RULES & REGULATIONS FOR RENEWABLE GENERATION SYSTEMS

1. PURPOSE

This document describes the technical requirements for connecting Renewable Generation Systems ("RGS") up to 150kW, or larger if approved in writing by Grand Bahama Power Company Limited ("GBPC"), to GBPC's electric distribution system ("GBPC's Grid"). These requirements are aimed at, among other things:

(i) ensuring the compatibility of the RGS with GBPC's Grid;
(ii) ensuring the safety of the RGS operating in parallel with GBPC's Grid;
(iii) facilitating the safety of GBPC's employees, agents, customers and the general public; and
(iv) maintaining a high standard of power quality.

2. SUMMARY OF APPLICATION AND INTERCONNECTION PROCESS

2.1 Persons desirous of installing the RGS must become familiar with these requirements for interconnection **BEFORE** acquiring the RGS.

2.2 Before finalizing the investment in a RGS, the Customer-Generator must obtain approval for available capacity from GBPC.

2.3 Customer-Generator is required to do the following:

(i) Understand GBPC's interconnection requirements before starting the project;
(ii) Submit an "Application for Grid Interconnection for Renewable Energy Rider" form along with an Electrical One-Line Diagram; **(See Appendix 1)**
(iii) Ensure a visible lockable AC disconnect is in an accessible location at or near GBPC's meter;
(iv) Submit an approval from the The Grand Bahama Port Authority, Limited (GBPA) or relevant government agency for the RGS together with such other approvals or licenses as may be granted by the said regulatory agencies ;
(v) Submit a valid certificate of insurance evidencing general liability insurance coverage
(vi) Conform to GBPC's "Rules & Regulations For Renewable Generation Systems" as evidenced by inspection and approval of the RGS by GBPC.
(vii) Submit certification documentation from the inverter manufacturer prior to interconnection to verify that voltage and frequency ride through requirements have been satisfied
(viii) Execute a Renewable Energy Rider Agreement **(RER Agreement)**.

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3. GENERAL CONDITIONS

Persons desirous of connecting a RGS to GBPC's Grid must be customers of GBPC and the power source must be located at the customer's premises.

The RGS must operate in parallel with GBPC's Grid and offset some or all of the customer's own electricity usage.

3.1 Electrical Generation Systems

3.1.1 To be eligible to connect and operate in parallel with GBPC's Grid, the RGS must be wind and/or solar

powered with a maximum aggregate capacity per facility of 1.5 times the customer's current average usage up to a maximum of 150kW. The average usage will be calculated based on the most recent twelve months that the customer relied on the grid or the most recent months where the customer does not have a twelve months history:

(i) For equivalent RGS capacity- the average monthly consumption is divided by 150. A multiplier of 1.5 times provides the maximum allowed capacity up to 150kW. **See Table 1.**

TABLE 1

Equivalent and Maximum PV system sizes at various monthly average consumption levels

Average monthly consumption over the last year (kWh)	Equivalent Capacity (kW)	Maximum system size (kW)
100	0.67	1
200	1.33	2
300	2	3
500	3.33	**5**
1000	6.67	10
5000	33.33	50
10000	66.67	100

15000	100	150
>15000	>100	150

(ii) Wind or hybrid – sized to produce 1.5 times the average monthly consumption, or 150kW, whichever is less.

3.1.2 The RGS may be single phase or three phase but its rated size is limited to 80% of the size of the main breaker servicing the installation.

3.2 Interconnection

3.2.1 Within eight (8) weeks of receiving notification from the Customer-Generator that the installation has been completed, GBPC will carry out inspections and tests and will advise the applicant in writing whether or not the proposed interconnection of the RGS qualifies for interconnection to GBPC's Grid. The Customer-Generator is required to submit certification documentation from the inverter manufacturer prior to interconnection to verify that voltage and frequency ride through requirements have been satisfied.

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3.2.2 The customer is required to sign the **RER Agreement** with GBPC prior to commencement of parallel operation. The **RER Agreement** outlines the applicable interconnection standards and requirements for on-going maintenance and operation and the terms of sale and billing, to allow the purchase and sale of energy between the customer generator and GBPC.

3.3 Unauthorized Connections

No RGS shall be connected to GBPC's Grid unless and until a RER Agreement has been executed by GBPC and the Customer-Generator**.** GBPC shall have the right to disconnect the service to any customer who connects a RGS to the GBPC's Grid without the appropriate authorization from GBPC.

