

INTERIM ARRANGEMENTS FOR GRID TIED DISTRIBUTED ENERGY RESOURCES

Technical Requirements for Grid-Tied DERs

Projects Division 6/29/2017

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1 Definitions and Acronyms

GPL Inc. – Guyana Power and Light Incorporated.

Electrical Power System (EPS) – Facilities that deliver electric power to a load.

Area Electrical Power System (Area EPS) – GPL's power system that supplies customer's local electrical power systems.

Local Electrical Power System (Local EPS) – An electrical power system that is contained entirely within a single premises or group of premises.

Cease to Energize – Cessation of energy outflow capability.

Distributed Energy Resources (DER) – Sources of electric power that are not directly connected to GPL's bulk power transmission system (69kV), but rather to GPL's distribution network (13.8kV, 120V, 240V, 440V). This includes both generation and energy storage technologies.

Point of Interconnection (POI) – The point where a Local EPS is connected to GPL's Area EPS. This is defined as the Electrical Connection to GPL's energy meter, where the meter acts as the couple between GPL's Area EPS and the Local EPS.

Point of DER Interconnection (PDI) – The point where a DER is connected to an EPS.



Interconnection System – The collection of all interconnection equipment and functions, taken as a group, used to interconnect a DER unit(s) to GPL's EPS.

Island – A condition in which a portion of an Area EPS is energized solely by one or more Local EPSs though the associated POIs while that portion of the Area EPS is electrically separated from the rest of the Area EPS.

Customer-Generator (CG) – A GPL customer whose Local EPS is grid-tied (interconnected) with GPL's Area EPS to allow them to export their excess electrical power into GPL's Area EPS.

2 Technical Interconnection Requirements

All grid-tied DER installations have to comply with the requirements of the National Electric Code 2014, such as (but not limited to) Article 705, Article 690, and Article 694; as well as the IEEE Std. 1547-2003 and its subsequent revision the IEEE Std. 1547a-2014. Further, all interconnection equipment must be verified as being in compliance with the IEEE Std. 1547.1-2005 and its revision the IEEE Std. 1547.1a-2015, or the UL Std. 1741 edition 2.

2.1 Point of Interconnection – Responsibilities

The DER shall be permitted to be connected GPL's EPS as per Article 705.12 of the National Electric Code 2014. GPL Inc. will coordinate the design, construction, maintenance, and operation of the facilities on the GPL side of the POI. The Customer-Generator is responsible for the design, construction, maintenance and operation of the facilities on the Customer-Generator side of the POI.

2.2 Point of Disconnection – Safety

As per Article 705.22 of the National Electric Code 2014 there must be a disconnect device that is to be installed by the CG in a visible and accessible location near to GPL's energy meter, as indicated in Appendix A – Location of AC Disconnect. The disconnect device must clearly show which state it is in (on or off) and must capable of being locked in the off positon. GPL must be provided with the means to open/lock the locking mechanism at any time.

2.3 Interconnection Grounding

The DER must be solidly grounded unless otherwise required as per manufacturer's recommendations. Grounding must be done in accordance to the National Electric Code 2014. Further, as per IEEE Std. 1547-2003, the grounding scheme of the DER interconnection shall not cause over-voltages that exceed the rating of the equipment connected to GPL's EPS, and shall not disrupt the coordination of the ground fault protection on GPL's EPS.

2.4 Interrupting and Short-Circuit Current Rating

As per Article 705.16 of the National Electric Code 2014, the design of the DER must consider the contribution of fault currents from all interconnected power sources, including GPL's EPS, when sizing the interrupting and short-circuit ratings of the equipment used in the DER location.

2.5 Over-current Protection

The DER facility must detect and promptly cease to energize for over-current fault conditions within its system. All conductors must be protected in accordance to Article 240 of the National Electric Code 2014.

