JAMAICA ELECTRIC UTILITY SECTOR

GENERATION CODE

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GENERATION CODE REVISIONS
LIST OF REVISIONS

Current Rev.	Date	Page affected	Prepared by	Checked by (technical)	Checked by (quality assurance)	Approved by
			REVISION HISTORY			
		All				

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GC 1 SCOPE

This Generation Code sets out the procedures and principles governing the operation of the Jamaica Electricity System and all interconnected Generation Facilities.

GC 2 INTERCONNECTION CONDITIONS

This section specifies the normal method of interconnection and the minimum technical, design and operational criteria which must be complied with by any Generator and prospective Generators including those with Variable Renewable Power Plant.

Additionally, details specific to each Generator's interconnection may be set out in a separate Interconnection Agreement or in some cases, the relevant Power Purchase Agreement. The Interconnection Conditions set out in the Code shall be read in conjunction with either or both of these Agreements as relevant. In the event that, there is any conflict between the provisions of the Code and any Interconnection Agreement and/or Power Purchase Agreement and the said Interconnection Agreement and/or Power Purchase Agreement was signed before the present Code came into effect, then, the provisions of the Interconnection Agreement and/or Power Purchase Agreement will supersede the Code. The foregoing, all Interconnection Agreements and/or Power Purchase Agreements shall be read in conjunction with the Code in force at any material time and in accordance with Sub-section 2.1 of this Code.

GC 2.1 Method of Interconnection

The method of interconnection shall be determined on the basis of several technical and economic factors which include:

i) Proximity to System;
ii) Generating Unit (MW) rating or Generating Facility (MW) capacity;
iii) Supply voltage;
iv) Reliability considerations;
v) Auxiliary power supply;
vi) Substation configuration
vii) Protection systems/devices; and
viii) Costs

It will not be technically or economically practicable to achieve uniformity of the method of interconnection. In all cases however, Prudent Utility Practice will guide the method adopted.

The method chosen by the Generator shall be reviewed and approved by the

System Operator on the grounds of System security, stability and safety.

GC 2.1.1 Interconnection Point

The Generating Unit(s) shall be interconnected to the System via a Substation. The Interconnection Point shall normally be on the High Voltage side of the generator step-up transformer and will demarcate the boundary of responsibility between the Generator and the System Operator.

Generators, with capacity of 60 MW or more shall be interconnected to the switchyard/substation to satisfy the N-1 security criteria. This implies that the loss of any single Transmission element connecting a Generator to the Transmission System shall not result in a loss of generating capacity greater than 60 MW.

The finalized number of Interconnection Points shall be determined by a system analysis study at the time of interconnection to the System.

The Generator shall be responsible for all costs related to interconnection to the System.

GC 2.1.2 Supply Voltage

The voltage level at which the Generating Unit(s) are connected to the System will be dependent on but not limited to the size and number of units and the other factors that determine the Interconnection Point.

Subject to other technical considerations, Generating Units with a Rated Capacity of 10 MW or above shall be interconnected to the Transmission System at 69 kV or 138 kV.

Generating Units with a Rated Capacity of below 10 MW may be interconnected to either the Transmission System at 69 kV or 138 kV or the primary Distribution System at 24 kV or less.

Embedded Generating Facilities with Rated Capacity between 1MW and 10MW may be interconnected via a dedicated feeder recloser from the Substation to the Facility.

GC 2.1.3 Configuration of Generation Substations

All Generation Substations shall have the capability to disconnect or separate, from the System, any transmission line and Generating Unit which is interconnected to the Substation.

For reasons of ensuring safety and reliability of operation, Generation Substations with more than three Transmission Lines and Generating Units interconnected to them shall be of a ‘breaker and a half’ configuration. The size of the Generating Units shall be considered for applicability of the breaker and a half requirement. The Substation shall be equipped with all requisite protection measures necessary to meet the System Operator's System protection standards as set out in Sub-

section GC 2.2.4.

GC 2.2 Generator Performance Standards and Technical Criteria

GC 2.2.1 Technical Standards

All components of the interconnection shall be constructed, installed and tested in accordance with the current edition at the time of construction of the following codes and standards, or their international equivalents and Prudent Utility Practice:

ACI	American Concrete Institute
ANSI	American National Standards Institute
ASCE	American Society for Civil Engineers
AME	American Society for Mechanical Engineers
ASNT	American Society for Non-Destructive Testing
ASTM	American Society for Testing Materials
AWS	American Welding Society
UL	Underwriters Laboratory
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronic Engineers
ISO	International Organization for Standardization
NBC	National Building Code (Jamaica)
NIST	National Institute of Standards and Technology
NEC	National Electric Code
NEMA	National Electric Manufacturers Association
NESC	National Electric Safety Code
NETA	National Electric Testing Association
NFPA	National Fire Protection Association
SSPC	Steel Structures Painting Council
BSJ	Bureau of Standards Jamaica
NEPA	National Environmental Planning Agency (Jamaica)
OSHA	Occupational Safety and Health Administration

GC 2.2.2 Performance Standards

Each Generating Unit interconnected to the System shall be required, as a minimum, to meet the following performance standards:

Sustained operation at any Load within the loading limits within the System frequency range of 49.5 Hz to 50.5 Hz;

i) Emergency operation within the Generator loading limits and within the system frequency range of 48.0 Hz to 52.5 Hz;
ii) Maintain normal rated output at the System normal voltages specified Sub-section GC 2.3 of this Code;

iii) Sustained operation at the rated Power Factor set out in the relevant and appropriate Interconnection Agreement; and
iv) System Interconnection Criteria (Appendix E)

