GRID CODE

Interconnection Requirements for Battery Energy Storage Systems At Voltages 24.9 kV and below

Prepared by The Barbados Light & Power Company Limited with the assistance of WSP UK Limited

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Grid Code Battery Storage Requirements

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1 General Conditions

1.1 Introduction

This document applies to all power conversion system (PCS) connected battery energy storage systems (BESS) for connection to the Barbados T&D system at 24.9 kV and 11 kV respectively and which provide grid services. The Requirements may vary according to the size of the BESS and the voltage level at the Point of Common Coupling.

This information excludes uninterruptible power supplies (UPS) or systems used solely to provide uninterrupted power supply to loads during grid disturbances.

1.2 Terms and Definitions

The Term	Definitions
Ancillary Services	A set of operations utilized to ensure the reliable operation of the power system, specifically the Transmission & Distribution Grid.
Availability	Availability can be expressed as a ratio or percentage of time the battery is available to supply power compared to the total time of operation being considered for the availability measurement. Time periods during which force majeure events occur are excluded from the measurement.
Backup Power	Backup Power – The battery energy storage system, either paired with a local generator or on its own provides power to loads at a customer's premises either residential, commercial or industrial in the event of a grid failure and when isolated from the grid. The battery energy storage system facilitates an intentional island of the customer until the grid is restored or until the available energy is depleted.
Battery Energy Storage System (BESS)	A battery energy storage system (BESS) is an electrochemical device that charges (or collects energy) from the grid or a power plant and then discharges that energy at a later time to provide electricity or other grid services when needed. The battery energy storage system comprises of a battery energy source, a power conversion system, control systems, protection equipment and auxiliary equipment integrated as one unit.
Black-Start	Black Start – The battery energy storage system restores operation to a portion of the electric grid by energizing transmission lines or provide supplementary power for the operation of larger power stations to begin the process of restoring the electric grid after a system wide failure, commonly known as a black out.
BLPC Grid Code	Interconnection Requirements at voltage 24.9kV and below for generating facilities. In this context reference is made to the document approved by the FTC on March 2017
Demand Response	The ability of customers to respond to either a reliability trigger or a price trigger from their utility system operator by lowering their power consumption.

Dispatchable	The ability to vary system parameters or output based on signals received from a control center
Distributed Energy Storage	In this context pertains to battery energy storage systems that are not centralised on the T&D System i.e. separate from Substation Based Energy Storage
Energy Arbitrage	Involves the charging of the battery energy storage system during periods when the system marginal costs are relatively low and later discharging the battery energy storage system during periods when the system marginal costs are high
Energy Shifting	Involves moving energy on the T&D system from one time period to another by storage and release of that energy at a later time. The battery energy storage system may also be charged in instances where there is a surplus of energy generated from renewable sources as driven by policy for efficient utilisation of renewable energy.
EPRI	Electric Power Research Institute
ESIC	Energy Storage Integration Council
Frequency Regulation	Frequency regulation describes the increase, known as regulation-up, or the reduction, known as regulation-down, of power generation to maintain the system frequency at approximately 50 Hertz. As defined by EPRI, regulation is the portion of a unit's unloaded capability that can be loaded, or loaded capability that can be unloaded, in response to Automatic Generation Control (AGC) signals from a central dispatcher.
Frequency Response	This involves the autonomous dispatch up or down of the battery energy storage system primarily based on the frequency deviation detected locally by the battery energy storage system. The battery energy storage system may also be asked to dispatch up or down based on a signal (dispatch notification) sent by the system operator. This is typically a fast response in the order of seconds.
IEEE	Institute of Electrical and Electronics Engineers
IFC	International Fire Code
IRRP	Integrated Resource & Resiliency Plan for Barbados
Islanded Grid Operation	The ability of the BESS to form an isolated electrical system or island, otherwise described as a microgrid.
Microgrid	A group of interconnected loads and distributed renewable energy sources, including a BESS that can act as a single controllable system. It can connect and disconnect to the main grid to operate in either grid connected or island mode.
NFPA	National Fire Protection Association
Power Conversion System (PCS)	This serves the purpose of converting the energy stored in a BESS to electrical energy in the form of alternating current (AC) and vice versa.
RE	Renewable Energy
Round Trip Efficiency (RTE)	A measure of how much energy is retained in a battery system over a full charge-discharge cycle and is a percentage of the quantity of energy exported by the battery energy storage system during discharge vs the amount of energy imported into the battery energy storage system during charging.
SOC	State of Charge

Reserves	An allocated portion of a battery energy storage system capable of responding to Generation or Transmission & Distribution outages. The battery energy storage system should be online and synchronized with the grid.
Substation Based Energy Storage	A battery energy storage system connected to the transmission network at the substation
PCC	Point of Common Coupling
Plant Controller	A facility level supervisory control and monitoring system that interacts with the BESS control system, energy management systems, power conversion system, SCADA system and all other critical and auxiliary equipment
Peak Load Management	This service involves the battery energy storage system to provide a reliable capacity to meet system and/or local peak demand
Power Quality	A measure of how much electrical parameters such as voltage, frequency, waveform and continuity deviate from declared specifications.
Voltage and/or Reactive Power Support	The response to voltage and/or reactive power requirements from a signal dispatched by the system operator.
Voltage Regulation	Voltage Regulation – This involves the autonomous response to voltage and/or reactive power system requirements as detected by the battery energy storage system to maintain the voltage within an acceptable range. The voltage and/or reactive power requirements may also be from a signal dispatched by the system operator.
T&D System	Transmission & Distribution System

1.3 Class of Storage

The requirements outlined in this document shall be fulfilled at the Point of Common Coupling or at a point defined separately by a specific requirement. Table 1 outlines the various classes of battery energy storage systems which are differentiated based on the installed capacity and connection voltage.

Table 1: Table outlining the various classes of Battery energy storage system by Capacity and Nominal Connection Voltage

Class	Capacity (kW)	Nominal Connection Voltage
Class 1	BESS ≤ 25 kW	≤ 400 V
Class 2	25 kW < BESS ≤ 150 kW	≤ 400 V
Class 3	150 kW < BESS ≤ 500 kW	≤ 400 V
Class 4	500 kW < BESS ≤1.5 MW	11 kV (except where 24.9 kV Distribution exists)
Class 5	1.5 MW < BESS ≤ 10 MW	24.9 kV
Class 6	BESS > 10MW	24.9 kV

The BESS can be connected to the power system behind a separate connection point or as part of an existing connection, for example the medium voltage busbar of a power plant or a demand system. The Grid Code Specifications for BESS are determined according to Table 1, and as a rule, they are not dependent on the rated capacities or specifications of other production or demand systems connected to the same connection point. If the BESS Developer wants to integrate the resources of the BESS into the control system of a power plant or a demand system, the power plant or a demand system specification shall be reviewed by BLPC as a whole. Those specifications shall be based on the rated capacity of the integrated system and the connection point voltage level.

1.4 Purpose of Battery Energy Storage Systems

The BESS shall have a subset of the following functions required by the T&D system and the need for storage to mitigate impacts of intermittent renewable energy (RE). The need for storage is generally guided by the IRRP for Barbados. However, the functional requirements shall be specifically determined by the Connection Impact Assessment (CIA) to address any mitigations or provide grid services required on the T&D system as follows:

I. Peak Load Management/Energy Shifting, or arbitrage, implemented via scheduled or manual dispatch; or with power output associated with a specific output of a generator or group of generators;
II. Grid flexibility and ancillary services by responding to direct P/Q control set points issued by BLPC control center
III. Dispatchable firm capacity equal to its Rated Power Capacity
IV. Grid frequency and voltage support by sensing and responding to grid fluctuations
V. Provision of reserves dispatchable by BLPC
VI. Blackstart capability and functionality
VII. Microgrid capability at specific sites
VIII. Back Up Power to a Customer's load (for example where BESS provides back up power when grid conditions are abnormal, which necessitates disconnection from the T&D system).
IX. Virtual Inertia

BESS would not be expected to perform all of the functionality listed above at the same time. BLPC will identify the functionality required during the CIA process. Functional requirements of the storage system

may also change over time and once identified shall be made available for dispatch as necessary by the System Operator.

The classes of storage systems may be broken down into the following categories as outlined in Table 2.

Table 2: BESS Functional Requirements based on the class of the energy storage system

Class	BESS Power Capacity Range	Nominal Connection Voltage	Typical Connection Application	Function
Class 1	BESS ≤ 25 kW	≤ 400 V	Residential/Commercial Storage (≥2 hours)	• Back Up Power to customer's load • Energy shifting • Demand Response • Aggregated participation in ancillary services • Voltage Regulation
Class 2	25 kW < BESS ≤ 150 kW	≤ 400 V	Residential/Commercial Storage (≥3 hours)	• Back Up Power to customer • Energy shifting • Demand Response • Aggregated participation in ancillary services • Voltage regulation/reactive power support at the site (including voltage control
Class 3	150 kW < BESS ≤ 500 kW	≤ 400 V	Distributed Energy Storage (≥3 hours)	• Peak Load Management/ Energy Shifting • Reserves provision • Frequency Regulation • Frequency Response • Voltage regulation/reactive power support • Islanded Grid Operation
Class 4	500 kW < BESS ≤1.5 MW	11 kV (except where 24.9 kV Distribution exists)	Distributed Energy Storage (≥3 hours)	• Peak Load Management/ Energy Shifting • Reserves provision • Frequency Regulation • Frequency Response • Voltage Regulation/reactive power support • Islanded Grid Operation

Class	BESS Power Capacity Range	Nominal Connection Voltage	Typical Connection Application	Function
Class 5	1.5 MW < BESS ≤ 10 MW	24.9 kV	Distributed Energy Storage (≥3 hours)	• Peak Load Management/ Energy Shifting • Reserves provision • Frequency Regulation • Frequency Response • Voltage Regulation/reactive power support • Islanded Grid Operation • Virtual Inertia
Class 6	BESS > 10MW	≥ 24.9 kV	Substation Based Energy Storage (≥4 hours)	• Peak Load Management/ Energy Shifting • Reserves provision • Frequency Regulation • Frequency Response • Voltage regulation/reactive power support • Islanded Grid Operation • Black-Start • Virtual Inertia

2 Battery Energy Storage System Functional Requirements

2.1 Introduction

This section provides information to support the engineering, design, and construction of BESS based on the current requirements of the T&D system. For the contracted life of the system under local conditions, the BESS shall have the capability to meet capacity, efficiency and availability requirements specified in the following sub-sections. The Developer of the BESS shall consider any warranties from the supplier in the design of the BESS to meet these requirements. Any system limitations during normal operation shall be disclosed by the Developer, demonstrating the relationship to depth of discharge and cycle life to the overall life of the system. The system shall be sized to account for these limitations.