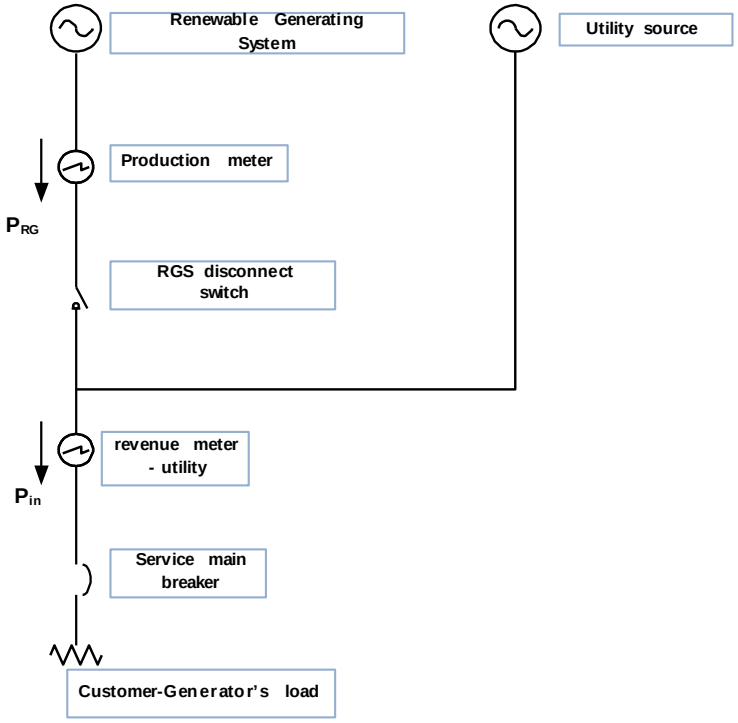
3.4 Metering

GBPC will furnish metering to measure separately the energy supplied from GBPC's Grid

to the customer and the energy supplied to GBPC's Grid by the customer whose RGS has been approved by GBPC For each service interconnected, Customer-Generators must also make provision for the appropriate meter socket base(s) or other appropriate metering facilities required to measure the total energy produced by the RGS and energy used by the Customer-Generator. The required meter(s) will be installed by GBPC. All metering locations must be readily accessible to GBPC personnel for the purposes of maintenance and regular meter reading.

3.4.1 The two metering configurations for grid tied RGSs are as follows:

METERING CONFIGURATION



Key:

P_{RG} power produced by renewable generating system
P_{in} – power received from the grid

N.B this drawing is intended for illustration purposes only in the application for interconnection and does not represent a design or installation manual

3.5 Labelling

The Customer shall install labelling on or near the meter socket base or manual AC disconnect. Signs are required to be a minimum of 6 inches in height and 8 inches in width, Font shall be 1.25 inches in height, black in colour with a yellow background. In the event that the disconnect is in a remote location, an additional sign must be installed indicating the location of the disconnect. A sample is shown in Appendix 2. In addition to the foregoing, the Customer-Generator shall install such other labelling as may be required by GBPC, GBPA or relevant Government agency..

3.6 Future Modifications and Expansion

Prior to modifying, expanding or altering the RGS, the Customer-Generator must obtain written permission from GBPC and GBPA or relevant Government agency..to alter or extend an existing installation. Thereafter, the Customer-Generator must provide a new Application Form, revised One-line Diagram, and **RER Agreement** to seek prior written approval from GBPC before interconnecting the modified RGS to GBPC's Grid.

3.7 Renewable Capacity on GBPC Grid

For the overall safety and protection of GBPC's Grid, the interconnection of all RGS' shall be subject to a limit which shall be reviewed and revised periodically by GBPC.

3.8 Customer-owned equipment protection

It is the Customer-Generator's sole responsibility to protect its facility loads and generation equipment and comply with the requirements of all appropriate and relevant standards, codes and local authorities. **Please see Appendix 1.**

4. GBPC OPERATING CONDITIONS

This Section describes typical GBPC distribution operating and power quality conditions within which the RGS is required to operate. These are representative values that GBPC attempts to maintain and include some abnormal conditions that the RGS should be designed to withstand. It is the Customer-Generator's responsibility to ensure that all equipment operates correctly in this environment.