GC 2.2.3 Station Capabilities

i) Synchronizing Facilities Each Generating Unit shall be equipped with synchronizing facilities to ensure Synchronization with the System. Two independent synchronizing facilities, preferably one automatic and one manual shall be provided, however, the primary must be automatic. The Synchronization facilities shall include a synchronism check relay to support synchronization under the following range of conditions:

a) System frequency within the limits 48.0 to 52.5 Hz; and
b) System voltages within the limits specified in Sub-section 2.3.

ii) Auxiliary Supply

Each Generating Unit shall have the facility to provide its auxiliary supply during normal operation. Each Generator shall provide the facility to connect to the System for an incoming station service supply from the System Operator.

iii) Automatic frequency response

It is required that dispatchable Generating Units have continuously fast acting response automatic governor and excitation control systems to control the Generating Unit's power output and voltage levels without instability of operation within the operating range of the unit.

iv) Governor response Capability

The droop characteristics from no load to full load for Generating Units shall be adjustable in the range of (0 - 5%).

v) Black Start Capability and Dead Bus Control

Some Generating Units shall be designated to have Black Start Capability primarily considering their type and location on the system. This shall enable Generators to restart their facilities without incoming supply from the System, connect to a Dead Bus, and supply load as necessary; once on line Generators are required to be in frequency sensitive mode so as to vary with load changes. In the event of the Generator “black starting” the System, the Generator may act, temporarily upon the provision of instructions from the System Operator.

The specification of the Black Start Generating Unit shall be a subject of the Interconnection Agreement (normally contained in the PPA as a Schedule) between the System Operator and the Generator.

Where a Generator has a facility with a capacity of 60MW (excluding intermittent renewables with high and rapid variability) or greater, at least one source of Black Start supply shall be located at the site. Black Start facilities shall be routinely tested by the Generator to ensure satisfactory operation. The System Operator shall have the right to require the Generator to demonstrate the performance of the Black Start Capability. At a minimum, the Generator is required to provide a formal report to the System Operator twice a year, detailing the results of the Black Start generator test. One of these reports must be based on a test done in May of that year and shall be submitted to the System Operator before June 1 (the official start of the hurricane season). A failed event shall automatically trigger the reporting of that black start test event by the relevant Generator to the System Operator. A further report is also to be immediately submitted by the Generator to the System Operator upon subsequent successful maintenance and operation of said black start generator.

vi) Fuel Supply Capability (Thermal Plants only)

The Generator shall at its own expense construct and maintain fuel supply infrastructure sufficient to store at least eighteen (18) days of fuel requirement at normal rated output subject to the provisions Section GC 7 of this Code.

GC 2.2.4 Protection Requirements

i) Protective systems shall be provided in accordance with the Technical Standards set out in Sub-section GC 2.2.1 and Prudent Utility Practice as generally accepted in the power industry.

ii) All protective relaying equipment shall comply with the appropriate Technical Standards. At a minimum, the following protection schemes shall be provided subject to the exigencies of the relevant generation technology including inter alia;

<u>AC generators (Reference is made to IEEE Guidelines 37.102.2006)</u>

a) Loss of Excitation (Under-reactance type)
b) Differential current protection (for generator phase-to-phase fault)
c) Negative phase sequence protection (for unbalanced load operation)
d) Stator ground fault protection (for generator phase-to-ground faults)
e) Reverse power protection
f) Backup protection in the event of circuit breaker failure to operate.
g) Over- and under-frequency
h) Over- and under-voltage
i) Thermal over-load
j) Rotor (or field) ground fault protection

<u>Transformers (Reference is made to IEEE Guidelines 37.91.2000)</u>

a) Differential current protection for generator step-up transformers
b) HV/LV phase and ground overcurrent protection (for station service/unit auxiliary transformers)

c) Buchholz and/or Sudden pressure (gas relay)
d) Over excitation protection (for generator step-up transformers)
e) Backup protection in the event of circuit breaker failure to operate for generator step-up transformers
f) Over-temperature protection (winding and oil)

Interconnection

a) Differential (line current high-impedance) for Phase and earth faults.
b) Backup interconnection protection in the event that external phase and earth faults are not cleared by remote protection system.
c) Backup protection in the event of circuit breaker failure to operate.

I. The protection requirements for the HV interconnection with System will depend on the interconnection voltage and the Substation configuration. The detailed arrangements for each Generating Facility are set out in the respective Interconnection Agreement. In all cases it should be ensured that each Generating Unit or Facility can be separated from the System as rapidly as possible in the event of a sustained electrical fault on either side of the Interconnection Point. The speed of separation shall be determined by the Interconnection Criteria.

iii) The protective relaying systems shall provide the levels of sensitivity, speed and reliability as required by the System Operator. The operation of all protection schemes shall be coordinated with the operation of the System Operator's equipment.

iv) The Generator shall submit the following design data for prior approval by the System Operator:

a) Protection and Metering single line diagrams;
b) Tripping logic diagrams;
c) AC and DC schematic diagrams for the interconnection and Generating Unit protection schemes;
d) Setting calculations and setting lists for the interconnection and Generating Unit protection schemes including opening/closing time for major circuit breakers; and
e) Rating and Transfer Function data as required for computer simulation of the Generating Unit(s). This shall include data on the generator(s), transformer(s), automatic voltage regulator(s) and prime mover governor.
f) Substation Equipment single line diagram.

GC 2.2.5 Variable Renewable Power Plant Interconnection Conditions

Automatic Voltage Regulation (AVR) & Fast Voltage Control.

