents may be obtained by searching for their number on the following websites: <https://www.energex.com.au> or <https://www.ergon.com.au/network>.

| Document number | Document name  |
|-----------------|--|
| STNW1174        | <a href="#">Standard for Low Voltage EG Connections - 3055320</a>  |
| STNW1175        | <a href="#">Standard for High Voltage EG Connections - 2946177</a> |
| STNW3522        | <a href="#">Standard for Major Customer Connections - 9148501</a>  |

### 3.2. Australian and International Standards

| Document number          | Document name  |
|--------------------------|--|
| IEEE519                  | Recommended Practice and Requirements for Harmonic Control in Electric Power Systems   |
| AS/NZS 61000.3.7         | Limits - Assessment of emission limits for fluctuating loads in MV and HV power systems  |
| AS/NZS TR IEC 61000.3.14 | Limits - Assessment of emission limits for harmonics, inter-harmonics, voltage fluctuations and unbalance for the connection of disturbing installations to LV power systems |

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## 4. BACKGROUND

A Compliance Report (CR) is to be submitted by the proponent for Embedded Generation (EG) systems greater than 30kVA up to 1500kVA connected on LV, or HV. The CR is to be certified by a Registered Professional Engineer of Queensland (RPEQ) to demonstrate the testing/measurements comply with the Power Quality (PQ) parameter requirements as set out in the Technical Study document provided by the DNSP for the proposed EG installation.

The PQ demonstration requirement within the CR is to confirm compliance to PQ parameters, allocation of harmonics, flicker and voltage unbalance if required, as per the Technical Study. This document provides guidelines on how the harmonics, flicker and unbalance test results must be presented as part of the CR where PQ demonstration is required.

The allocation and measurement of PQ parameters is at the Connection Point. All electrical loads at the customer's installation within the Connection Point shall need to be made active as per normal operating circumstances within the period of measurement.

The duration of measurement specified in Sections 4.1 and 4.2 is considered the minimum. If it is found that PQ parameters exceed the limits, it may be required to extend the data observations as per Section 8.

### 4.1. For EG Systems > 30kVA to ≤ 200kVA

The period of observation shall be 3 (continuous) days, for power quality data under normal operating conditions.

One day of this period shall be without the EG unit operating. Alternatively, two instances when the EG unit is not operating, totalling 24 hours, this period shall cover a normal business day. The remaining 2 days will be with the EG unit operating.

The data (parameters) shall:

1. Capture two repeated cycles (with the EG operating) from the lowest output to a maximum output and back to the lowest. The two operating cycles shall total to a minimum of 24 hours. The operating output range expected would typically be 10%-90% of the approved maximum output of the EG unit.
2. Be observed in 10-minute intervals for the entire observation period.

### 4.2. For EG Systems > 200kVA to ≤ 1,500kVA

For connections with an aggregate capacity greater than 200kVA, where the above conditions and operating ranges in Section 4.1 could not be achieved, the observation period shall be extended up to 7 continuous days.

One day of this period shall be without the EG unit operating. Alternatively, two instances when the EG unit is not operating, totalling 24 hours, this period shall cover a normal business day.

### 4.3. Maximum of 10 minute Values

All parameter values should be based on the 99th percentile of the maximum value of the 10-minute value for each parameter. These values should be presented in tabulated form against the allocation values provided by Ergon Energy or Energex.

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Recording equipment should provide recorded values for each phase. Providing the values for each phase is acceptable, but the average across the phases is the minimum requirement.

Relevant charts and data files can be provided for information; however, tables are mandatory. If requested, logged data shall be forwarded to the DNSP in a timely manner, preferably in a Microsoft Excel file or CSV file format.

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## 5. HARMONICS

### 5.1. Low Voltage (LV) Connection

For LV connections, harmonic allocations are provided in current (A) form for individual harmonics from 2 - 40th order, as per the example in Table 1. The Total Demand Distortion (TDD<sub>i</sub>) value will also be provided.