2.2 Safety

BESS systems shall be designed to ensure that they mitigate any risk of harm to plant, personnel, the general public, to BLPC employees who work on the T&D System and to personnel working at the BESS Facility. The system shall be designed to minimize any potential risks such as fires and explosions. However, in the case of a fire or explosion, the enclosure(s)/container(s) shall be equipped according to applicable fire and explosion safety standards such as the International Fire Code (IFC) and the National Fire Protection Association standard for the Installation of Stationary energy storage systems (NFPA 855).

Designs shall also be compliant with international standards that govern the manufacture and construction of the specific BESS and its components.

Alarms, monitoring and other safety systems shall be operational at all times. Signage requirements of Section 4.2.3 shall be adhered to in order to identify and manage areas of possible risk.

2.3 Power Capacity

The BESS shall be designed to have a “Rated Power Capacity” described in kW or MW AC net of all system losses and auxiliary loads, as measured at the PCC. The capacity that can be connected to the BLPC system will be determined through a grid study and/or in the CIA.

2.4 Energy Capacity

BESSs shall be designed to have a "Rated Energy Capacity" at commissioning and shall facilitate continuous discharge at the Rated Power Capacity measured at the PCC for the minimum duration as shown in Table 3. A Capacity Test shall be used to confirm the rated energy capacity of the BESS at commissioning and during the life of the BESS at regular intervals (Refer to Section 7.1 for guidance on Capacity Test procedure). Test certification documents for the BESS may also used to support commissioning of systems in Class 1 and 2 in the absence of a commissioning test. The storage system shall be capable of providing declared usable energy capacity for at least ten years or the contracted period where the contracted period takes precedence. The usable energy capacity of the BESS is defined by a degradation curve for the system. Storage systems shall also be capable of discharging its energy capacity with minimum duration as indicated in Table 3, 10 years after commissioning as measured at the PCC on the condition that the storage system is cycled on average of one (1) full charge and discharge cycle per day such that it allows for a maximum of 3650 cycles over ten years without impact on storage performance.

Regardless of actual installed energy capacity, the BESS must be able to provide charge and discharge from 0 – 100% SOC for any operating year in accordance with the Rated Power Capacity specified in the degradation curve, unless otherwise permitted by BLPC.

Table 3: Table indicating the minimum discharge duration requirements for the various classes

Class	Minimum Discharge Duration At Commissioning (Hr)	Minimum Discharge Duration 10 Years After Commissioning
Class 1	2 - 3 dependent on use case requirement	70% of commissioning duration
Class 2	3 - 4 dependent on use case requirement	75% of commissioning duration
Class 3	3 - 4 dependent on use case requirement	75 % commissioning duration
Class 4	3 - 4 dependent on use case requirement	75 % of commissioning duration
Class 5	3 - 4 dependent on use case requirement	75% of commissioning duration
Class 6	4 dependent on use case requirement	75% of commissioning duration

The Developer shall provide supporting documentation to verify the capacity performance of the storage system which shall include vendor specifications.

2.5 Reactive Power Requirement

For systems of Class 2 and above, the BESS shall be capable of providing or absorbing reactive power i.e. they should be capable operating in all 4 quadrants. The Absolute Reactive Power Test in Section 7.1 can be used to confirm reactive power capability. A more detailed test procedure can be adopted form the EPRI ESIC Test Manual Rated Continuous Power Test or IEEE1547.1 Nameplate Data Test. For systems of Class 1 and 2 manufacturer specifications and certification tests can support verification of reactive power capability.

2.6 Round Trip Efficiency

The battery energy storage system shall provide a minimum Round Trip Efficiency, "RTE", as measured at the PCC at commissioning as follows.

I. Class 1 & 2 – 80%
II. Class 3 and above - 85%

The RTE shall be evaluated by specific tests during commissioning and at regular intervals during the system lifetime. A capacity test to verify power and energy capacity, and RTE shall be performed at commissioning and at intervals as determined by utility.

The RTE calculation can be found at Appendix 7.3

2.7 Availability

The BESS shall be online and available at-least as follows:

I. Class 1 & 2 – 80%
II. Class 3 and 4 - 90%
III. Class 5 and above: 95%

The Availability Calculation can be found at Appendix 7.4.

2.8 Plant Controller

2.8.1 Plant Controller Functional Requirements

The BESS Plant Controller shall be the single interface between the BLPC's Control Centre and the Local Plant Control. The BESS Plant Controller shall provide control and monitoring of the BESS and visibility and control of all plant subsystems, including the fire and gas detection / suppression and ventilation, safety, individual equipment control, and inverter system. Plant controller capability could be subsumed within the BESS system as opposed to a separate unit.

The BESS Plant Controller shall be able to provide or perform the following at a minimum:

1. Interface with and be capable of accepting control, data and status signals from BLPC Dispatch or System Operator.
2. Communicate with BLPC's Dispatch/Control Center. The BLPC Control Centre shall be able to control the BESS within the specified control envelope.
3. Monitor and report on the BESS, including but not limited to information such as state of charge (SOC), state of health (SOH), voltage, current, frequency, temperature, and status. A full set of required telemetry can be found within the Connection Code Section 4.7.
4. Provide fault and surge detection and protection, as appropriate.
5. Support autonomous operation, including stand-by mode, start-up, shut-down and disconnection, in case of communication failure or emergency. Provide operator over-ride capabilities to all automatic control functions if manual intervention is requested.
6. Manage disconnect/reconnect operations of BESS as appropriate to ensure safe, reliable and resilient operation.
7. Interface with or be capable of interacting with a data historian/repository for easy access, storage and retrieval of BESS operational data as well as external signal data (such as future BLPC AGC signal) for analysis and reporting purposes. The data shall be stored for a minimum of 3 months. See Section 5.6.3 of The BLPC Grid Code for Operating Data, Telemetry, and Monitoring Requirements.
8. The BESS Plant Controller shall include an appropriate interface to BLPC's SCADA system over DNP 3.0, IEC61850 or Modbus depending on the system size. The communication protocols included are based on the IEEE 1547 - 2018 which list standardized protocols for BESS of all classes.

9. Include a physical selectable control selector switch to determine the remote/local operation of the BESS Plant Controller with indication of the state of the switch visible to BLPC.
10. Ensure that failure of BESS local control shall not impact the operation of the remote SCADA control of the plant and vice versa.
11. Shall be capable to program combinations of different battery control modes.
12. Allow BESS ramp rate to be adjusted by a local operator or BLPC Dispatch
13. For Class 4 and above - provision of inertial response to the grid (synthetic inertia): The BESS via the BESS Plant Controller shall be capable of delivering an inertial response similar to synchronous generator output to help mitigate grid instability. The battery power output shall have an additive response proportional to the first derivative of grid frequency during active and inactive power modes. The inertia constant shall be calibrated at the site controller and is not required to be remotely set.

2.8.2 BESS Plant Controller Modes of Operation

The plant controller shall be configured to allow for two modes of operation:

1. Grid following modes shall be provided by all BESS.
2. Grid forming mode shall only be provided to satisfy specific islanding and synthetic inertia requirements as determined by the relevant CIA.

The controls shall allow for seamless transition between grid forming and grid following modes where required.

Droop Control (Applicable to Class 3 and above):

BESS shall be able to operate in frequency droop mode whereby active power is adjusted as a result of system frequency. The droop characteristic shall be configurable with a compensation gain parameter to allow for modification of system response over the lifespan of the facility.

BESS that are required to utilise the frequency response shall be capable of transitioning from zero output to Rated Power Capacity in 100ms.

Islanding Mode:

Selected BESS shall be required to have controllers capable of islanding specific sections of the grid. Refer to Section 4.5.1 of this document for specific information.

2.9 Power Conversion System

The PCS at a minimum shall be able to:

1. Operate in all four power quadrants at rated power (kVA). Any combination of kW and kVAR output shall be possible that is consistent with the systems rated power (kVA)
2. Provide voltage regulation at the PCC such that the BESS is capable of regulating voltage in accordance with the BLPC Grid Code and IEEE1547 -2018 via the following exclusive control modes.
    a. Voltage Regulation by reactive power control
        i. Constant power factor mode
        ii. Voltage reactive power mode
        iii. Active power – reactive power mode
        iv. Constant reactive power mode
    b. Voltage regulation by Active power control
        i. Active Power Control
3. Meet the BLPC Grid Code voltage and frequency ride-through requirements.

In the case where BESS is required to have Microgrid capability, the Ride-Through set points shall be field adjustable to allow for optimization of Microgrid operation.

2.10 Backup Requirements

For BESS of Class 4 and above, power supply redundancy shall be provided for the BESS Plant Controller such that the loss of one power supply does not affect the operation of the BESS. The BESS shall continue operating for at least one hour after the loss of the first power supply.

2.11 Corrosion Prevention

The BESS, in its entirety, shall be protected from corrosion due to known or expected atmospheric conditions local to the Site.

Outdoor equipment shall at a minimum have protection to IEC 60529, IP 65 or NEMA 4X rating.

3 Planning Code

This section provides the information required to assess the connection of new BESS to the BLPC T&D system. The requirements outlined in Section 2 and 3 of the BLPC Grid Code, where applicable, serve as the main reference document when preparing documentation for a potential BESS connection. Reference may be made to latest planning requirements as outlined by the relevant planning authority as required.

3.1 Documentation and Engineering

The Developer shall provide all specifications and design drawings for BLPC review as required.

Site civil and other infrastructure designs for systems of Class 3 and above shall be signed by a registered civil engineer.

All designs and drawings for systems in Class 3 and above, studies, and documentation submitted to any relevant authority shall be under the responsible charge of and signed by a professional engineer registered in Barbados.