4.1 System Voltage

GBPC supplies secondary voltages as stated in the latest revision of the Rules and Regulations for Electric Services" . A voltage tolerance of +/- 6 % is applicable to allow for varying load conditions as shown in **Table 2**. Contingencies may arise that cause the voltage to deviate outside of this tolerance and the RGS must be capable of operating satisfactorily beyond the extreme voltage level variation limits shown in **Table 2**. These extremes of voltage pertain to voltages that may occasionally occur on the grid during transient events. Table 3 in Section 5 describes the operating voltages limits for RGSs and expected inverters responses to various voltage conditions.

TABLE 2

Nominal system voltages	**Voltage variation limits for secondary distribution voltages**			
	Extreme	**Operating**		**Conditions**
		Normal Operating Conditions		
Single Phase 115/230V				
115V	104V	108V	122V	127V
230V	207V	216V	244V	253V
3 Ph 4 wire 115/200V or 230/400V Wye				
115	104V	108V	122V	127V
200	180V	188V	212V	220V
230	207V	216V	244V	253V
400	360V	376V	424V	440V
3 Phase 3 wire 115/230V				
115	104V	108V	122V	127V
230	207V	216V	244V	253V

4.2 System Frequency

GBPC's Grid operates at 60 Hz. Frequency deviations typically range from 59.8 to 60.2 Hz for small contingencies resulting in modest disturbances where the RGS is expected to remain connected to GBPC's Grid. For larger contingencies, broader frequency variations may occur such as when major generation or transmission is lost and load shedding occurs. The RGS' required response in these situations is

specified in **Table 4**.

4.3 Configuration

Single phase 120/240V 60 Hz service is derived from a split-phase transformer with centre-tapped secondary windings to provide a 3-wire supply comprising two phase conductors and one grounded neutral conductor.

4.3.1 Interconnection of grid-synchronous inverters

GBPC requires that:

(i) the inverter is equipped with ground fault protection

GBPC shall not accept responsibility for and shall not be liable for any equipment malfunction or damage to the Customer-Generator's RGS

4.4 Harmonic Distortion

GBPC requires that the voltage distortion limits, as a percentage of the nominal fundamental frequency voltage in the utility service, should not exceed 5% for the total voltage harmonic distortion and 3% for any individual harmonic.

5. TECHNICAL INTERCONNECTION REQUIREMENTS

This Section provides the technical requirements to be met by the RGS in order to qualify for interconnection to GBPC's Grid and lists typical conditions and response to abnormal conditions that the RGS is required to meet. The RGS system must comply with the specific requirements as detailed in this document.

5.1 Point of delivery – Responsibilities

The Point of Delivery must be identified on the renewable system Electrical One- Line Diagram sent with the Application. GBPC will co-ordinate the design, construction, maintenance and operation of the facilities on the GBPC side of the Point of Common Coupling. The Customer-Generator is responsible for the design, construction, maintenance and operation of the facilities on the Customer-Generator side of

the Point of Delivery.

5.2 Point of Disconnection – Safety

A lockable disconnecting device with visible break is required to provide a point of isolation between the RGS and GBPC's Grid for safe working purposes. It should be installed by the Customer-Generator in a visible and accessible location near to GBPC's revenue meter or the Point of Delivery, whichever is acceptable to GBPC. A sample disconnect switch is shown in Appendix 3.

5.3 Interconnection Grounding

The RGS must be grounded as per the manufacturers' recommendations and according to the requirements of the GBPA or relevant government agency. GBPC provides a grounded neutral service conductor.

5.4 Interrupting Device Ratings

The design of the RGS must consider the fault current contributions from both generation sources to ensure that all circuit fault interrupters are adequately sized.

5.5 Over-current Protection

The RGS must detect and promptly cease to energize for over-current fault conditions within its system.

5.6 Under-Voltage and Over-Voltage Protection

Every grid-tied RGS shall have under/over-voltage protection and, on detection of such voltage, shall cease to energize within the timeframe indicated in **Table 3**. Three phase inverter systems shall detect the individual phase to neutral voltage on a grounded Wye system or any individual phase to phase voltage on an ungrounded Wye or delta system for the purposes of **Table 3**. Single phase inverter systems shall detect the phase to neutral voltage if connected to the neutral conductor. Single phase inverter systems connected phase to phase (not connected to the neutral conductor) shall detect the phase to phase voltage. The RGS shall not attempt to regulate the voltage or adversely affect the voltage at the Point of Delivery.