2.6 Voltage Regulation

The DER shall not actively regulate the voltage at the POI, unless this regulation is done in coordination with and with the approval of GPL. Further, the DER shall not cause GPL's EPS service voltage at other consumers Local EPS to vary more than $\pm 5\%$ of the nominal voltage, as defined in ANSI C81.1-2011, Range A.

2.7 Voltage Unbalance

When single phase DERs are connected in multiple units and a three phase service is available, then approximately equal amounts of generation capacity should be applied to each phase of a three phase circuit. Voltage unbalance caused by the DER at the POI shall be limited to 1%. Voltage unbalance is defined as the maximum deviation of the phase voltages from their average divided by their average, expressed as a percentage. For example, for three phase voltages of 230V, 232V, and 225V the average is 229V; the maximum deviation from the average is 4V; and hence:

Voltage Unbalance
$$=$$
 $\frac{4V}{229V} \times 100 = 1.75\%$

2.8 Synchronization

Any DER that can generate an AC waveform independent from GPL's EPS shall only be connected in parallel with GPL's EPS if it is synchronized with GPL's EPS. The DER shall parallel with GPL's EPS without causing voltage fluctuation at the POI greater than $\pm 5\%$ of the prevailing voltage of GPL's EPS at the POI, and meet the flicker requirements of Section 2.9.

2.9 Voltage Flicker

Any interconnected DER shall not cause voltage flicker above the borderline of visibility of flickers as indicated in the IEEE Std. 519-1992 and shown in Figure 1 below:



Figure 1 - Flicker Tolerance Curve (IEEE Std. 519-1992)

2.10 Harmonics

DER facilities are expected to comply with the IEEE Std. 519-1992 with respect to current and voltage distortion limits at the POI. The harmonic current injection from the DER shall not exceed the current values given in Table 1 below, where the current *I* is the greater of GPL's EPS load current integrated demand (15 or 30 minutes) without the DER unit, or the DER unit rated current capacity (transformed to the POI when a transformer exists between the DER unit and the POI).

Table 1 - Max	imum harmo	nic current	distortion in	percentage	of current, I
				1	-)

Individual Harmonic Order (b)	Percentage		
Individual Harmonic Order (<i>II</i>)	Odd Harmonics	Even Harmonics	
h < 11	4.0%	1.0%	
$11 \le h \le 17$	2.0%	0.5%	
$17 \le h \le 23$	1.5%	0.4%	
$23 \le h \le 35$	0.6%	0.2%	
$35 \le h$	0.3%	0.1%	
Total Demand Distortion (TDD)		5.0%	

Voltage distortion limits at the POI shall be restricted to 3% for Individual Voltage Distortion and 5% for Total Voltage Distortion (THD). The harmonic current injections shall be exclusive of any harmonic currents due to harmonic voltage distortion present in GPL's EPS without the DER connected.

2.11 DC Current Injection

The DER and its interconnection system shall not inject DC current greater than 0.5% of the full rated output current at the POI.

2.12 Anti-Islanding

For an unintentional island in which the DER energizes a portion of GPL's EPS though the POI, the DER interconnection system shall detect the island and cease to energize GPL's EPS <u>within two (2) seconds</u> of the formation of the island. This requirement may be met by the following:

- 1. The DER is certified to pass an applicable non-islanding test,
- 2. The DER installation contains reverse or minimum power flow protection, sensed between the PDI and the POI, which will disconnect or isolate the DER if power flow from GPL's EPS to the Local EPS reverses or falls below a set threshold, or
- 3. The DER contains other non-islanding means such as:
 - a. Forced frequency or voltage shifting
 - b. Transfer trip

2.13 Protection from Electromagnetic Interference

The interconnection system shall have the capability to withstand electromagnetic interference (EMI) environments in accordance with IEEE Std. C37.90.2-1995

2.14 Surge withstand performance

The interconnection system shall have the capability to withstand voltage and current surges in accordance with the environments defined in IEEE Std. C62.41.2-2002 or IEEE Std. C37.90.1-2002 as applicable.