**Table 1: Example of supplied harmonic current emissions limits at 230/400V**

| Harmonic Order | Emission Limit (as allocated) at Connection Point (A) | Harmonic Order       | Emission Limit (as allocated) at Connection Point (A) |
|----------------|---|----------------------|---|
| 2              | 6.71  | 22                   | 2.68  |
| 3              | 26.84   | 23                   | 4.03  |
| 4              | 6.71  | 24                   | 1.02  |
| 5              | 26.84   | 25                   | 4.03  |
| 6              | 6.71  | 26                   | 1.02  |
| 7              | 26.84   | 27                   | 4.03  |
| 8              | 6.71  | 28                   | 1.02  |
| 9              | 26.84   | 29                   | 4.03  |
| 10             | 6.71  | 30                   | 1.02  |
| 11             | 12.08   | 31                   | 4.03  |
| 12             | 3.03  | 32                   | 1.02  |
| 13             | 12.08   | 33                   | 4.03  |
| 14             | 3.03  | 34                   | 1.02  |
| 15             | 12.08   | 35                   | 1.88  |
| 16             | 3.03  | 36                   | 0.48  |
| 17             | 10.73   | 37                   | 1.88  |
| 18             | 2.68  | 38                   | 0.48  |
| 19             | 10.78   | 39                   | 1.88  |
| 20             | 2.68  | 40                   | 0.48  |
| 21             | 10.73   | TDD <sub>i</sub> (%) | 32.20   |

The results should be presented as shown in

Table 3.

The Alpha ( $\alpha$ ) values for the General Summation Law are as per Table 2.

**Table 2: Summation exponent for harmonics**

| Harmonic Order     | $\alpha$ |
|--------------------|----------|
| $h < 5$            | 1        |
| $5 \leq h \leq 10$ | 1.4      |

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|      |   |
|------|---|
| h>10 | 2 |
|------|---|

**Table 3: CR table of allocated harmonic limits and test result values - Current**

| Harmonic Order             | Emission Limit at Connection Point (A) for Full Load (as allocated)<br>(Example limits) | Emission Test Results EG <u>ON</u> (99 <sup>th</sup> percentile of the 10-minute values) (A) | Emission Test Results EG <u>OFF</u> (99 <sup>th</sup> percentile of the 10-minute values) (A) | General Summation Law<br>$(I)h$<br>$= \sqrt[\alpha]{abs(I_{on}^\alpha - I_{off}^\alpha)}$ |
|----------------------------|---|--|---|---|
| 1                          |   |  |   |   |
| 2                          | 6.71  |  |   |   |
| 3                          | 26.84   |  |   |   |
| 4                          | 6.71  |  |   |   |
| 5                          | 26.84   |  |   |   |
| 6                          | 6.71  |  |   |   |
| 7                          | 26.84   |  |   |   |
| 8                          | 6.71  |  |   |   |
| 9                          | 26.84   |  |   |   |
| 10                         | 6.71  |  |   |   |
| 11                         | 12.08   |  |   |   |
| 12                         | 3.03  |  |   |   |
| 13                         | 12.08   |  |   |   |
| 14                         | 3.03  |  |   |   |
| 15                         | 12.08   |  |   |   |
| 16                         | 3.03  |  |   |   |
| 17                         | 10.73   |  |   |   |
| 18                         | 2.68  |  |   |   |
| 19                         | 10.78   |  |   |   |
| 20                         | 2.68  |  |   |   |
| 21                         | 10.73   |  |   |   |
| 22                         | 2.68  |  |   |   |
| 23                         | 4.03  |  |   |   |
| 24                         | 1.02  |  |   |   |
| 25                         | 4.03  |  |   |   |
| 26                         | 1.02  |  |   |   |
| 27                         | 4.03  |  |   |   |
| 28                         | 1.02  |  |   |   |
| 29                         | 4.03  |  |   |   |
| 30                         | 1.02  |  |   |   |
| 31                         | 4.03  |  |   |   |
| 32                         | 1.02  |  |   |   |
| 33                         | 4.03  |  |   |   |
| 34                         | 1.02  |  |   |   |
| 35                         | 1.88  |  |   |   |
| 36                         | 0.48  |  |   |   |
| 37                         | 1.88  |  |   |   |
| 38                         | 0.48  |  |   |   |
| 39                         | 1.88  |  |   |   |
| 40                         | 0.48  |  |   |   |
| <i>TDD<sub>I</sub></i> (%) | 32.20   |  |   |   |