TABLE 3

Inverter Response to Abnormal Voltage Levels

Range (% of nom V)	Operating Mode	VRT Duration (s) Ride Through	VRT Duration (s) Trip	Reconnect Criteria (% of nom V)
V > 120	Trip	None	0.20	88%<=V<=110%
110 <V<=120	Ride Through	0.92	1	88%<=V<=110%
90<V<=110	Normal Operation	Indefinite	Indefinite	-
50<V<=90	Ride Through	10-20*	11-21*	88%<=V<=110%
V<50	Trip	None	0.20	88%<=V<=110%

*May be adjusted within these ranges at manufacturer's discretion

5.7 Under Frequency and Over Frequency Protection

RGS shall cease to energize during under/over frequency conditions within the maximum delay times shown in **Table 4** and shall not reconnect until GBPC's Grid has stabilized.

TABLE 4

Inverter Frequency Operating Limits

Range (Hz)	Mode	FRT Duration (s) Ride Through	Trip	Reconnect Criteria (Hz)
f > 53.3	Trip	None	0.20	49.9 <= f <=50.10
52.5<f<=53.3	Ride Through	20	21	-
47.5<f<=52.5	Normal Operation	Indefinite	Indefinite	-
46.7<=f<=47.5	Ride Through	20	21	-
f<46.7	Trip	None	0.20	49.9 <= f <=50.10

5.11 Voltage Imbalance

When single phase RGS are connected in multiple units and three phase service is available, then approximately equal amounts of generation capacity should be applied to each phase of a three phase circuit. Voltage imbalance caused by the RGS at the point of common coupling is limited to 3 %.

5.12 DC Injection

The RGS shall not inject a DC current greater than 0.5% of the unit's rated output current at the Point of Delivery after a period of 6 cycles following connection to GBPC's Grid.

5.13 Synchronization

The RGS that can generate an AC Voltage Waveform independent of GBPC's Grid shall be connected in parallel only in combination with its synchronizing capabilities. The RGS shall synchronize to GBPC's Grid while meeting the Flicker requirements of Section 5.9. Synchronization may occur once GBPC's Grid is stabilized and in accordance with

Tables 3 and 4.

5.13.1 Grid-tied inverters

Grid-tied inverters are required to produce a sine wave output of 60 Hz frequency, be synchronous with GBPC's Grid and comply with the requirements of this document. Note that systems comprising grid-tied inverters with battery backup are configured differently and are more complex than battery-less grid-tied systems. In the interest of safety, the designs of interconnection and meter configurations for battery back-up grid-tied systems must be approved by GBPA or relevant governmental agency and the GBPC prior to installation.

5.14 Interconnection Protection Function Requirements

5.14.1 The RGS shall incorporate the following protective functions:- (i) AC disconnecting;

(ii) Anti-Islanding;

(iii) Automatic synchronizing (inverters with stand-alone capability); (iv) Under-voltage trip (on each phase for 3-phase equipment);

(v) Over-voltage trip (on each phase for 3-phase equipment);

(vi) Instantaneous over-current trip (on each phase for 3-phase equipment);

(vii) Timed over-current trip (on each phase for 3-phase equipment); (viii) Under-frequency trip; and

(ix) Over-frequency trip.