All electrical designs and drawings for systems in Class 1 & 2 shall be signed by a competent person as designated by the GEED. Relevant manufacturer documents received shall be made available to BLPC as required. Developer shall make all drawings available in DWG (AutoCAD) as well as in Portable Document Format (PDF). The Developer shall make all engineering documentation available in PDF.

Further design and engineering requirements may be stipulated by the relevant authority having jurisdiction such as the Ministry of Energy, Planning and Development Department, Environmental Protection Department and the Barbados Fire Service.

Developer shall include in the Design Documents, general arrangement drawings indicating the location of all major equipment including dimensions of key site features and a suitable baseline location including GPS coordinates of the main site. The general arrangement drawing(s) shall include, as a minimum the following elements as applicable:

1. BESS DC side system
2. BESS AC side system
3. BESS Plant Controller
4. PCS (Inverter) units and transformers
5. Circuit breakers, fuses and disconnect switches

6. Protection Relays
7. Internal Meters and provisions for placement of BLPC metering according to the system capacity
8. Local Control and communication infrastructure and SCADA interface
9. Data monitoring, storage and other IT equipment
10. Grounding grids as required by the BLPC Grid Code
11. Point(s) of interconnection, e.g. the Point of Common Coupling shall be identified as per Grid Code Section 5.2.5 or Section 4.2.1

4 Connection Code

4.1 Introduction

This section provides the technical requirements to be met by the various classes of battery energy storage systems connecting to BLPC T&D system. The requirements outlined in Sections 4 and 5 of the BLPC Grid Code for various capacities shall be met for the BESS and serve as the main document of reference for connection of the battery energy storage system. The requirements outlined in this document supplement the requirements in Sections 4 and 5 of the BLPC Grid Code. Where a conflict exists this document supersedes the Grid Code.

4.2 General Requirements

The following outlines the general requirements for the BESS so that it does not affect the reliability and quality of service to BLPC customers or compromise the safe operation of the T&D system for the general public, customers and employees. The design of all electrical equipment shall comply with applicable codes and standards.

4.2.1 Safety

The BESS interconnection and operation shall not create a safety hazard to BLPC's personnel, customers, the general public or personnel working in the BESS facility. The BESS shall be assembled and installed in accordance with applicable international standards. Clearances and access ways shall comply with the latest revision of the National Fire Protection Association NFPA 855 Standard for the Installation of Stationary Energy Storage Systems for safety of personnel.

4.2.2 Point of Common Coupling and Point of Delivery

The BLPC Grid Code Sections 5.2.5 and 4.2.1, define the Point of Common Coupling and Point of Delivery respectively.

The Developer shall assume responsibility for the provision of the following major components of the BESS.

1. The AC side power conversion system (e.g. inverter for BESS) to deliver the rated power capacity at the PCC net of all losses and auxiliary loads.
2. BESS plant controller for operation and safety.

3. AC Balance of Plant (BOP) Equipment inclusive of LV interrupting device
    a. AC BOP Equipment inclusive of Interconnection Transformer (for BESS with a rated power capacity greater than 500 KW)
    b. AC BOP Equipment inclusive of HV interrupting and isolating device (for systems with rated power capacity greater than 1.5 MW)
4. Revenue Metering requirements as outlined in Section 4.8

BLPC shall provide the following components to supplement the installed BESS.

1. Interconnecting Transformer and AC BOP equipment for systems with sizes with rated power capacity up to 500kW, except where the interconnection transformer is provided by the Developer.
2. AC BOP Equipment limited to HV interrupting and isolation device for systems with rated power capacity greater than 500kW and up to 1.5 MW.
3. Revenue Metering requirements as outlined in Section 4.8
4. Communication interface

4.2.3 Signage Equipment Marking and Labeling

Labelling shall conform to the requirements of Grid Code Sections 4.6.4 for all BESS. Signage and labels shall be weather-proof, corrosion-proof, UV-stabilized and fade-resistant and shall last for the duration of the minimum Design Life. Signs shall be posted indicating:

I. the presence of electrical equipment

II. the presence of multiple power sources

III. the presence of electrical, chemical, thermal or other hazards specific to the BESS

IV. that entry is restricted to authorized personnel only

A single line diagram of the as-built system which clearly identifies the ac disconnect shall be posted permanently near the PCC and on the metering cabinet. If not apparent from the single line diagrams, a Project map shall also be provided indicating the approximate locations of the disconnect switches. Disconnect switch designations shall match the electrical drawings device labels. All transformers and disconnect switches shall have engraved or printed a visible permanent identification label that provides the unique identification number as indicated on the single line diagram and electrical as built drawings.

Disconnecting means shall be clearly marked "***Battery Energy Storage System– AC DISCONNECT***".

4.2.4 Lightning Protection

Developer shall provide all measures of protection against lightning and switching surges including surge arresters and/or surge capacitors to protect equipment against damage where necessary. Refer to Grid Code Section 5.2.18 for further guidance.

4.2.5 Protection from Electromagnetic Interference (EMI)

For Class 3 and above the BESS and associated equipment shall meet the Electromagnetic Interference requirements specified in the Grid Code Section 5.2.21.

4.2.6 Grounding

Grounding system design and testing shall be performed in accordance with grounding and safety requirements of Grid Code Sections 4.2.3 and 5.2.11 as well as applicable ANSI/IEEE or IEC standards.

For BESS of Class 4 and above, grounding design shall comply with requirements of the BLPC Grid Code and IEEE Std. 80 for switchyards/substations and major equipment pads or IEC 61936-1 or BS EN 50522. All metallic objects, likely to be energized shall be grounded. This list includes, but is not limited to: module frames, all racking structure members, metal conduit, metal enclosures, fencing, equipment pads, skids, etc.

For BESS of Class 5 and above, grounding system design shall be based on site soil electrical resistivity test data and modelling performed per IEEE Std 81

Developer shall provide an overall electrical grounding schematic of the Project for systems of Class 5 and above. The grounding schematic shall indicate the primary connections to earth and the manner in which all components are grounded.

4.3 Performance Requirements

4.3.1 Ride Through Capability

The BESS and all associated equipment shall meet voltage and frequency fault ride-through requirements for a generating facility as specified in the BLPC Grid Code:

a) For Class 1 and 2: Sections 4.3.7 and 4.3.8
b) For Class 3 and above: Sections 5.3.7 and 5.3.8

4.3.2 Overvoltage/ Under Voltage Protection

The BESS Overvoltage/ Under Voltage Protection shall be set in accordance with Sections 5.4.10 and 4.4.3 of the BLPC Grid Code.

4.3.3 Voltage and Current Harmonics

The PCS shall meet IEC 61000-3-06 or IEEE 519 - Recommended Practices and Requirements for Harmonics Control in Electrical Power Systems, as a source of generation, with a limit of 5% at its output terminals as specified in the BLPC Grid Code

a) For Class 1 and 2: Section 4.3.2
b) For Class 3 and above: Section 5.3.2.4

4.4 Protection Requirements

Plant protection design, shall include all required protection, coordination and redundant systems within the BESS in particular at the PCC in keeping with the protection requirements of Grid Code

a) For Class 1 and 2:Sections 4.4
b) For Class 3 and above: Section 5.4.

All protective relays shall be utility-grade and shall have the required ANSI protection functions (e.g. 25, 32, 27, 67N, 67, 59, 81u, 81o, 50/51, etc.) as prescribed in IEEE 1547-2018 and BLPC's technical protection requirements.

The protection devices, including circuit breakers and fuses, in the BESS shall provide adequate protection at the minimum and maximum short circuit levels on the BLPC's T&D System.

BESS PCS units shall be capable of providing sufficient negative sequence fault current (to the extent possible) to provide protective relays with adequate selectivity and sensitivity. The step-up transformer (or earthing transformer if required) shall provide a path for zero sequence current of magnitude sufficient to operate protective devices. The control system shall have the capability to control the negative sequence current during an unbalanced fault event.

Closing of the PCC main breaker to reconnect with the T&D System will require appropriate check synchronization elements and shall consider all possible system configurations including islanded and grid-connected modes. The check synchronization relay shall be set in consultation with BLPC.

Overcurrent protection devices shall be appropriately rated for the expected continuous operating voltages and currents as required by BLPC and GEED as applicable to the equipment design and work scope.

Overcurrent protection devices shall have directional functionality where required.

4.5 Operating Requirements

4.5.1 Islanding

1. Selected BESS shall island for system events or manual switching by BLPC Dispatch or System Operator. The response time of the PCS shall be fast enough to smoothly transition from charging to supplying the island load at up to 70 % of capacity in no more than 100ms.
2. The trigger to island mode may be from a protection relay or BLPC Dispatch or System Operator.
3. If a BESS Plant Controller with microgrid functionality is provided, microgrid control hardware and software shall meet the specification and testing requirements in line with the requirements of IEEE Std. 2030.7 and IEEE Std. 2030.8 respectively. The following core microgrid control functionality shall be provided:
    I. Dispatch function
        i. Dispatch Battery System within operating limits under grid-connected mode
        ii. Dispatch Battery System within operating limits under islanded mode
    II. Transition function
        i. Planned islanding - upon request, dispatch BESS to achieve proper balance within the microgrid and reduce active and reactive power (P, Q) to zero at PCC; send open command to PCC breaker(s).
    III. Reconnection – dispatch the BESS to synchronize the microgrid-side voltage to the grid-side voltage before closing the PCC breaker.

4.5.2 Under Voltage and Over Voltage Current Injection

4.5.2.1 Low Voltage Ride-Through (LVRT) Current Injection

1. For BESS of Class 4 and above: To support the power system to maintain the voltage during a remote or close-in fault, the BESS shall inject reactive current (capacitive) of at least 2% of the maximum rated current of the BESS for each 1% reduction of the connection point voltage from the voltage level prior to the fault event. This reactive current injection shall be in addition to the pre-fault reactive current injection. The rise time for the reactive current response shall not be more than 50 ms.
2. The BESS shall commence the additional reactive power injection when the connection point voltage drops below 90% of the nominal voltage. However, this threshold value may be subject to change as required. Refer to IEEE 1547 – 2018 and IEEE 2800 - 2022 for guidance.