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## 5.2. High Voltage (HV) Connection (11kV, 22kV, 33kV)

For HV connections, the harmonic allocation values are provided as voltage (V) values in a format like Table 1. Again, when presenting the results of the harmonic testing, the results should be based on a minimum recorded period. The values should be presented in a format as shown in Table 4 based on the 99th-percentile of the 10-minute measured maximum values per phase.

**Table 4: CR table of allocated harmonics and testing result values - voltage**

| Harmonic Order | Emission Limit at Connection Point for Full Load (V)<br>(as allocated)<br>(Example limits) | Emission Test Results with EG ON<br>(99 <sup>th</sup> percentile of the 10-minute values) (V) | Emission Test Results with EG OFF<br>(99 <sup>th</sup> percentile of the 10-minute values) (V) | General Summation Law<br>$V_h = \sqrt[\alpha]{abs(VOn^\alpha - VO f f^\alpha)}$ |
|----------------|--|---|--|---|
| 1              |  |   |  |   |
| 2              | 0.12   |   |  |   |
| 3              | 0.24   |   |  |   |
| 4              | 0.05   |   |  |   |
| 5              | 1.55   |   |  |   |
| 6              | 0.09   |   |  |   |
| 7              | 1.2  |   |  |   |
| 8              | 0.09   |   |  |   |
| 9              | 0.33   |   |  |   |
| 10             | 0.12   |   |  |   |
| 11             | 2.33   |   |  |   |
| 12             | 0.11   |   |  |   |
| 13             | 2.14   |   |  |   |
| 14             | 0.11   |   |  |   |
| 15             | 0.18   |   |  |   |
| 16             | 0.15   |   |  |   |
| 17             | 1.40   |   |  |   |
| 18             | 0.15   |   |  |   |
| 19             | 0.94   |   |  |   |
| 20             | 0.15   |   |  |   |
| 21             | 0.15   |   |  |   |
| 22             | 0.15   |   |  |   |
| 23             | 1.11   |   |  |   |
| 24             | 0.15   |   |  |   |
| 25             | 0.64   |   |  |   |
| 26             | 0.15   |   |  |   |
| 27             | 0.15   |   |  |   |
| 28             | 0.15   |   |  |   |
| 29             | 0.61   |   |  |   |
| 30             | 0.18   |   |  |   |
| 31             | 0.18   |   |  |   |
| 32             | 0.18   |   |  |   |
| 33             | 0.18   |   |  |   |
| 34             | 0.18   |   |  |   |
| 35             | 0.60   |   |  |   |
| 36             | 0.18   |   |  |   |
| 37             | 0.18   |   |  |   |
| 38             | 0.18   |   |  |   |



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|         |       |  |  |
|---------|-------|--|--|
| 39      | 0.18  |  |  |
| 40      | 0.18  |  |  |
| THDv(%) | 1.89% |  |  |

## 6. FLICKER

The flicker limits for the EG connection are specified as Flicker short term Pst and Flicker long term Plt. The LV flicker limits are allocated as per STNW1174 and shown in Table 5.

**Table 5: LV Flicker limits**

| Connection Type                    | Pst  | Plt  |
|------------------------------------|------|------|
| Dedicated distribution transformer | 0.50 | 0.40 |
| Shared distribution transformer    | 0.30 | 0.25 |

The flicker emission shall be measured over the same period as harmonics. The measured values should be presented as per Table 6.

**Table 6: Flicker values - measured**

|                 | Flicker limits as allocated | Measured Flicker with EG ON (99 <sup>th</sup> percentile of the 10-minute values) | Measured Flicker with EG OFF (99 <sup>th</sup> percentile of the 10-minute values) | General Summation Law<br>$P_{st}/l_t$<br>$= \sqrt[3]{abs(On^3 - Off^3)}$ |
|-----------------|-----------------------------|---|--|--|
| P <sub>st</sub> |                             |   |  |  |
| P <sub>lt</sub> |                             |   |  |  |

### 6.1. LV.

The allocated Flicker limits are specified as per STNW1174 and are subject to any change of STNW1174.