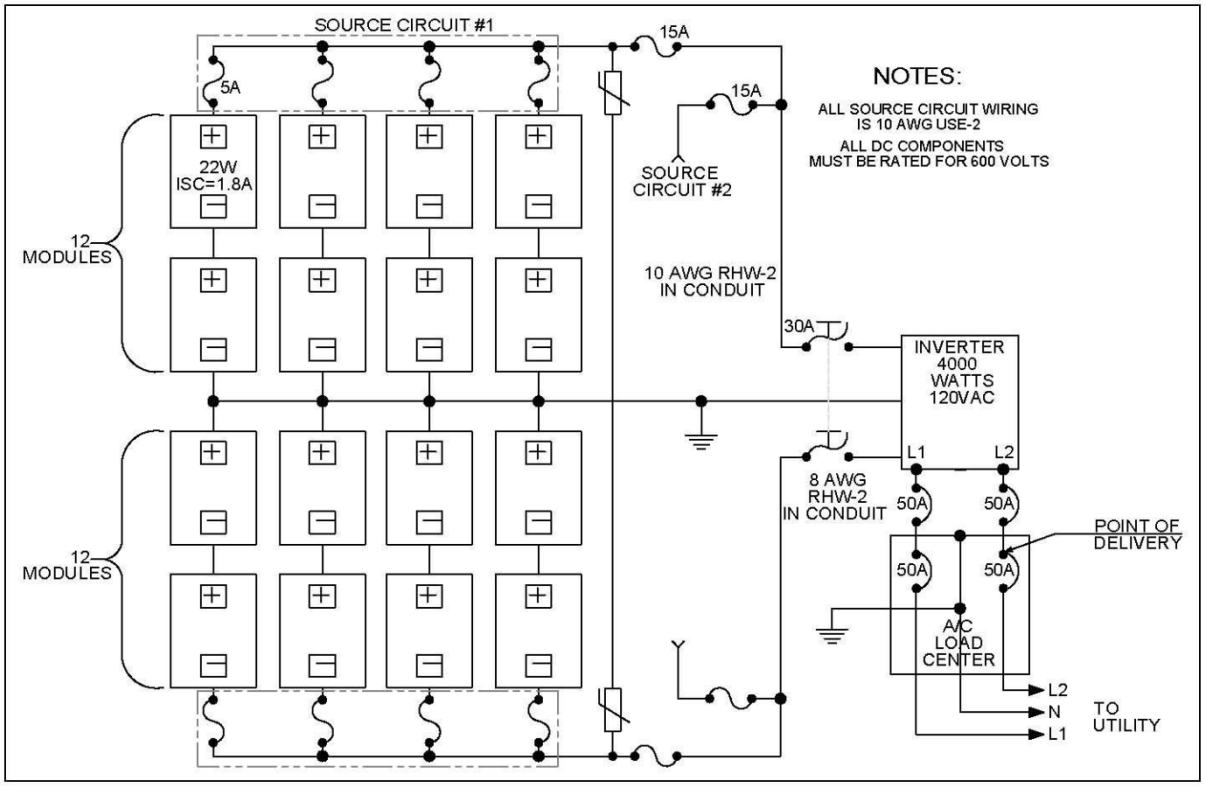
5.15 Voltage rise

During normal operation, the voltage rise caused by the RGS at the point of common coupling shall not exceed by 3% the magnitude of the voltage when the RGS is not connected.

APPENDIX 1

SAMPLE ELECTRICAL ONE-LINE DIAGRAM

Centre-tapped PV grid-interconnected PV system



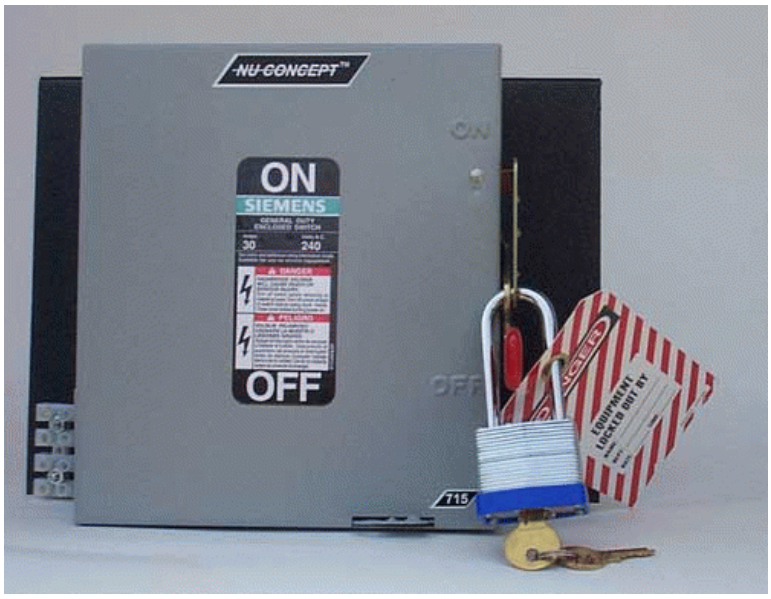
APPENDIX 2

SAMPLE OF UTILITY WARNING SIGN OF CUSTOMER GENERATION

(Size not less than 8" x 6", Font shall be 1.25 inches in height, black in colour with a yellow background.)