VRPP must be capable of operating in a voltage control mode to maintain the voltage at the Point of Interconnection to stay at a set point provided by System Operator to the VRPP. The voltage setting requirement shall be within the normal operating range of the system (+/- 10% of nominal. VRPP must respond to a sudden voltage decrease/increase with the corresponding fast positive sequence fundamental frequency reactive current output controllers. However, to fulfil these requirements at the Point of Interconnection the appropriate system studies must be carried out by the VRPP Operator.

VRPP System Connected Transformer Configuration.

VRPPs shall provide with on-load tap-changing (OLTC) facilities for its System connected power transformer. The transformer configuration and tap changing steps shall be proposed and pre- approved by the System Operator.

VRPP System Connected Transformer Configuration.

VRPPs shall provide with on-load tap-changing (OLTC) facilities for its System connected power transformer. The transformer configuration and tap changing steps shall be proposed and pre- approved by the System Operator.

Reactive Power Requirements.

It must be possible to operate the VRPP plant in reactive power control mode, and follow any operating point within the range cos ϕ = 0.95 leading under-excited (inductive) to cos ϕ = 0.9 lagging over-excited (capacitive) at the Interconnection point.

Additionally the full lagging reactive capability of 0.9 pf of the VRPP registered capacity (generally being the same as the rated nameplate capacity) shall be made available at 100% to 90% of the nominal voltage. The full leading reactive capability of 0.95 pf of the rated VRPP capacity shall be made available at 100% to 110% of the nominal voltage.

Voltage Flicker.

Voltage Flicker is the rapid change in voltage that distorts or interferes with the normal sinusoidal voltage waveform of the Transmission System. VRPPs are not allowed to introduce significant Voltage Flicker on the Transmission Network as measured at the Point of Interconnection. The VRPP facility must not create objectionable flicker for other customers on JPS system. The voltage dip at the Point of Interconnection should not be more than 4% on connecting the single largest generation unit in the facility and should remain within 10% of nominal voltage when the entire facility trips. The VRPP Owner shall take steps to make sure that flicker requirements are met; there may be the need to add loss of synchronism protection, stagger generator energization, etc.

In setting and analysing voltage flicker limits, the appropriate standards should be applied.

VRPP Harmonic Distortion.

Harmonics are waveforms that distort the fundamental 50 Hz wave. The electrical output of the customer's generating facility shall not contain harmonic content which may cause disturbances (unacceptable voltage distortion) on or damage to JPS' electrical system, or other customer's systems, such as but not limited to computer, telephone, communication and other sensitive electronic or control systems. The VRPP facility shall follow the requirements of internationally accepted standards such as the IEEE and IEC.

GC 2.2.6 Energy Storage Interconnection Requirements (Reserved)

GC 2.3 System Operator Performance and Technical Standards

GC 2.3.1 System Frequency

The normal operating frequency of the System shall be controlled by the System Operator to be within 50.0 Hz ± 0.2 Hz.

For the avoidance of doubt, Generators including Variable Renewable Resource Power Plants shall be designed for sustained operation within the frequency limits as specified in Sub-section GC 2.2.2 (i) and for restricted time based operation within the emergency frequency limits as specified in Sub-section GC 2.2.2 (ii).

GC 2.3.2 Generator frequency Requirements

Generators must refer to the Generation code Sub-section GC 2.3.1 for requirements for frequency support.

Under extreme system fault conditions all Generator units must be disconnected at a frequency greater than 52.5 Hz. At a frequency less than 48.0 Hz the generator may be disconnected. Where under and over frequency relays are installed, these relays shall be set such that the automatic removal of the Generator from the Transmission System. The System Operator however may specify slightly different tripping points for the various Generator in order to avoid having all generators on the Transmission System trip at the same time in a frequency constraint.

Generators must remain connected to the Transmission System during rate of change of Transmission System frequency of values at least up to and including 0.5 Hz per second.

i) No additional Generator shall be started while the Transmission System frequency is above 50.2 Hz.

ii) The operational characteristics of the relay operation must be coordinated with other control systems of the Generator (such as excitation, frequency (speed) governor response, and other controls where applicable).

iii) The Generators at a Distributed Generation Facility must operate at a nominal frequency of 50 Hz (±0.2Hz). For frequencies considered out of this range the Generating Unit is required to trip off the System.

GC 2.3.3 Generator Governor – Primary frequency response (PFR)

Generator that have capacity available to either increase output or decrease output in real-time must provide PFR, which may make use of that available capacity response to System frequency deviations. The PFR shall be similar to the droop characteristic of the governor system used by conventional steam generators. The governor droop shall be set by System operator and be in the range of 0% to 5%, with a default of 5%.

The Generator resource automatic control system design shall have an adjustable dead band that defaults at +/- 0.03 Hz. This dead band means that until frequency error is beyond a threshold, the governor ignores it. When frequency error exceeds the threshold (0.03 Hz) the governor becomes active.

In Primary frequency response mode, the PFR control system shall have the capabilities as displayed in the Power-frequency response Curve in Figure GC 2.3.1 where the power and frequency ranges required for points A, B, C, D, and E shall be defined by System Operator.

All Generators in operation must reduce their instantaneous active power output when the system frequency is more than 52.5 Hz as shown in Figure GC 2.3.1 Points A, B, C, D and E in Figure GC 2.3.1 depend on a combination of the Transmission System frequency, Active Power and Active Power Control Set-point settings, and may be different for each Generator depending on system conditions and Generator location. Points A, B, C, D and E therefore may be adjusted by System Operator to accommodate requirements for system reliability which will be communicated to and agreed upon with the Generator on a case by case basis. In this figure the only defined power output point is maximum available power (100%) of the Generator; the Active Power Set Point could be in any value between 100% and down to 10%. The Active Power Set Point shall correspond to System Operator's operator designation of this value.