4.5.2.2 High Voltage Ride-Through (HVRT) Current Injection

1. For BESS of Class 4 and above: To support the power system to maintain the voltage during system event which causes an overvoltage, the BESS shall absorb reactive current (inductive) of at least 2% of the maximum rated current of the BESS for each 1% increment of the connection point voltage from the voltage level prior to the fault event. This reactive current absorption shall be in addition to the pre-fault reactive current absorption. The rise time for the reactive current response shall not be more than 50 ms.
2. The BESS shall commence the additional reactive power absorption when the connection point voltage rises above 120% of the nominal voltage. However, this threshold value may be subject to change as required. Refer to IEEE 1547 – 2018 and IEEE 2800 - 2022 for guidance.

4.5.3 Active and Reactive Power

1. BLPC Dispatch or System Operator shall provide active (P) and reactive (Q) power setpoints to the BESS Plant Controller. BESS Plant Controller shall operate the BESS to meet the P/Q setpoints as defined below:

   I. Active or Reactive power priority:

      The control system shall have the capability to prioritize the active or reactive power during the normal operation and Voltage Ride-Through events. The selection of active power and reactive power priority shall be available from the BLPC Dispatch or System Operator.

   II. AC Voltage Control:

      When operating in ac voltage control mode, the ac voltage of the regulated ac bus is controlled with an adjustable reference voltage setting that can be selected between the specified minimum and maximum continuous bus voltages. An adjustable droop setting shall be provided between 0% and 10% based on the rating of the PCS. It shall be possible to set the reference voltage and the droop from the local interface or from BLPC Dispatch.

   III. Reactive Power Control:

      When operating in reactive power control mode, the reactive power into or out of the PCS AC bus shall be controlled within the reactive power capability limits of the BESS PCS. If the AC voltage goes outside the minimum or maximum limits set by the operator, control will revert to AC voltage control to prevent the ac voltage exceeding the limits. The maximum and minimum voltage limits shall be settable from BLPC Dispatch of the System Operator.

   New P and Q set points can override any scheduled behavior as determined by the System Operator.

2. A SCADA communications system failure shall not affect the operation of the BESS.
3. BLPC Dispatch or the System Operator shall be able to provide additional parameters such as ramp rate, droop curves, fault behavior and operational thresholds.

4.5.4 Rise Time / Settling Time

1. The BESS response for an active power set point change shall have a rise time of 1s and settling time of 2s.
2. The response for reactive power (or voltage) set point change shall have a rise time of 0.5s and settling time of 1s.
3. The response for a voltage disturbance at the PCC shall have a rise time of 50ms and settling time of 80ms.
4. The active and reactive power recovery after LVRT/HVRT event shall have a rise time of 100ms and settling time of 500ms.

These rise times are subject to change depending on the grid generator composition as determined by the System Operator.

4.6 Control and Monitoring Requirements

4.6.1 General

1. The Developer shall be responsible for all hardware, software, communications and programming for all equipment to serve the functions of the BESS control system.
2. The BESS control system shall include all instrumentation, hardware and capability to support the required data acquisition.
3. The Developer shall provide hardware and software manufacturer and specification sheets.
4. The Developer shall provide a Single Line Drawing, including devices, interconnection of devices, wiring types and protocols used.
5. The Developer shall provide data list with the device name and individual addresses of data points as required by BLPC.

4.6.2 Communication Requirements

1. Interfacing the BESS communication network to the BLPC Communications and Control System shall be performed in accordance with Section 2.8.2 of this document and Grid Code Section 5.7.3.
2. Developer shall conduct BESS local and remote operation tests in cooperation with BLPC.

3. BLPC provided communications shall pass through a firewall and use the BLPC operations network to reach the BESS Plant Controller.

4.7 Operating Data, Telemetry and Monitoring

At a minimum, the BESS control system shall monitor, record and store the following measurements for interface to BLPC's Dispatch or System Operator. BLPC requires monitoring capability for all BESS from Class 3 and above, however, BLPC intends to aggregate BESS systems from 5 kW up to 150 kW. The CIA would indicate the need for monitoring systems below Class 3.

I. State of charge
II. Operating mode
III. Power consumption kW, kVAR, kVA charging and discharging,
IV. Energy measurement kWh charging and discharging
V. Frequency
VI. Voltage (instantaneous and rms)
VII. Current (instantaneous and rms)
VIII. Power factor
IX. PCS set points
X. Status and fault codes
XI. Protection relaying feedback and alarms
XII. Lifetime energy throughput
XIII. AC disconnect switch position (Class 4 and above)
XIV. Status, alarms and diagnostics from fire protection system and UPS (Class 4 and above)

1. System data acquisition shall record data within at most 5-second time interval and storage shall record data within - and at least 1-minute time interval.
2. BLPC may require that certain measurements be recorded at 10 to 100 millisecond intervals and potentially at 1 millisecond resolution for recording alarms or events. Developer shall coordinate with BLPC to provide such functionality where required.
3. Historian data over project life shall be readily available for access and download.
4. Real time operations and performance of the system shall be available for monitoring and controls through a Human Machine Interface (HMI).

4.7.1 BESS SCADA Data Collection and Storage

For BESS Class 4 and above:

1. Data recorded shall be time series data (e.g., voltage, current, power, temperature) and event data (e.g., faults, warning, errors, operator initiated changes)
2. Time series data shall be recorded with an averaging period of four seconds to one minute and shall include mean, min, max and standard deviation.
3. Data sampling rates for time series data shall be independent of site communications network. Sampling rates shall be 2 Hz or higher for time series data.
4. Processed data shall be stored locally in queue so that no data is lost if site communications network is temporarily lost. When communication is regained, the queue shall be downloaded to the SCADA computer/server.
5. All data shall be stored in an industry standard relational database. Any Open Database Connectivity (ODBC) compliant database may be used. The data shall be time-stamped and searchable with a range of data access query functions provided. It shall be possible to store user generated query functions. The query-returned data shall be capable of graphical or tabular presentation. It shall be capable of being exported to external analysis programs in appropriate formats, e.g., comma-separated values (CSV) and Excel.
6. The control system shall back-up all recorded data, on-site. Developer shall coordinate with BLPC regarding all data storage, handling, and security requirements.
7. Backups shall be written to standard media using open, non-proprietary file formats.
8. Historical data shall be stored for at-least eight (8) years.
9. Measurement error of 2% shall be provided with reference to Grid Code Section 5.6.3.

4.7.2 Developer Information Security

1. Developer shall design the BESS system to align with the NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 4.0 including all firewalls, access control and data protection requirements.
2. The Developer will provide cybersecurity documentation, in accordance with BLPC's cyber security requirements, to mitigate critical vulnerabilities in hardware and software, such that where possible, no single point of failure exists within the systems.

4.7.3 SCADA server and Human Machine Interface

For BESS of Class 4 and above

1. The Developer shall provide HMI hardware and operation station on site.
2. SCADA server and HMI station shall allow full viewing, analysis, reporting, fault diagnosis, fault resetting, PCS and BESS control functionality.
3. Communication to BLPC Control Center shall be via Secured VPN connection, in accordance with BLPC's existing cyber security requirements.

Time synchronization

1. A GPS satellite receiver shall be installed to provide time synchronization signals. This device shall provide time synchronization signals for the BESS control system and all devices communicating with the BLPC Dispatch.
2. As an alternative, BESS control system can use a time synchronization source at the grid interconnection source if it exists.

4.8 Metering Requirements

1. For Class 2 and below and less than 200 A, BLPC shall provide a single meter for the BESS at the PCC. LV meter sockets shall be provided by the Developer.
2. Where the current produced by BESS of Class 2 and Class 3 is in excess of 200A and metered at LV, the revenue meter, meter socket and metering CTs shall be provided by BLPC. LV metering cabinets for CTs shall be provided by the Developer
3. Metering for Class 4 BESS shall involve BLPC providing HV metering equipment at the Developer's cost.
4. For Class 5 and 6 BESS, the Developer shall make available 3-phase current transformers and potential power transformers at the PCC. BLPC will provide the main and check meters and meter sockets.
5. The CTs may have a rated secondary current of 5A and shall be ANSI Class 0.2s or better accuracy with burden 15VA.
6. The PT voltage measurements shall provide 3-phase and a grounded neutral, 120Vac L-N. The PT Class shall be 0.5 and burden of 50VA
7. Revenue meter data shall be stored by BLPC Dispatch for a minimum of eight (8) years

5 Operating Code

This section provides the operational requirements and procedures of BLPC so that BESS Developers understand what their obligations are regarding the operation of their BESS facilities. The requirements outlined in Sections 6 and 7 of the BLPC Grid Code shall be met for the BESS, dependent on Rated Power Capacity, and serve as the main document of reference for the operational requirements of BESS. The requirements outlined in this document supplement the requirements in Sections 4 and 5 of the BLPC Grid Code. Where a conflict exists this document supersedes the Grid Code.

5.1 Event Reporting

For BESS of Class 4 and above, equipment shall be installed to record all significant signals or events to enable post event troubleshooting and analysis. The sequence of events recorder shall also record critical digital (contact-type) inputs for all protection/trip functions. Recorded traces and trending analysis shall be remotely accessible. Please refer to Section 7.8 of the BLPC Grid Code for related requirements.

6 Functionality and Operation of System

6.1 Commissioning

1. A standardized test procedure shall be utilized by BLPC for Class 1 and 2 systems. For systems of Class 3 and above, a Commissioning Plan shall be provided by Developer to the BLPC for review and acceptance. The scheduled commissioning dates shall be shown in the project baseline schedule which will be coordinated with BLPC.
2. BESS commissioning shall be conducted by the Developer in coordination with the manufacturer representatives as applicable and BLPC.

6.2 Information for BLPC review and approval

Developer shall provide documents which shall contain the following as a minimum:

1. Project Overview
    a. BESS database with model number, power and voltage rating, test data, etc. for all DC-side and AC-side components in BESS.
    b. Site master control system data base with model number, serial number, power and voltage rating, test data for all components
    c. BOP Database complete with model number, applicable rating for all equipment including but not limited to PCS units, transformers, switchgear and breakers.
2. Specification sheets for all subcomponents
3. Studies and Reports
4. Commissioning Reports, Test Reports, Inspection Reports
5. Acceptance Test Reports
6. All Factory Test Results and Certiofications
7. Independent Laboratory Test Results /Type Tests reports
8. Quality Assurance/Quality Control Documentation including Non-Conformance Register (NCR) with all non-conformance actions closed.
9. Dynamic simulation model of BESS system with reference to Section 5.2.23 of the BLPC Grid Code. Electromagnetic Transient (EMT) simulation models may also be required.