APPENDIX 3

SAMPLE OF SAFETY DISCONNECT SWITCH



APPENDIX 4

CONFIGURATION

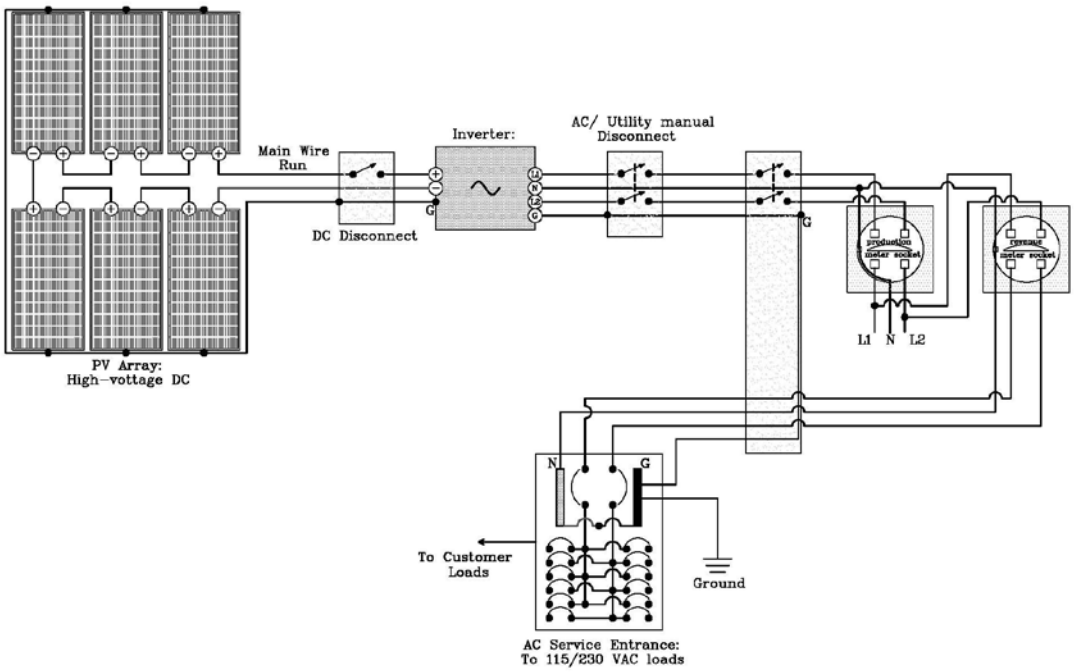


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Fig.2 Configuration 2 – total production to grid

GLOSSARY

Alternating Current (AC): An electric current that reverses its direction at regularly occurring intervals, known as the frequency which, in the case of Grand Bahama, is 60 times per second.

Automatic Reclosing: This refers to the automatic restoration of power by devices following a fault. It may involve a sequence of short interruptions before permanent restoration or cessation of power.

Capacity (gross): The full-load continuous rating of the Renewable Generation System, under specified conditions, as designated by the manufacturer. It is usually indicated on the nameplate attached to the equipment.

Customer-Generator: The person or entity accepting responsibility for the electricity account associated with the Renewable Generation System.

Delta (∆) connection: A method for connecting three phase supply where each phase is connected in series with the next, separated by a phase rotation of 120 degrees. Compare with Wye (Y) (star) connection.

Direct Current (DC): An electric current that flows in a constant direction. The magnitude of the current does not vary or has a very slight variation.

Distribution System:
The local poles, wires, transformers, substations and other equipment used to deliver electricity to consumers. (See Grid also)

Flicker: Flicker (voltage) is an unsteady visual sensation associated with changing lighting luminance caused by sudden and repetitive increases or decreases in voltage over a short period of time. It is normally associated with fluctuating loads or motor starting.**Frequency Protection (over/under):** Use of relays or other devices to protect lines

or equipment by causing circuits to open based on the degree by which the measured frequency varies from a set value.

Generation (Electricity): The process of producing electric energy from other forms of energy;

also, the amount of electric energy produced, expressed in Watthours (Wh).

Grid: A network for the transmission of electricity throughout a region. The term is also used to refer to the layout of an electric distribution system.

Grounding: An electrical connection to the earth or a body that extends from an earth connection for the purposes of safety and voltage reference.

Harmonics: Distortions in the sinusoidal voltage and current waveforms caused by the overlapping of the fundamental waveform at 60 Hz with other waveforms of integral multiple frequencies of the fundamental waveform. Total harmonic distortion (THD) is summation of all the distortions at the various harmonic frequencies.

Hybrid System: A self-generation system that combines multiple power sources (such as solar and wind) and is located behind a single electric utility service meter. Energy storage systems such as batteries do not constitute a power source for the purpose of this definition.