### 6.2. HV.

The Flicker allocation for HV connection is determined and allocated as per AS/NZS 61000.3.7.

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## 7. VOLTAGE UNBALANCE

The voltage unbalance limits for the EG connection are specified as a percentage of negative sequence for voltage. The LV values are as per STNW1174 and are subject to any change of STNW1174. A copy of STNW1174 LV unbalance limits is shown in Table 7.

**Table 7: Unbalance limits**

| Condition            | Averaging Period | Voltage Unbalance |
|----------------------|------------------|-------------------|
| No Contingency       | 30 minute        | 2.0%              |
| Credible Contingency | 30 minute        | 2.0%              |
| General              | 10 minute        | 2.5%              |
| Once per hour        | 1 minute         | 3.0%              |

Refer to STNW1175 for applicable limits relating to HV connections.

The measured voltage unbalance values should be measured over the same period as harmonics. The measured values should be presented as per Table 8.

**Table 8: Unbalanced value - measured**

|                   | Voltage Unbalance limit as allocated | Measured Unbalance with EG <u>ON</u><br>(99 <sup>th</sup> percentile of the 10-minute values) | Measured Unbalance with EG <u>OFF</u><br>(99 <sup>th</sup> percentile of the 10-minute values) |
|-------------------|--------------------------------------|---|--|
| General 10 minute | 2.5%                                 |   |  |

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## 8. DATA COMPLIANCE

1. In all cases in which the results (for on and off) exceed the emission limit allocated, it may result in non-compliance and will stop progression of the connection.
2. In the case when the OFF result is breaching the emission limit (for Harmonic, Flicker and/or Unbalance), take the following steps:
  - a. Re-check data recordings and consider re-doing the tests.
  - b. Re-check data to determine why the data is exceeding the required percentile value.
  - c. If the situation remains, consult the proponent, and advise the proponent that the site maybe breaching the connection agreement.
  - d. Continue data recording up to 3 days.
  - e. Provide all data recorded during the period and the recorder details (make and model and calibration compliance certificate) for further analysis.
3. In the case of an ON result breaching the emission limit please take the following steps:
  - a. Re-check data recordings and consider re-doing tests.
  - b. Re-check data to determine why the data is exceeding the required percentile value.
  - c. Continue data recording up to 7 days.
  - d. If the situation remains, the customer/client should be advised that mitigation options may be required.
4. If a site is non-compliant with the EG operating or not (ON or OFF) provide within the CR, reasons on why the site is not compliant. This may include the type of load and equipment used at the site.
5. Consideration will be given where the testing shows the site is non-compliant solely due to existing load. In these cases, the customer will be contacted by Ergon Energy or Energex to discuss mitigation actions that will need actioned by the customer. The RPEQ undertaking the EG System compliance testing should discuss the non-compliance issue with the customer.

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## 9. EQUIPMENT

The calibrated equipment used for data measurement purposes shall comply with the relevant standards listed below:

| Parameter  | Relevant Standard                   |
|--|-------------------------------------|
| Methods for measurement and interpretation of results                | AS/NZS 61000.4.30                   |
| Class of measurement   | Class A of AS/NZS 61000.4.30        |
| Voltage, Amperes, Frequency, Power Factor, kV, kVA, kVA <sub>r</sub> | AS/NZS 61000.4.30                   |
| Sample rate  | AS/NZS 61000.4.7                    |
| Total harmonic distortion & harmonics                                | AS/NZS 61000.4.7, AS/NZS 61000.4.30 |
| Flicker  | AS/NZS 61000.4.15                   |
| Voltage and current unbalance  | AS/NZS 61000.4.30                   |

Information on the equipment used for the calculation is provided within the CR as below.

| Parameter         | Manufacturer, Model |
|-------------------|---------------------|
| Harmonics         |                     |
| Flicker           |                     |
| Voltage unbalance |                     |