10. Other project documentation that would reasonably be required for BLPC to document the interface and control facilities for operation of the BESS in the future.
11. Developer shall provide comprehensive site-specific Operating Manual(s), detailing all functionality to be provided throughout the duration of the life of the system and outline any system limitations.

6.3 BESS Commissioning

6.3.1 General

1. Commissioning shall be performed in accordance with the manufacturer's installation, commissioning, and O&M manuals, and in accordance with the Commissioning Requirements laid out in this section and the Commissioning Plan developed by the Developer.
2. BESS commissioning shall be conducted by the Developer in coordination with BLPC representative(s).
3. BESS Plant Controller and SCADA system commissioning shall be conducted by the Developer in coordination with BLPC and the appropriate subject matter experts.
4. Fire and smoke detection, fire suppression, and fire and smoke containment systems shall be tested as part of the commissioning procedure.
5. Ventilation and thermal management systems shall be tested as part of the commissioning procedure.
6. Electrical safety and emergency shutoff devices shall be tested as part of the commissioning procedure.
7. The Developer shall develop and provide a detailed Commissioning Plan for the Project. The Commissioning Plan shall include inspection and verification of all safety aspects of the BESS. For this purpose, Developer shall provide a check list for BLPC's approval. The inspected items shall include, but are not limited to:
    a. BESS operability
    b. Signage
    c. Area Completions: Egress, access, and physical security illumination

8. The Commissioning Plan should define the minimum requirements for field inspection and testing of electrical equipment.
9. The latest edition of codes and standards, in effect at the time the work is executed, shall be used.
10. Developers may refer to the EPRI ESIC Energy Storage Test Manual, IEEE1547.1 -2020 and IEEE 2030.3 - 2016 for test procedures. The procedures will be approved by BLPC.
11. The Commissioning Plan shall include all relevant testing required to demonstrate compliance with the Grid Code requirements.
12. BLPC has the right to recommend and perform any additional tests at the site.
13. The Developer shall be responsible for fully commissioning the BESS and shall furnish all labor, equipment, tools, and materials required to perform the Commissioning Tests.
14. Technicians performing the work shall be qualified by virtue of training and experience for the type of work performed and shall be familiar with the equipment under test. They shall be trained in the nature of the hazards involved and shall be capable of judging the serviceability of the equipment.
15. Test instruments shall be calibrated by an accredited calibration laboratory and shall be in good working order. Calibration test records shall be available to BLPC upon request.
16. Developer shall provide for BLPC review and approval, a complete set of commissioning test protocols and accompanying forms at least sixty (60) days prior to commencing the Commissioning Tests.
17. A copy of the complete report (Commissioning Test Report) of all testing shall be provided to the BLPC representative present immediately on completion of commissioning. As a minimum, the report shall include all information described in 2017 NETA-ATS section 5.4 and copies of all testing records.
18. Test results that fall within the guidelines of NETA-ATS are considered acceptable, unless otherwise specified.

6.3.2 BESS Plant Controller Commissioning

For BESS of Class 3 and above

1. Commissioning of the BESS Plant Controller shall be performed for each BESS sub-unit consisting of a PCS and all connected storage units.
2. Commissioning of the BESS Plant Controller shall also be performed for the overall BESS plant.
3. The time window of the full Commissioning of the BESS Plant Controller tests shall be set by the BLPC. Commissioning of the BESS Plant Controller shall, at a minimum, include the tests listed in the Appendix.

6.3.3 Site Acceptance Testing

For BESS of Class 3 and above, the Developer shall provide a Site Acceptance Test Plan.

The Site Acceptance Test Plan shall be used to verify that:

1. All components of the Project meet or exceed the minimum target capacities, for the BESS.
2. The BESS Plant Controller can communicate with the PCS units, meters, and BESS.
3. The BESS can receive charge and discharge signals within the timeframes in Section 4.5.4 of this document.
4. The BESS can meet all functional requirements as required by this document and specific use cases for the BESS.
5. The components of the project can meet ride-through and fault requirements for an asynchronous generating facility as specified in the BLPC Grid Code.
6. The BESS can meet all tests demonstrating successful operation with regard to asynchronous plant technical requirements in the BLPC Grid Code at the PCC.

Site Acceptance Test Plan shall include the BESS Capacity and RTE test and Ramp Rate test required.

Testing shall comply with Good Industry Practices, Applicable Laws, and Applicable Standards.

The Site Acceptance Test Plan shall include a schedule and comprehensive test procedure detailing the timeline and plan for all site acceptance testing activities, no less than 60 days prior to the initiation of commissioning activities. This plan will include:

1. Overall time frame, including key milestones.
2. Site testing and commissioning plan, including detailed schedule, procedures, necessary tools required on site, testing criteria, and acceptance criteria.

6.3.4 Final Acceptance and Completion

Developer shall complete all activities related to Commissioning and Acceptance testing and submit to BLPC a Final Test Report.

Any departure from referenced codes must be fully described and submitted to BLPC for consideration, review and possible acceptance.

7 Appendix

7.1 Commissioning Tests

A list of commissioning test that may be required by BLPC is provided below:

1. **Capacity Tests:** The "BESS Capacity Test" is a performance test to demonstrate that the BESS energy capacity, maximum charge and discharge power are in compliance with the Functional Requirements.
2. **Round Trip Efficiency Test:** The "Round-trip Efficiency Test" (RTE Test) is a performance test to demonstrate the charging and discharging requisite to satisfy the performance standard required in the BESS Functional Requirements
3. **Response Time, Ramp Rate and Settling Time Test (RRS Test):** The RRS Test is a performance test to measure the response time, ramp rate and settling time of the BESS to reach rated power during charge or discharge from initial measurements taken when the BESS is at rest
4. **Absolute Active Power Test:** Test shall validate the closed loop active power logic using inverter controls to produce the desired PCC active power measurement within 2 sec. This test is performed by adjusting the BESS Plant Controller Active Power Setpoint value. Test procedure and acceptance criteria shall be agreed with BLPC.
5. **Absolute Reactive Power Test:** Test shall validate the closed loop reactive power logic using PCS controls to produce the desired measurement at the PCC in a reasonable time. This test is performed by adjusting the BESS Plant Controller Reactive Power Setpoint value. Test procedure and acceptance criteria shall be verified per Developer interconnection requirements.
6. **Over-frequency and Under-frequency Active Power Response Test:** Test to validate the closed loop active power logic in response to grid over-frequency and under-frequency events. This test is performed by adjusting the alternate grid frequency data source's value. Test procedure and acceptance criteria shall be verified as per BLPC interconnection requirements.
7. **Automatic Voltage Regulation (AVR) Test:** Test which involves letting the controller respond to a voltage step change. The BESS Plant Controllers' voltage reference will be stepped and the kVA and Voltage will be measured, and the plant performance will be monitored for a period to observe the plant's response to naturally occurring voltage fluctuations. In closed loop voltage regulation mode, the system must maintain a voltage regulation accuracy of +/- 1.0% of the controlled voltage at the PCC (assuming the grid is in steady state condition) over the range of

controllability the controller has at the site. The voltage regulation system shall achieve 90% of its final value no later than 1 second following a step change in voltage at the BESS Plant Controller. The response should be overdamped (no overshoot). Test procedure and acceptance criteria shall be verified per Developer interconnection requirements.

8. **The Power Factor Control Test:** Test which involves measuring plant step change and steady state performance in fixed power factor control mode. Ideally, in response to a step input, the plant responds without oscillation; without overshoot and can maintain a fixed PF setting within the given steady state tolerances at the PCC. The procedure for performing the test requires iteration through several step changes that vet the controllers' ability to control leading and lagging power factors in compliance with limits on the PCC power factor (+/-0.85). Test procedure and acceptance criteria shall be verified as per BLPC interconnection requirements.

7.2 Standards

- A non-exhaustive list of applicable standards is provided below for the design and construction and connection of battery energy storage systems to the T&D System:
- IEEE 1547 -2018
- IEEE 1547.1 – 2020 - IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces
- IEEE 1547.3 – 2023 - IEEE Guide for Cybersecurity of Distributed Energy Resources Interconnected with Electric Power Systems
- IEEE 1547.9 - 2022 Guide for Using IEEE Std 1547™for Interconnection of Energy Storage Distributed Energy Resources with Electric Power Systems
- IEEE 2030 – 2011 - IEEE Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), End-Use Applications, and Loads
- IEEE 2030.3 – 2016 - IEEE Standard Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications
- IEEE 2800 – 2022 - IEEE Standard for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems
- UL 1642 - Standard for Lithium Batteries
- UL 1973 - Standard for Batteries Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications

- UN 38.3 - UN Transportation Testing for Lithium Batteries
- NFPA 855-2023 - Standard for the Installation of Stationary Energy Storage Systems
- UL 9540 - Energy Storage Systems Requirements
- UL 1741 - Standard for Safety Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources
- Requirements of the relevant authorities in Barbados for example the Barbados Fire Service, Government Electrical Engineering Department

7.3 RTE and BESS Efficiency Calculation

It is proposed that two measures of the efficiency of the BESS be taken:

1. Round Trip Efficiency: proposed to be measured at commissioning and at regular intervals. The RTE calculation is provided below:

   RTE = (Discharged Energy) / (Charged Energy) x 100%

   Where: "Discharged Energy" is calculated during the discharging step of the BESS Capacity Test
   "Charged Energy" is calculated during the charging step of the BESS Capacity Test.

2. BESS Efficiency: proposed to be measured annually from the date of commissioning of the BESS. The BESS Efficiency shall be calculated using the annual measurements of the total annual exported energy and total annual imported energy by the BESS.

   BESS $Efficiency$ (%) = Total Exported Energy at POI / Total Imported Energy at POI × 100

   With this calculation, the losses can be calculated as the difference between Total Imported Energy and Total Exported Energy measured at the POI.