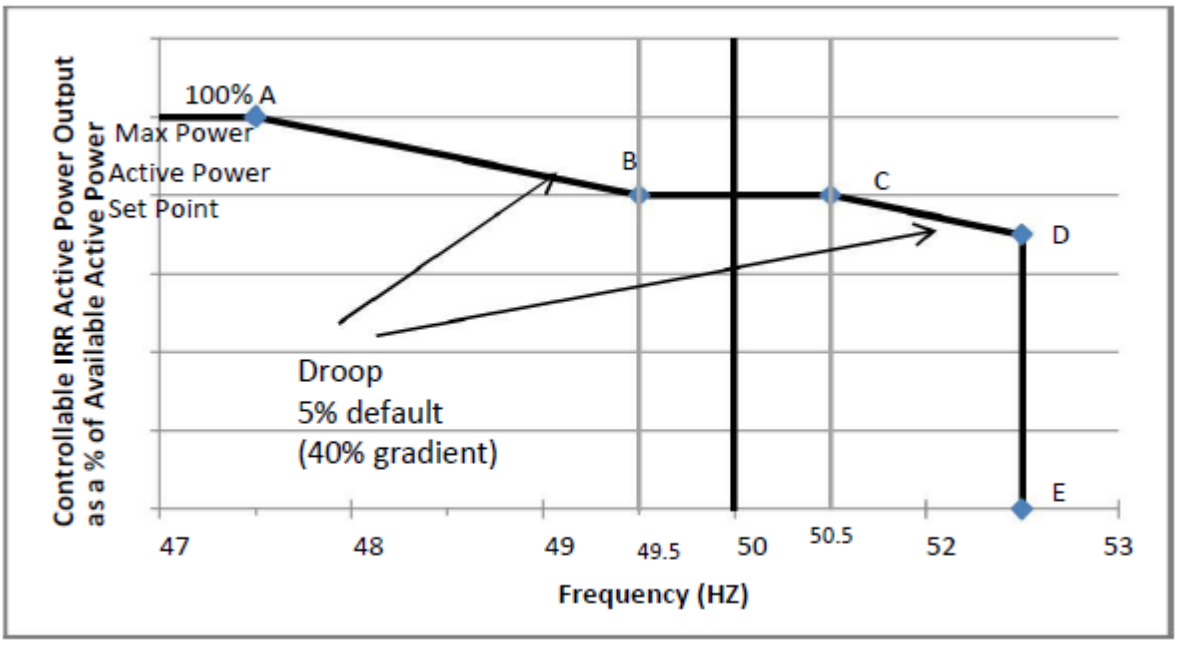


Figure GC 2.3.1 – Power-frequency response Curve

GC 2.3.2 System Voltage

The nominal operating voltages on the System shall be;

a. 138 kV and 69 kV on the transmission System; and
b. 24 kV, 13.8 kV, 12 kV, 6.9 kV, 4 kV on the Distribution System.

The normal Operating voltages shall be within:

± 5 % at the Generator Bus;
± 5 % on the Transmission System;

The contingency (abnormal) operating voltages shall be within:

± 5 at the Generator Bus;

± 10 % on the Transmission System

GC 2.3.3 Generator Fault Ride Through (LVRT)

The Low Voltage Ride-Through (LVRT) specifies the capability range for Generators to remain connected to the system during and following System faults, including the requirement to participate in the dynamic voltage control. Figure GC-S1 in Schedule F gives the Low Voltage Ride Through capability for Generators. A detail description of the operating limits are given in Schedule F of the Code.

GC 2.3.4 High Voltage Ride Through (HVRT)

Figure GC 2.3.3 refers to the positive sequence voltage at the nominal frequency. Exceeding the solid border line triggers the immediate disconnection of the unit. Generators must be capable of remaining connected at or below this limit during and immediately after any system condition. Any other disturbances as well should not result in the border line shown in Figure GC-S2 in Schedule G being crossed. These are minimum requirements; however System Operator requires equipment that is capable of riding through higher voltage and longer duration to deploy their full capability in coordination with the System Operator.

GC 2.3.5 Short Circuit Levels

The system shall be designed to withstand both symmetrical and asymmetrical short circuit conditions at the Generating Unit Substation for fault levels as specified in the appropriate Technical Standards as set out in Sub-section GC 2.2.1.

GC 2.4 Other Rights Vested With the System Operator

GC 2.4.1 Inspection of Generating Plant by System Operator

The System Operator retains the right to inspect any aspect of the Generator's plant in so far as that plant is pertinent to the provision of capacity and/ or energy to the System, or to the safe and secure operation of the System, in order to verify the correct operation of all equipment including controls, circuit breakers, relays (and relay settings), metering and telemetering. Prior to exercising its right to inspect the Generator's facilities and Metering System, the System Operator shall give the Generator two (2) working days' notice and provide adequate reason for the inspection.

The Generator shall keep records to provide verification of tests and maintenance in accordance with agreements between the System Operator and Generator.

GC 2.4.2 Disconnection of Generator by the System Operator

The System Operator retains the right to disconnect any Generating Facility from the System thereby isolating equipment, without prior notice under the following circumstances:

i) in cases of System Emergency;
ii) during system restoration following partial or complete loss of power;
iii) if at any time the Generating Facility is being operated outside acceptable operating parameters in a manner which violates the Interconnection Conditions set out in the Code or which is likely to cause any of the following:

a. A safety risk to personnel;
b. Risk to stability or security of the System or Other Generating Units;
c. Any behavior causing sustained operation outside the normal System operating frequency and voltages as stated under Sub-section 2.3

Notwithstanding the forgoing in the event of any material breach of Interconnection Conditions which prevents the System Operator from meeting its Licence obligations, the System Operator may disconnect after using best commercial efforts to give notice to the Generator.