Interrupting Device Rating: The highest current that a device is intended to interrupt safely at rated voltage.

Inverter: A device that converts dc electricity into ac electricity. Some types are used for stand- alone systems (not connected to the grid) and others are designed as utility-interactive (grid- tied) systems to operate in parallel with the utility to supply common loads and may deliver power to the utility.

Overcurrent Protection: Use of a device or relay to protect the system by tripping it offline based on the degree by which the measured current varies from a set value. The trip may be instantaneous or after a preset time.

Kilowatt (kW): A measure of instantaneous power equal to one thousand Watts of

electricity
(See Watt).

Kilowatthour (kWh): A quantity of electricity usage equal to one thousand Watthours.

Manual Disconnect switch: A manual switch required for interconnection to disconnect the renewable generation source from the utility line.

Net Metering: An arrangement that permits a facility to offset its electrical consumption against energy delivered by the grid at the retail value and sell power in excess of its local consumption.

Net billing: Arrangement that permits the utility (using two meters or one meter that separately measures inflows and outflows of electricity) to sell power delivered to the customer at the prevailing tariff, and buy excess power from the customer's RGS at a rate contracted by the utility. The utility issues a net bill for each billing period.

Peak Watt: A manufacturer's unit indicating the amount of power a photovoltaic cell or module will produce at standard test conditions (normally 1,000 watts per square meter and 25 degrees Celsius).

Photovoltaic (PV) Cell: An electronic device capable of converting incident light directly into electricity (direct current)

Photovoltaic (PV) Module: An integrated assembly of interconnected photovoltaic cells designed to deliver a selected level of working voltage and current at its output terminals, packaged for protection against environment degradation, and suited for incorporation in photovoltaic power systems

Point of Common Coupling: The point where the electrical conductors of the utility's distribution system are connected to the customer's conductors and where any transfer of electric power between the customer and the distribution system takes place.

Point of Delivery: The point where the Renewable Generation System is electrically connected to the electric utility for metering purposes.

Point of Disconnection: The point at an accessible location where the disconnect switch used to isolate the Renewable Generation System from the utility is located.

Renewable Energy: Energy flows that occur naturally and repeatedly in the environment (such as solar, wind, biomass) and can be harnessed for human benefit.

Renewable Generation System: The total components and subsystems that, in combination, convert renewable energy into electrical energy suitable for connection to utilisation loads.

Renewable Energy Rider Agreement: A legal document authorizing the flow of electricity between the facilities of two electric systems. Renewable energy systems must be permanently interconnected and operating in parallel to the electrical distribution grid of the utility serving the customer's electrical load. This agreement also authorises and describes the terms and conditions under which the purchase and sale of electrical energy between the customer generator and the GBPC occurs.

Root Mean Square (RMS): Used for AC voltage and current, this quantity equals the square root of the average of the squares of all the instantaneous values occurring during one cycle. It is considered as the effective value of AC because, for a fixed resistive load, the AC rms voltage will produce the same heating effect as a DC voltage of equivalent value.

Solar Energy: The radiant energy of the sun, which can be converted into other forms of energy, such as heat or electricity. Sunlight can be converted to electricity directly, as in the case of photovoltaic (PV) applications or indirectly as in the case of solar thermal applications.

Synchronization: The process of connecting two previously separated ac sources such as the customer's private generation system and the utility's grid, to allow them to operate in parallel (after matching frequency, voltage, phase angles etc.).

Total Harmonic Distortion (voltage and current): This is a single number representation of the amount of distortion of a voltage or current electrical waveform from a true sine wave.
Voltage protection (over/under): Use of relays or other devices to protect lines or

equipment by causing circuits to open based on the degree by which the measured voltage varies from a set value.

Voltage (current) Waveform: The variation of voltage (current) over one cycle indicated by the pattern which results when the instantaneous value of voltage (current) is plotted with respect to time over a cycle. Ideally, AC waveforms are represented by sinusoids and DC waveforms are constant over time.

Watt (Electric): The electrical unit of power represented by the rate of energy transfer of 1 Ampere of electric current flowing under a pressure of 1 Volt at unity Power Factor.

Watthour (Wh): The electrical unit of energy represented by 1 Watt of power supplied to, or taken from, an electric circuit steadily for 1 hour.

Wind energy: Energy present in wind motion that can be converted to mechanical energy for driving pumps, mills, and electric power generators.