7.4 Availability Calculation

Availability can be calculated as follows:

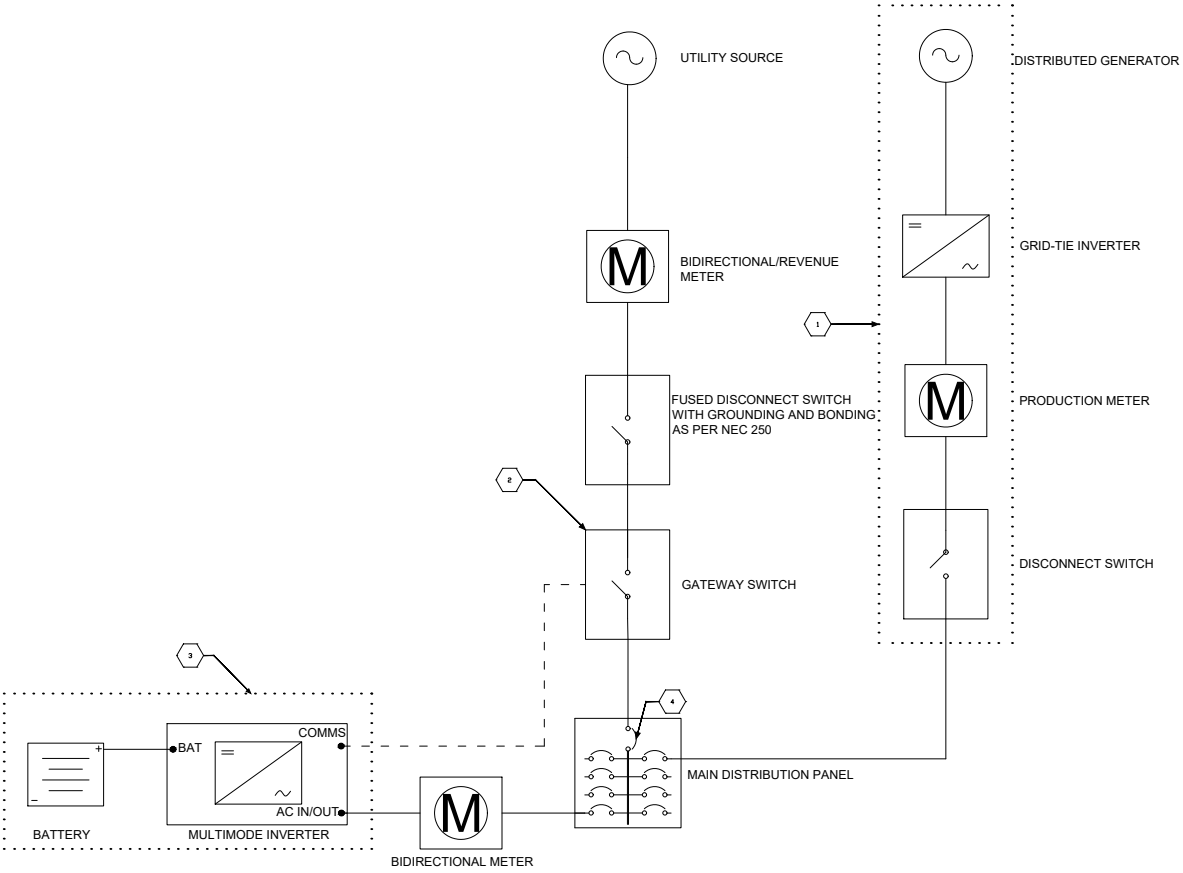
BESS Availability = Uptime of BESS / Total Time X 100%

Where

- Uptime of BESS refers to the time during which the BESS is operational and ready to provide power
- Total Time is the overall time period being considered. This total time period includes the time during which the BESS is operational and downtime for maintenance or failures.
- Time periods where force majeure events occur are excluded from the Uptime and Total Time
- Uptime measurement relies on an in-service status of the BESS and its ability to perform as expected based on its State of Charge

7.5 Single Line Diagrams Illustrating the Various Classes of Storage

- These battery storage system drawings supersede the battery configurations outlined in the 2017 Grid Code (Section 4.6.2: Metering for SDG with Battery Storage), which are not intended for grid services.
- Any alternative configurations must receive approval from BLPC. Additionally, changes to an existing installation will require an "Alter and Extend" certificate issued by the Government Electrical Engineering Department. BLPC will review this certificate before proceeding with any alterations to facilitate the battery storage system.
- It should be noted that additional requirements may apply beyond those shown in the diagrams, depending on the functionality required for the specific use case.



GENERAL NOTES

1. THE INTERCONNECTION OF PHOTOVOLTAIC OR WIND TURBINE SYSTEMS IS OPTIONAL AND IS ILLUSTRATED HERE SOLELY FOR DEMONSTRATION PURPOSES IN RELATION TO A BESS.
2. THE ILLUSTRATED GATEWAY FEATURES A SINGLE OUTPUT BUS DESIGNED FOR WHOLE-HOME BACKUP. DURING AN OUTAGE THE BUS IS ISOLATED FROM THE GRID, ENABLING ALL CONNECTED LOADS IN THE HOME TO BE BACKED UP BY THE BESS.
3. THE PLANT CONTROLLER MAY BE SUBSUMED WITHIN THE BESS RATHER THAN AS A STANDALONE CONTROL UNIT. THE SUPPLIER IS EXPECTED TO PROVIDE DOCUMENTATION FOR BLPC'S REVIEW ON THE PLANT CONTROLLER AND IT'S INTERFACING CAPABILITIES WITH BLPC'S DISPATCH.
4. THE MAIN CIRCUIT BREAKER PROVIDES THE FUNCTIONALITY OF THE OVERCURRENT PROTECTION DEVICE.

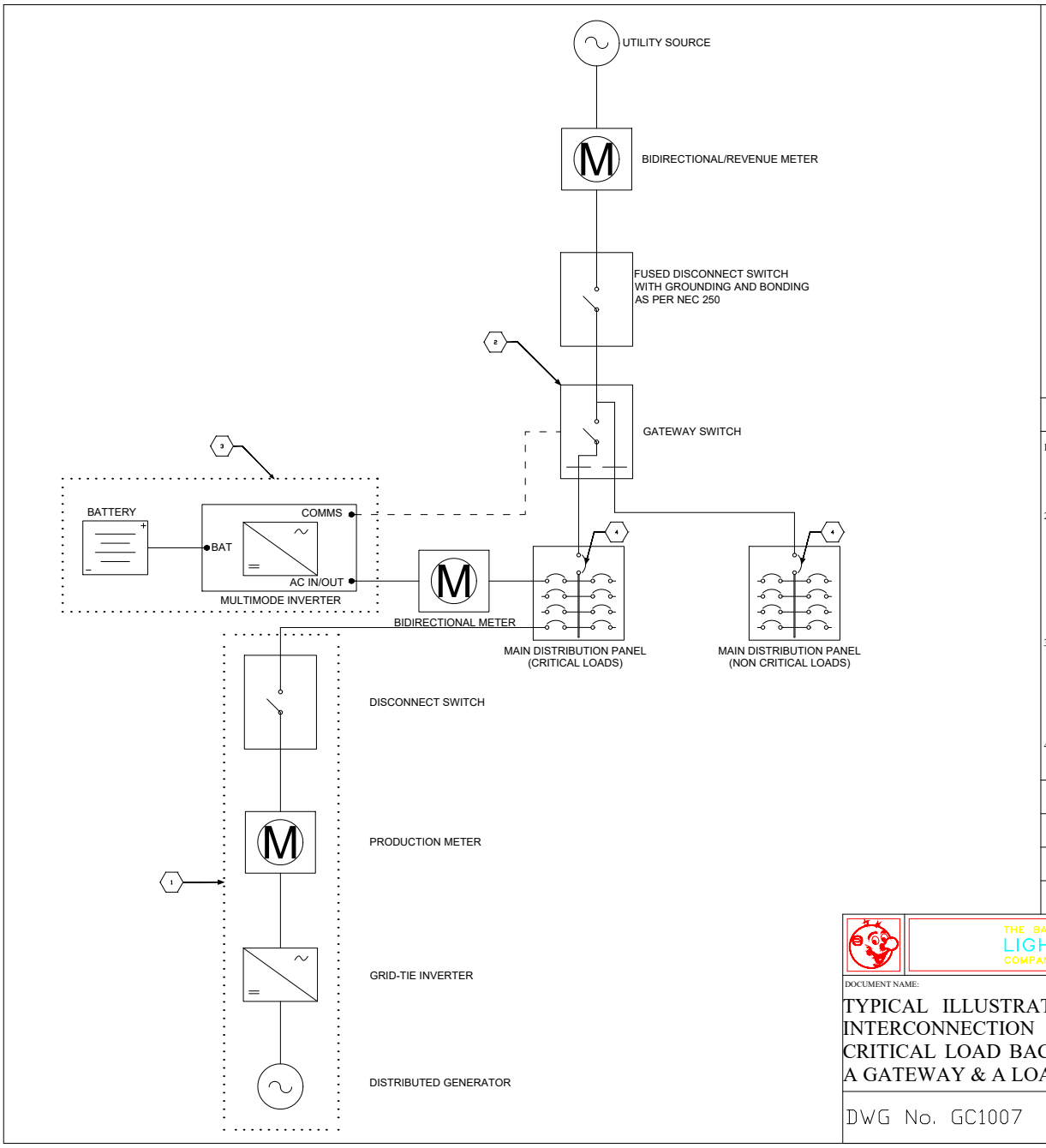
	LEGEND
1	TECHNICAL NOTE REFERENCE
	AC/DC POWER LINE
	COMMUNICATION/DATA LINE

THE BARBADOS LIGHT & POWER COMPANY LIMITED

DOCUMENT NAME:

TYPICAL ILLUSTRATION OF CLASS 1 BESS INTERCONNECTION REQUIREMENTS FOR WHOLE HOME BACKUP COORDINATED VIA A GATEWAY & A LOAD SIDE CONNECTED DG

DWG No. GC1006



GENERAL NOTES

1. THE INTERCONNECTION OF PHOTOVOLTAIC OR WIND TURBINE SYSTEMS IS OPTIONAL AND IS ILLUSTRATED HERE SOLELY FOR DEMONSTRATION PURPOSES IN RELATION TO A BESS.
2. THE ILLUSTRATED GATEWAY FEATURES TWO SEPARATE OUTPUT BUSES: ONE FOR NON-CRITICAL LOADS AND THE OTHER FOR CRITICAL LOADS. DURING AN OUTAGE, THE NON-CRITICAL LOAD BUS REMAINS CONNECTED TO THE GRID, WHILE THE CRITICAL LOAD BUS IS ISOLATED. THIS CONFIGURATION ENABLES THE LOADS CONNECTED TO THE CRITICAL LOAD BUS TO BE BACKED UP BY THE BESS.
3. THE PLANT CONTROLLER MAY BE SUBSUMED WITHIN THE BESS RATHER THAN AS A STANDALONE CONTROL UNIT. THE SUPPLIER IS EXPECTED TO PROVIDE DOCUMENTATION FOR BLPC'S REVIEW ON THE PLANT CONTROLLER AND IT'S INTERFACING CAPABILITIES WITH BLPC'S DISPATCH.
4. THE MAIN CIRCUIT BREAKER PROVIDES THE FUNCTIONALITY OF THE OVERCURRENT PROTECTION DEVICE.