2.15 Voltage

The protection function of the interconnection system shall detect the effective (r.m.s) or fundamental frequency value of each phase-to-phase voltage. Unless if the transformer connecting the Local EPS (on the CG's premises) to GPL's EPS is a grounded wye-wye configuration or single-phase installation, then in these instances the phase-to-neutral voltage shall be detected. The voltages shall be detected at either the PDI or the POI when any of the following conditions exists:

- 1. The aggregate capacity of DER systems connected to a single POI is less than or equal to 30kW,
- 2. The interconnection equipment is certified to pass a non-islanding test for the system to which it is to be connected,

When any voltage is within a range given in Table 2, the DER shall cease to energize GPL's EPS within the clearing time as indicated.

Voltage Range (% of base voltage)	Clearing Time
V < 45%	0.165
$45\% \le V \le 60\%$	1.00s
$60\% \le V \le 88\%$	2.00s
$110\% \le V \le 120\%$	1.00s
<i>V</i> ≥ 120%	0.16s

 Table 2 - Interconnection system default response to abnormal voltages

Under mutual agreement between GPL and the CG, other static or dynamic voltage and clearing time trip settings shall be permitted, up to ranges given in Table 3.

Table 3 – Interconnection system possible response to abnormal voltages, under mutual agreement with GPL

Voltage Range (% of base voltage)	Clearing Time: adjustable up to and including
V < 45%	0.16s
$45\% \le V \le 60\%$	11.00s
$60\% \le V \le 88\%$	21.00s
$110\% \le V \le 120\%$	13.00s
$V \ge 120\%$	0.16s

Clearing time, in this instance, is defined as the time between the start of the abnormal condition and the DER ceasing to energize GPL's EPS. For DER less than or equal to 300W in peak capacity, the voltage set points and clearing times shall be either fixed or field adjustable. <u>For DER installations greater than</u> <u>300W, the voltage set points and clearing times shall be field adjustable.</u>

2.16 Frequency

Frequency measurements shall be done at either the POI or the PDI. When the system frequency is in a range given in Table 4, the DER shall cease to energize GPL's EPS within a pre-set clearing time as indicated. Under mutual agreement between GPL and the CG, other static or dynamic frequency and clearing time trip settings shall be permitted. Clearing time is the time between the start of the abnormal condition and the DER ceasing to energize GPL's EPS.

Eunstion	Default Settings		Possible Ranges of adjustability		
Function	Frequency	Clearing Time	Frequency	Clearing time adjustable up to and including	
UF1	< 57 <i>Hz</i>	0.16s	56Hz - 60Hz	10s	
UF2	< 59.5 <i>Hz</i>	2.00s	56 <i>Hz</i> – 60 <i>Hz</i>	300s	
OF1	> 60.5 <i>Hz</i>	2.00s	60 <i>Hz</i> – 64 <i>Hz</i>	300s	
OF2	> 62 <i>Hz</i>	0.16s	60Hz - 64Hz	10s	

Table 4 - Interconnection system default response to abnormal frequencies

<u>The frequency and time set points in Table 4 shall be field adjustable</u>. Adjustable under-frequency (UF) and over-frequency (OF) trip settings shall be coordinated with GPL. As mutually agreed upon by GPL and the CG, DERs shall be permitted to provide modulated power output as a function of frequency in coordination with functions UF1, UF2, OF1, and OF2. The operating parameters shall be specified when this function is provided.

2.17 Reconnection to GPL's EPS

After a disturbance on GPL's EPS which causes the DER to be disconnected, no reconnection shall take place unless GPL's EPS voltage is within $\pm 5\%$ of the nominal voltage, in compliance with the ANSI C81.1-2006, at the POI, and the frequency within 58.0Hz to 61.2Hz. <u>The DER interconnection system shall</u> include an adjustable delay (or a fixed delay of five (5) minutes) that may delay reconnection for up to five (5) minutes but no less than two (2) minutes after GPL's EPS steady-state voltage and frequency are restored to the ranges identified above.

3 Appendix A – Location of AC Disconnect