GC 3 OPERATIONAL METERING

Adequate Metering Systems consistent with the technical specifications of this Generation Code shall be installed by the Generator. The Metering System shall comprise a Primary and Backup Metering System and shall be designed, financed and installed by the Generator. The System Operator shall own and maintain the Primary Metering System while the Generator shall own and maintain the Backup Metering System.

GC 3.1 Technical Standards for Operational Metering

GC 3.1.1 Location of Metering Equipment

i. Both Primary and Backup Metering Systems shall be installed to accumulate the outputs and/or inputs at the High Voltage side of the generator step-up transformer.
ii. Each meter shall have its own current transformer (CT) and potential transformers (PT) and necessary independent systems to function effectively.
iii. For Generators less than 100 kW, metering requirements of the Standard Offer Contract in addition to the provisions of Sub-section GC 3.2.4 of this Code shall apply. Refer to " JAMAICA PUBLIC SERVICE COMPANY LIMITED STANDARD OFFER CONTRCT FOR THE PURCHASE OF AS-AVALIABLE ENERGY FROM INTERMITTENT RENEWABLE ENERGY FACILITIES UP TO 100 kW".

GC 3.1.2 Metering Standards

a) Instrument transformers shall conform to ANSI Standards C12.11 and C57.14 Class 03 and shall have sufficient capacity to supply the burden produced by the wiring and metering equipment.
b) The current transformers secondary winding used for metering purposes shall supply only the metering equipment and associated systems. Notwithstanding the foregoing each current transformer may have other secondary windings that may be used for purposes other than metering.

c) Potential transformers' secondary windings may be used for metering and other purposes provided that the total loading does not exceed one half the rating of the transformer.
d) Any metering and accumulating equipment shall have sufficient accuracy so that any error resulting from such equipment shall not exceed ±0.5% of full scale ("Allowable Error").

GC 3.1.3 Sealing, Field testing and Inspection of Metering Systems

Meters and associated instrument transformer boxes or enclosures shall be sealed by and at the expense of the Generators at the respective meters. The type of seal shall be approved by the System Operator.

For wiring used only for metering purposes, solid metallic conduit runs shall be used to enclose the wiring connecting the instrument transformers and the related accumulating and metering equipment. Any boxes or enclosures or other devices used to join two or more sections of conduit shall be securely covered, fastened and sealed with seals approved by the System Operator.

If the wiring used for metering must pass through a panel, panel board or switchgear structure, it shall be fastened together and cabled as a unit separate and apart from the rest of the wiring.

At its own expense, the Generator shall provide any terminal blocks that may be used along the length of the metering conductors within a panel, panel board or switchgear with covers or strips that limit access to the respective connections and said covers or strips shall be affixed with a seal approved by the System Operator. Boxes or enclosures shall be sealed with pre-numbered seals approved by the System Operator.

Seals shall not be broken by anyone except the System Operator's personnel when the meters are to be inspected, tested or adjusted. The System Operator shall notify the Generator in advance of such inspection, testing or adjustment, and the Generator has the right to have a representative present.

Before the commissioning of any Generating Unit, the System Operator shall test the Metering System for correct wiring and accuracy, using equipment whose accuracy is equal to or better than that of the individual meters. Individual meter components found to be inaccurate before commissioning shall be returned to the Generator for replacement. Malfunctions identified after full acceptance of the Metering System shall be the responsibility of the individual owners.
The System Operator shall test the Metering System within ten (10) days after:

i. The detection of a difference larger than the Allowable Error in the readings of the meters;

ii. The repair of all or part of a meter caused by the failure of one or more parts to operate in accordance with the specifications; and/or

iii. Each anniversary of the commissioning date of the unit. If any errors in the readings of the meters are discovered by such testing, the Party owning those meters shall repair, recalibrate or replace those meters and shall give the other Party reasonable advance notice so that the Party receiving notice may have a representative present during any such corrective activity.

GC 3.2 Meter Reading Procedures

GC 3.2.1 Parameters for Meter Reading

The Generator shall provide and install appropriate equipment and shall make continuous recordings on appropriate magnetic media or equivalent of the Net Energy Output and Dependable Capacity if applicable, of the Generating Unit(s).

The parameters to be metered shall be subjected to the Interconnection Agreement between the Generator and the System Operator, and may consist of but not limited to any or all of the following parameters:

1) Active energy (MWh) OUT;
2) Active energy (MWh) IN;
3) Reactive energy (MVARh) First Quadrant;
4) Reactive energy (MVARh) Fourth Quadrant;
5) Active Power Demand (MW) OUT;
6) Active Power Demand (MW) IN;
7) Reactive Power Demand (MVAR) First Quadrant; and
8) Reactive Power Demand (MVAR) Fourth Quadrant.

GC 3.2.2 Frequency of Reading

The Demand interval shall be (15) minutes and shall be set to start at the beginning of the hour. Demand shall be calculated by averaging the respective over the stated Demand Interval.

The System Operator shall read the appropriate meters to prevent clock drift. The clocks shall be checked and reset as agreed by the Parties. If readings are obtained remotely, copies of the data produced by the computer which initiates the reading protocol can be made and provided to the Generator if requested.

GC 3.2.3 Control Procedures

The System Operator shall inform the Generator at least 24 hours prior to reading the meters and the Generator shall have the right to have a representative to witness such readings.

For the Demand actually experienced throughout the billing period, the meters

shall be equipped with a mass memory module of a minimum of 3 months which shall record the parameters in Sub-section GC 3.2.1.