LEGEND

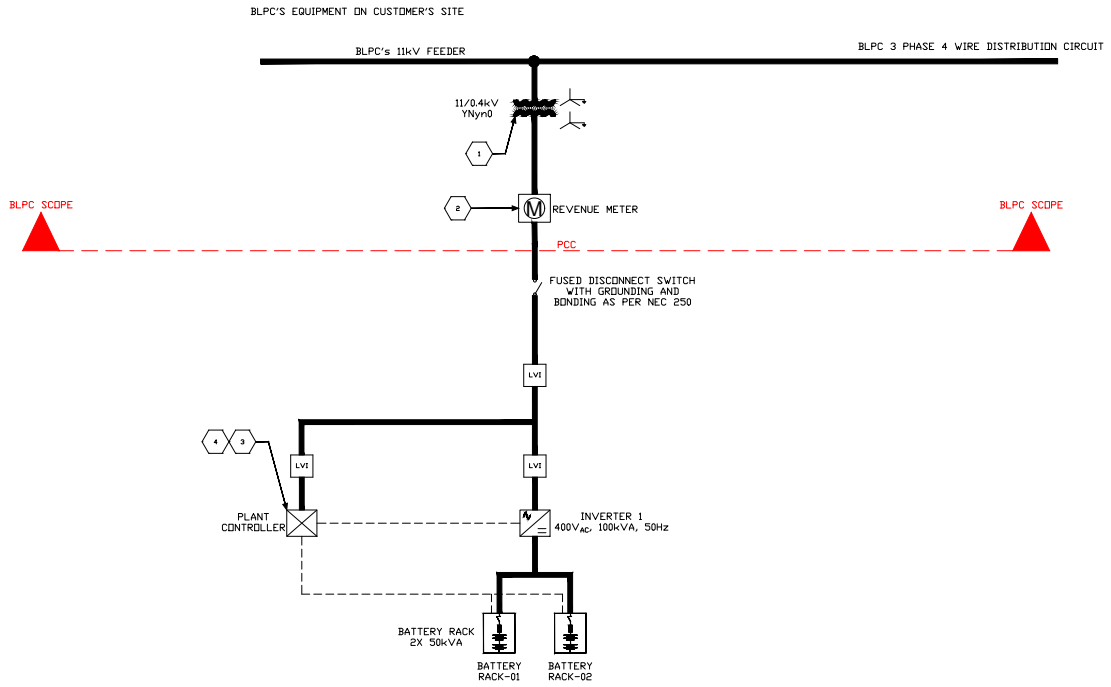
1	TECHNICAL NOTE REFERENCE
	AC/DC POWER LINE
	COMMUNICATION/DATA LINE

THE BARBADOS
LIGHT & POWER
COMPANY LIMITED

DOCUMENT NAME:

TYPICAL ILLUSTRATION OF CLASS 1 BESS INTERCONNECTION REQUIREMENTS FOR CRITICAL LOAD BACKUP COORDINATED VIA A GATEWAY & A LOAD SIDE CONNECTED DG

DWG No. GC1007



GENERAL NOTES

1. THE TRANSFORMER MAY BE POLE-MOUNTED, DEPENDING ON SITE CONDITIONS.
2. CTs WILL BE PROVIDED BY BLPC IF THE CUSTOMER'S MAIN CIRCUIT BREAKER EXCEEDS 200AMPS.
3. CUSTOMER MUST MAKE PROVISIONS FOR CONNECTIVITY OF DEVICE TO BLPC DISPATCH.
4. THE PLANT CONTROLLER MAY BE SUBSUMED WITHIN THE BESS RATHER THAN AS A STANDALONE CONTROL UNIT. THE SUPPLIER IS EXPECTED TO PROVIDE DOCUMENTATION FOR BLPC'S REVIEW ON THE PLANT CONTROLLER AND IT'S INTERFACING CAPABILITIES WITH BLPC'S DISPATCH.

LEGEND

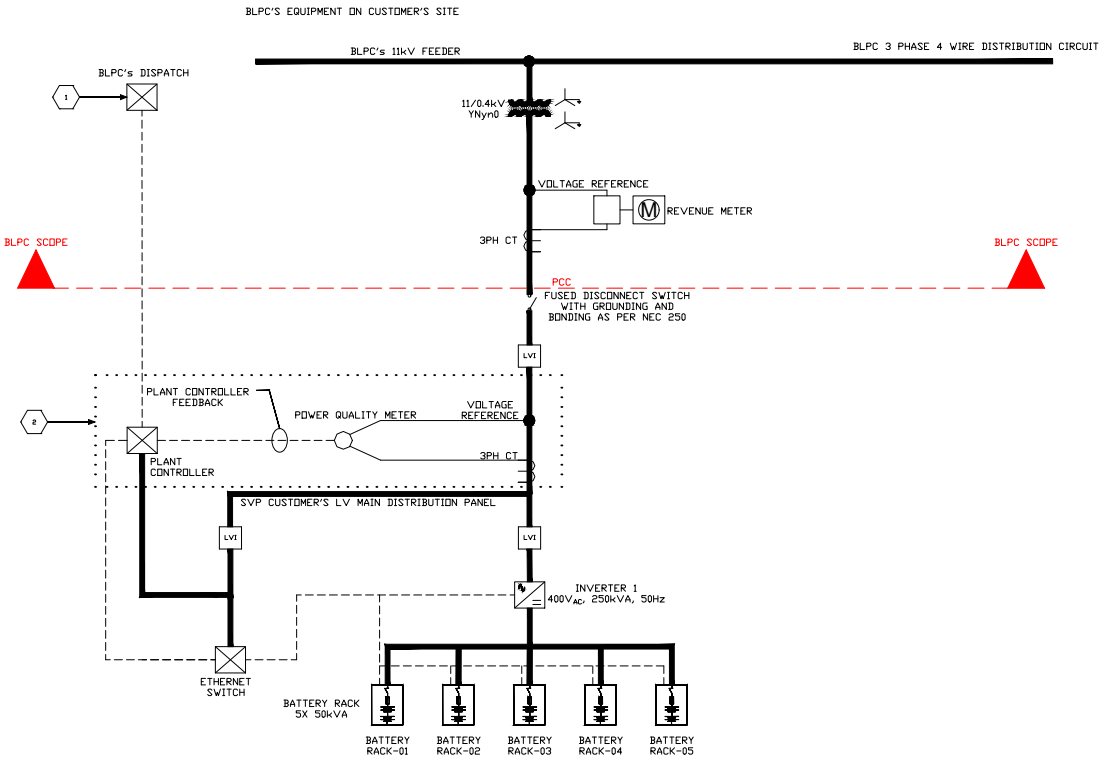
	BESS
	INVERTER
	PADMOUNT TRANSFORMER
	LV ISOLATOR
	LV AC CIRCUIT BREAKER
	TECHNICAL NOTE REFERENCE
	AC/DC POWER LINE
	COMMUNICATION/DATA LINE

THE BARBADOS
LIGHT & POWER
COMPANY LIMITED

DOCUMENT NAME:

TYPICAL ILLUSTRATION OF CLASS 2 BESS INTERCONNECTION REQUIREMENTS

DWG No. GC1008



GENERAL NOTES

1. THE IPP MUST PROVIDE CONNECTIVITY TO BLPC DISPATCH TO ENABLE MONITORING AND CONTROL OF SELECTED DEVICES.
2. THE DEPICTED PLANT CONTROLLER CONFIGURATION AND ETHERNET SWITCH ARE FOR ILLUSTRATIVE PURPOSES ONLY. THE PLANT CONTROLLER INSTALLATION CONFIGURATION DEPENDS ON OEM GUIDELINES.

LEGEND

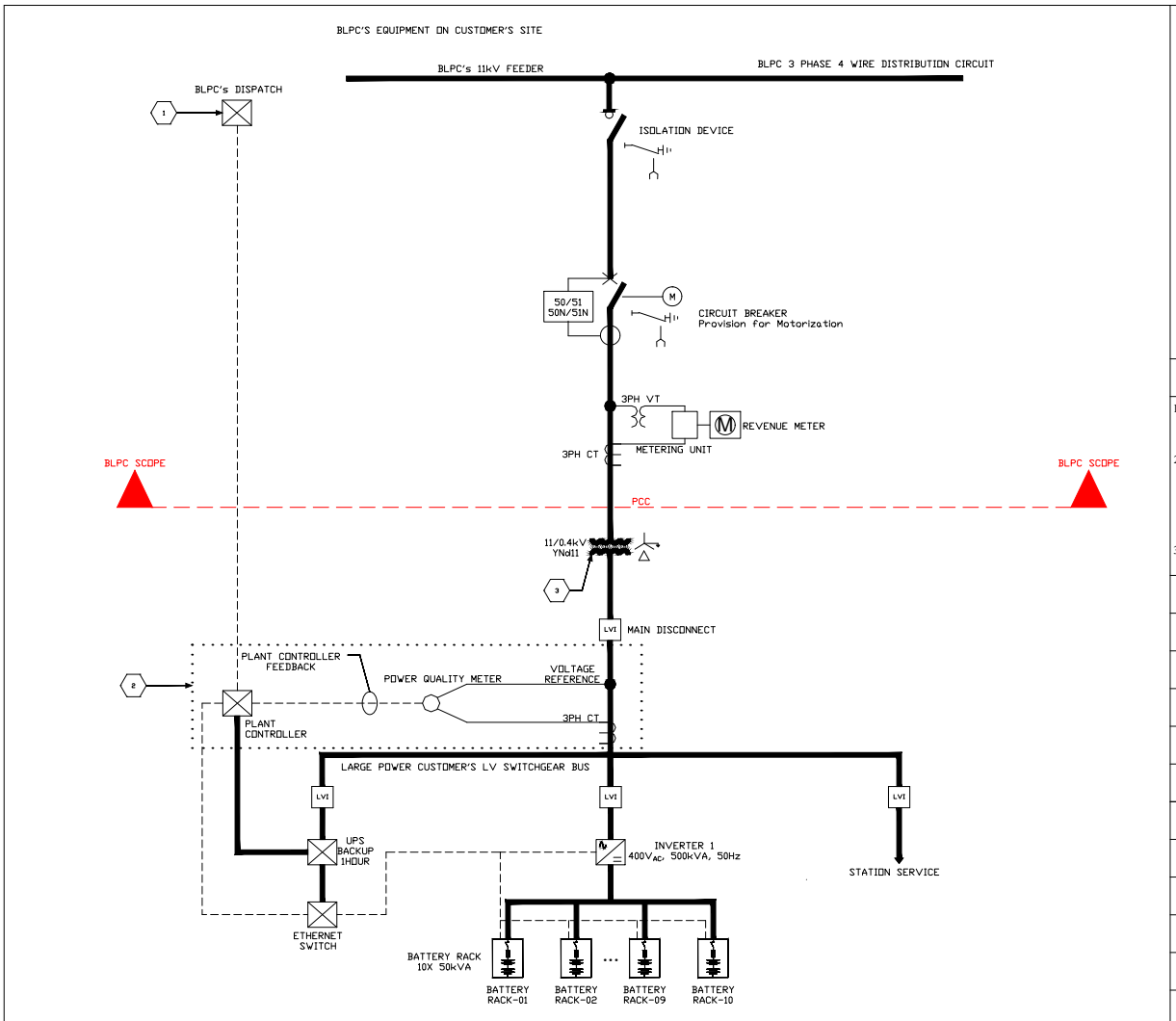
	BESS
	INVERTER
	PADMOUNT TRANSFORMER
	LV ISOLATOR
	LOW VOLTAGE INTERRUPTER
	POTENTIAL TRANSFORMER
	CURRENT TRANSFORMER
	TECHNICAL NOTE REFERENCE
	AC/DC POWER LINE
	COMMUNICATION/DATA LINE

THE BARBADOS
LIGHT & POWER
COMPANY LIMITED

DOCUMENT NAME:

TYPICAL ILLUSTRATION OF CLASS 3 BESS INTERCONNECTION REQUIREMENTS

DWG No. GC1009



GENERAL NOTES

1. THE IPP MUST PROVIDE CONNECTIVITY TO BLPC DISPATCH TO ENABLE MONITORING AND CONTROL OF SELECTED DEVICES.
2. THE DEPICTED PLANT CONTROLLER CONFIGURATION AND ETHERNET SWITCH ARE FOR ILLUSTRATIVE PURPOSES ONLY. THE PLANT CONTROLLER INSTALLATION CONFIGURATION DEPENDS ON OEM GUIDELINES.
3. LOW VOLTAGE VALUE OF 400V (L-L) IS FOR ILLUSTRATIVE PURPOSES ONLY.

LEGEND

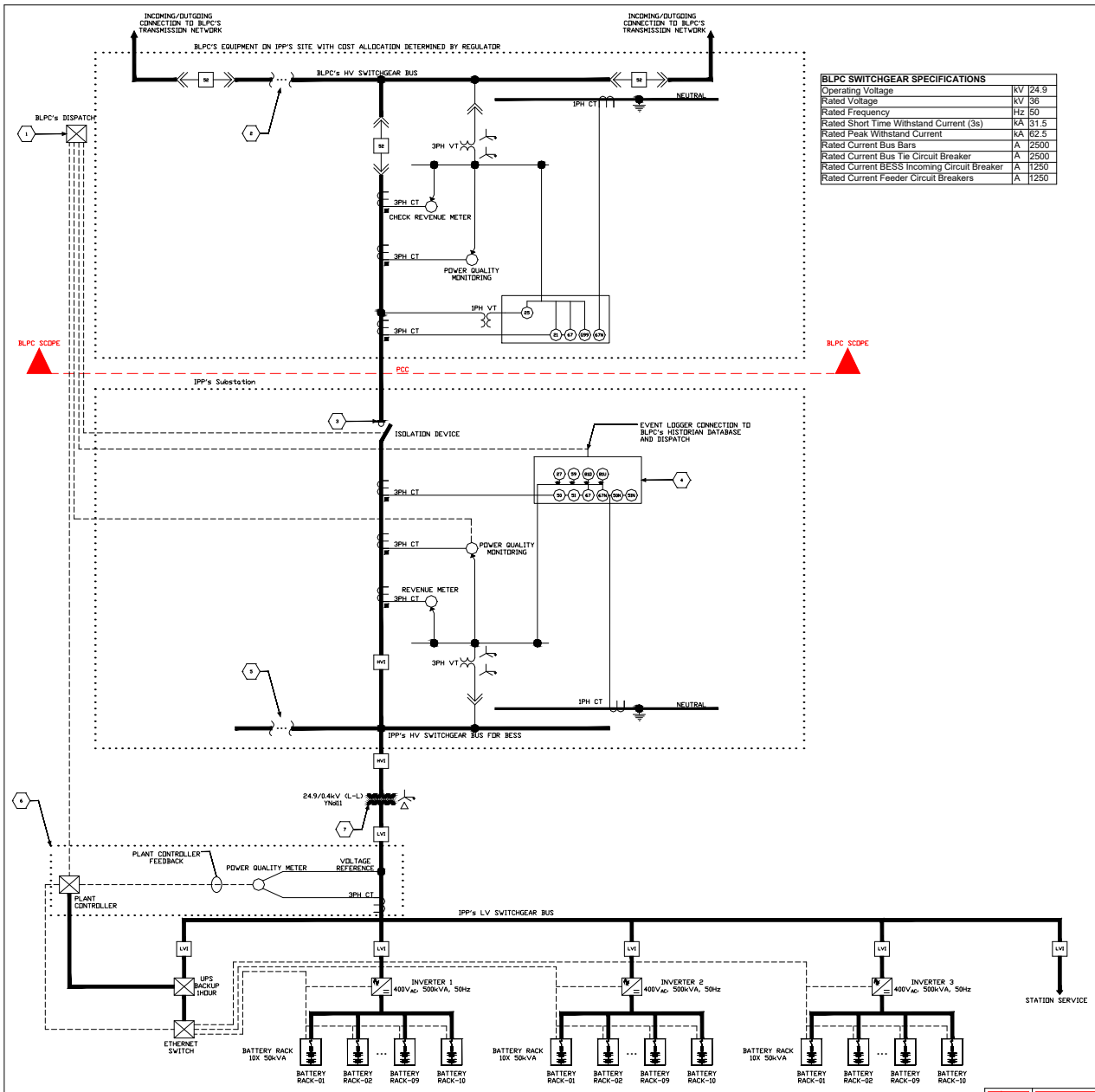
	BESS
	INVERTER
	PADMOUNT TRANSFORMER
	MV AC CIRCUIT BREAKER
	MV ISOLATOR
LVI	LOW VOLTAGE INTERRUPTER
	POTENTIAL TRANSFORMER
	CURRENT TRANSFORMER
1	TECHNICAL NOTE REFERENCE
	AC/DC POWER LINE
	COMMUNICATION/DATA LINE

THE BARBADOS
LIGHT & POWER
COMPANY LIMITED

DOCUMENT NAME:

TYPICAL ILLUSTRATION OF CLASS 4 BESS INTERCONNECTION REQUIREMENTS

DWG No. GC1010



BLPC SWITCHGEAR SPECIFICATIONS		
Operating Voltage	kV	24.9
Rated Voltage	kV	36
Rated Frequency	Hz	50
Rated Short Time Withstand Current (3s)	kA	31.5
Rated Peak Withstand Current	kA	62.5
Rated Current Bus Bars	A	2500
Rated Current Bus Tie Circuit Breaker	A	2500
Rated Current BESS Incoming Circuit Breaker	A	1250
Rated Current Feeder Circuit Breakers	A	1250

GENERAL NOTES

1. THE IPP MUST PROVIDE CONNECTIVITY TO BLPC DISPATCH TO ENABLE MONITORING AND CONTROL OF SELECTED DEVICES.
2. CONNECTION POINT VIA CIRCUIT BREAKERS FOR INTEGRATION OF OTHER DG TECHNOLOGIES AND/OR FUTURE ON SITE DEVELOPMENT.
3. THE ISOLATION DEVICE MUST BE CAPABLE OF BEING REMOTELY CONTROLLED BY BLPC'S DISPATCH.
4. PROTECTION RELAYS MUST INCLUDE AN EVENT LOGGER WITH CONNECTIVITY TO BLPC'S HISTORIAN DATABASE AND DISPATCH SYSTEM AND SHALL BE CAPABLE OF GPS TIME SYNCHRONIZATION AS PER THE 2017 GRID CODE.
5. CONNECTION POINTS VIA CIRCUIT BREAKERS TO FACILITATE FUTURE ON SITE BESS EXPANSION.
6. THE PLANT CONTROLLER INSTALLATION CONFIGURATION DEPENDS ON OEM GUIDELINES.
7. LOW VOLTAGE VALUE OF 400V (L-L) IS FOR ILLUSTRATIVE PURPOSES ONLY.

LEGEND

	BESS
	INVERTER
	PADMOUNT TRANSFORMER
	MV AC CIRCUIT BREAKER
	MV AC CIRCUIT BREAKER
	MV ISOLATOR
	POTENTIAL TRANSFORMER
	CURRENT TRANSFORMER
	LV AC CIRCUIT BREAKER
	TECHNICAL NOTE REFERENCE
	AC/DC POWER LINE
	COMMUNICATION/DATA LINE

THE BARBADOS LIGHT & POWER COMPANY LIMITED

DOCUMENT NAME:

TYPICAL ILLUSTRATION OF CLASS 5 AND CLASS 6 BESS INTERCONNECTION REQUIREMENTS

DWG No. GC1011