GC 3.2.4 Metering Requirements for Generators <100 kW

For small Generating Facilities with rated capacity below 100 kW the full metering requirements in Sub-section 3.1 may be reduced. These Facilities will be permitted to be metered using separate import and export meters. The terms and conditions of this arrangement shall be guided by the Standard Offer Contract (SOC).

The metering equipment shall be a bi-directional device or a smart meter having the capability of mass memory, remote reading and power quality monitoring. Specification of the meter shall be provided by the System Operator and the Qualifying Entity shall purchase the metering equipment which shall be owned and maintained by the System Operator.

GC 3.3 Reconciliation Procedures

If the Primary Metering System is known to be inaccurate or otherwise functioning improperly, then the Backup Metering System shall be used during the period that the Primary Metering System is not in service and the provisions described in Sub-section 3.2 shall apply to the reading for the Backup Metering System.

If the Primary Metering System is found to be inaccurate by more than the Allowable Error or to otherwise have functioned improperly during the previous Month, then the correct amount of Net Energy Output and Dependable Capacity for the actual period during which inaccurate measurements, if any, were made shall be determined as follows:

i) First, the reading of the Backup Metering System shall be utilized to calculate the correct amount of Net Energy Output and Dependable Capacity, unless a test of such Backup Metering System, as required by either Party, reveals that the Backup Metering System is inaccurate by more than the Allowable Error or is otherwise functioning improperly;

ii) and If the Backup Metering System is not within the acceptable limits of accuracy or is otherwise functioning improperly, then the Generator and the System Operator shall jointly prepare a reasonable estimate of the correct reading on the basis of all available information and such guidelines as may have been previously agreed to between the Generator and the System Operator. This estimate shall take into account but not be limited to Dispatch Instructions as recorded in the System Control Center dispatch log and meter readings, remote or manual.

GC 3.4 Resolution of Disputes over Recorded Metering Data

If the System Operator and the Generator fail to agree upon an estimate for the

correct reading within a reasonable time (as specified in the relevant PPA) of the Dispute being raised, then the matter may be referred for arbitration by either Party in accordance with the relevant PPA.

GC 4 MERIT ORDER SYSTEM

The System Operator shall establish a Merit Order based on the real or contracted Variable Operating Cost component of each Generating Unit or Complex, whichever is applicable.

The Variable Cost of each Generating Unit or Complex is the sum of the Variable Operating & Maintenance Cost (VOM) and the Fuel Cost. In mathematical form:
Merit Order Cost ($/MWh) = Fuel Cost ($/MBTU) x Full Load Heat Rate (MBTU/MWh) + VOM ($/MWh)

This information allows the System Operator to rank the Generating Units in the order of their Full Load Point cost of operation.
Refer to Section DSC 5 of the Dispatch Code for details of the Merit Order System.

GC 5.0 SCADA INTERFACING

This Section sets out the technical requirements for connections to the Operator's Supervisory Control and Data Acquisition (SCADA) system outstation in terms of electrical characteristics.

GC 5.1 General Requirements

In all cases signals shall be arranged such that the level of electrical interference does not exceed those defined in IEC 870-2-1: "Telecontrol Equipment and Systems - Operating Conditions - Power Supply and Electromagnetic Compatibility" and IEC870-3: "Telecontrol Equipment and Systems - Specification for Interfaces (Electrical Characteristics)".

Digital Inputs

Digital inputs cover both single and double points for interconnection to digital input modules on the System Operators outstation equipment. The Equipment contacts shall be free of potential, whereas the input circuitry of the outstation are common to the negative 48 volt potential.
Single Points

Single point inputs must be used for alarms and where single contact indications are available. The off (contact open or 0) state is considered to be the normal state and the on (contact closed or 1) state the alarm condition.

Double Points

Double points are used to indicate primary plant states by the use of complementary inputs for each plant item. Only the "10" and "01" states are considered valid with the "00" and "11" states considered invalid. The "10" state is considered to be the normal or closed state.

Energy Meter Inputs
Energy meter input pulses for interconnection to pulse counting input modules on the System Operator's outstation equipment must operate for a minimum of 100ms to indicate a predetermined flow of MWh or MVArh. The contact must open again for a minimum of 100ms. The normal state of the input must be open.

Analogue Inputs

Analogue inputs for interconnection to analogue input modules on the System Operator's outstation equipment must all be electrically isolated with a two wire interconnection required. Signals shall be in the form of 4-20mA (or other range to be agreed between the User and the System Operator) for both unidirectional and bi-directional measured values. Signal converters shall be provided as necessary to produce the correct input signals.

Command Outputs
All command outputs for interconnection to command output modules on the System Operator's outstation equipment switch both the 0 volts and -48 volts for a period of 2.5 seconds at a maximum current of 1 amp. All outputs shall be electrically isolated with a two wire interconnection to control interposing relays on the plant to be operated.

GC 6.0 COMMUNICATION AND REPORTING

The Generator is required to provide information as requested, pertaining to the operation of their Generating Unit(s).

GC 6.1 Designated Contact Persons

The System Operator shall at all times have a person designated as the System Control Engineer.

Each Generator shall at all times have a person designated as the Generating Unit Controller in charge of operation and control of each Generating Unit.

GC 6.2 System Control Center Record of Dispatch

A record of events shall be kept at the System Control Center, which shall include, but not be limited to:

i. All instructions regarding switching, voltage control and Generating Unit operation;
ii. Deviations in frequency outside the normal range;
iii. Each operation or sequence of operations of circuit breakers, disconnectors and earthing switches under the control of the System Control Engineer and, where appropriate, alarms and protection indications; Transformer tap changers instructed or operated by the System Control Engineer;
iv. The synchronization or taking off-line of Generating Units;
v. Details of the application and removal of main short and grounds and other

safety precautions, including the issue and cancellation of safety documents and HV live line working certificates, by the System Control Engineer or his designate as required by the System Operator's safety rules;

vi. The commissioning, taking out of service or re-commissioning of plant and apparatus, including automatic switching systems, protection and changes to relay settings, together with relevant details;

vii. The failure, or change of state, of plant or apparatus on the System together with relevant details;

viii. The failure of plant or apparatus affecting the availability of Generating Unit(s), together with relevant details;

ix. The location and identification of switchgear for which a risk of trip is expected;

x. Generating Units which are not operating in the frequency sensitive mode;

xi. Any significant abnormal or dangerous occurrence in operation including incidents involving the use of emergency public service;

xii. Any interruption and restoration of supply together with relevant details;

xiii. Details of the System Operator System load reductions, restorations and Demand control;

xiv. System/ standard time deviation at 7:30 a.m. Eastern Standard Time and 9:30 p.m. Eastern Standard Time or as may be required.

GC 6.3 Generator Operations Log

The Generator shall maintain an accurate and up-to-date Operations Log. The purpose of this Operations Log is to record significant events, plans, requests and instructions. Entries into the Operations Log should be made on a daily basis and should include, as necessary, the following:

i) Dispatching Instructions and times of receipt of such instructions from the System Control Engineer;

ii) Time of implementation of instructions;

iii) Any request from the Generator to the System Control Engineer which includes:
   a) Scheduled outages;
   b) Forced outages;
   c) Load adjustments;
   d) Maintenance Outages;
   e) Emergencies of any kind affecting the operation of the Generating Facility and Daily available Capacity.
   f) Names and status of all personnel on each shift;
   g) Daily midnight readings of the fuel used and in stock;

iv) Statements relating to abnormal running conditions of Generating Unit(s) and auxiliaries;

v) All Real (kW) and Reactive (KVAR) Power at half hour intervals, frequency and

voltage, at the 69 kV busbar and 138 kV busbar at half hour intervals, unit auxiliary and station busbar voltage and real and reactive power; any units connected at the distribution level should record similar information at the connected busbar.

vi) Generating Facilities operating on an energy-only basis with installed capacity below 15MW may not be manned at all hours and hence may not record these parameters immediately at every half hour. For these types of Generators, adequate SCADA infrastructure shall be put in place by the Generator for remote monitoring of said parameters by the Generator and System Operator, as well as local real time data capture and storage of the above parameters by the Generator.

vii) Time of trip-out or removal of Generating Units from service and the time of return to service; and Visits by factory inspectors to the Generating Facility.

GC 7 FUEL SUPPLY AGREEMENT

The Fuel Supply Agreement shall:

i) Demonstrate a dependable and sufficient fuel supply;
ii) Detail the infrastructure installed for delivery of the fuel from the central storage point to the plant gate;
iii) Provide mitigating strategies in the event of natural disaster affecting the supply of fuel delivery to Jamaica;
iv) Detail Fuel Transportation Agreement; and
v) Detail alternative fuel supply arrangements and infrastructure requirements.

All Generators shall be required to:

a) Obtain and maintain reliable supply of fuel (on-site storage exclusive to the Generating Facility) of quality and quantity sufficient to generate the Dependable Capacity and the Net Energy Output requirements of their Generating Facilities for a period of at least eighteen (18) days and the minimum inventory level should be 7-10 days. Note that the System Operator must canvas the Generators to obtain the inventory levels and advise the Generator to evaluate available options if the levels are below required levels or trending negatively for uninterrupted operations. The System Operator shall seek permission via an application to the OUR to trigger an emergency plan.
b) Provide the System Operator the Fuel Supply Plan; as duly approved by the OUR, in consultation with the System Operator.
c) Only enter into fuel supply arrangements consistent with the Fuel Supply Plan.
d) Any Renewable Fuel Feed Stock that a Renewable Energy Generating Plant uses in the conversion process to ultimately generate electricity must be derived from indigenous source(s).

GC 8 GENERATOR SCHEDULING & DISPATCHING TOOLS

The System Operator is required to ensure consistency and objectivity in the decision-making mechanisms used. These mechanisms may be in the form of standardized procedures and/or computational systems.

The System Operator is responsible for updating the System Control Policy & Procedures as required, due to changes in the system characteristics or international best practices, where it has relevance to the Jamaican Electric Power System. Documentation of the procedures followed in making System operations decisions must be promulgated to individual Generators after ratification by the OUR.

The tools used to assist in the Generator Scheduling and Dispatch optimization process must be based on an internationally accepted optimization algorithm. The tools must be used in accordance with its intended design and the System Operator is responsible for ensuring that it is functional and accurate.

GC 8.1 Generation Forecast and Dispatch

All Generators shall cooperate with System Control Center by providing generation forecasts that System Operator shall use to schedule the demand energy and dispatch the necessary units to operate the system reliably.

GC 8.2 Variable Resource Forecasting

System Operator requires the VRPP to provide quality resource forecast from reputable and industry proven methods, and or in accordance with requirements that will be dictated by System Operator in a Power Purchase Agreement or other Agreement between System Operator and the VRPP. The forecast should provide the following information:

GC 8.2.1 **Medium-Term Forecast:** a rolling hourly resource forecast submitted to System Operator for the next 168 hours. The rolling hourly forecast means the forecast must be provided on an hourly basis.

GC 8.2.2 **Short-Term Forecast:** System Operator reserves the right to also request a rolling 5-minute resource forecast to be submitted to System Operator and/or the centralized forecasting vendor for the next 6 hours.

The System Operator is required to consolidate forecasting functions in a single provider to assure uniformity of quality and improved forecasting prediction capacity, and to share the costs among the users.

The forecasts shall be provided to the System Operator through web service or ftp (File Transfer Protocol) site delivery in a format to be agreed upon with the

System Operator. The System Operator reserves the right to request a specific file format that the VRPP must accommodate

GC 8.3 Transparency and Fairness

In order to assure transparency and fairness while being cognizant of the confidentiality provisions in individual contracts, the following outlines how and what type of information will be shared among stakeholders in the generation market. Unless explicitly stated otherwise in the document, the following shall prevail:

I. **The Regulator:** The OUR shall be allowed access to any and all available information it requires from both the individual Generators or Complex, and the System Operator. Periodically as agreed between the System Operator and the OUR, Technical Reports will be compiled by the System Operator and provided to the OUR, and will contain information from the logged system parameters as agreed from time to time.

II. **Individual Generator:** The System Operator is required to provide, in a timely manner, individual Generators with any technical system information that affects the operation of interconnected Generating Units for example, fault information should be shared with all Generators, with due consideration of the specific confidentiality provisions contained in each PPA and Licence.

III. **System Operator:** The System Operator shall have timely access to all information it reasonably requires from the individual Generators.

GC 9 NEW TECHNOLOGIES

New generation technologies that have parameters not covered by this Code may be given consideration for inclusion to the System. However, the OUR, in full consultation with the System Operator, shall first provide written approval of the technical compatibility of the technology with the System, before the new technology can be interconnected.

GC 10 GENERATOR MAINTENANCE PLANNING

GC 10.1 Long Term Maintenance

GC 10.1.1 Planning Horizon

The System Operator shall develop an overall generation maintenance plan for three (3) years in advance. The first year shall be sufficiently detailed with less detail for the following years 2 and 3. The plan which shall incorporate statutory maintenance requirements shall be reviewed annually and updated as may be necessary.

To achieve this objective, Generators shall submit to the System Operator on or before the first day of July of each year a rolling three year plan for the scheduled maintenance requirement for their facility beginning in January of the following year. The System Operator shall submit the finalized, overall generation maintenance plan to the OUR by January 1 of each year and each Generator shall submit its final generation maintenance plan to the OUR by January 1 of each year.

The System Operator shall schedule both long and short term Maintenance Outages in a non-discriminatory manner as far as System security constraints reasonably allow. Both System Operator and Generator shall ensure that interconnection and other related facilities are maintained within the periods stipulated for scheduled maintenance of the Generating Facility, given the relevant technical constraints.

GC 10.1.2 Annual Commitment of Maintenance Program

Generators shall submit to System Operator on or before the first day of July of each Year, a schedule (the 'Maintenance Schedule') describing the proposed availability of the Generating Facility for each Month of the twelve (12) Month period beginning with January of the following Year. The Maintenance Schedule shall indicate the Generators' preferred dates and durations of all scheduled maintenance. In developing the plan the System Operator shall take into account the manufactures recommendations for maintenance of the plant.

The System Operator shall notify Generators in writing whether the scheduled maintenance periods requested on the Maintenance Schedule are acceptable. The System Operator shall have the right to request the Generators to conduct scheduled maintenance during periods other than those indicated in the Maintenance Schedule, provided that the period specified by the System Operator shall be as close as reasonably practicable to the periods requested by the Generators, shall be of equal duration as the periods requested by the Generator and shall be within the range of time periods identified by the Generator as the range of time periods within which such scheduled maintenance must be performed in accordance with the manufacturer's recommendations for the Generating Facility.

GC 10.1.3 Changes to the Committed Maintenance Schedules

Committed Generating Unit Maintenance Schedules shall be strictly adhered to unless unanticipated circumstances may mean interruption of supply to customers or a compromise in System security if the Maintenance Schedule is not adjusted. Under such circumstances both the System Operator and the Generator shall make best efforts to reschedule the outage as follows:

i) System Operator may upon five (5) days prior notice request Generator to reschedule a scheduled maintenance provided, however, that System Operator shall not request that scheduled maintenance be rescheduled to a time that is outside of the range of time periods identified by the Generator as the range of time periods within which such scheduled maintenance must be performed in accordance with the manufacturers recommendations for the Generating Facility;

ii) Generator may, upon five (5) days prior written notice, request that it be permitted to conduct additional scheduled maintenance for a period not identified in the Maintenance Schedule if the maintenance to be conducted cannot be postponed until the next period of scheduled maintenance identified on the Maintenance Schedules without damaging or otherwise threatening the Generating Facilities. Generator's request shall also identify the range of time periods within which such additional scheduled maintenance shall be performed in order to avoid damaging or otherwise threatening the Generating Facilities. System Operator may upon three days prior written notice, request Generator to reschedule such additional scheduled maintenance; provided, however, that System Operator shall not request that such additional scheduled maintenance be rescheduled to a time that is outside of the time periods identified by the Generator as the range of time period within which such additional scheduled maintenance shall be performed in order to avoid damaging or otherwise threatening the Generating Facilities.

iii) If the Generator is inside a scheduled maintenance period and requires an extension of the maintenance period, the System Operator shall have the right to review and determine if the extension can be accommodated or the extended work period is to be classified as Forced Outage.

GC 10.2 Short term Outage Program

For short term outages Generators shall give the System Operator at least two (2) hours' notice prior to taking the Generating Facilities out of service.

The granting of such outages shall be at the sole discretion of the System Operator.

GC 11 SCHEDULES OF RESPONSIBILITY

GC 11.1 Ownership, Operation and Maintenance Schedules

Schedules specifying the ownership and the responsibilities for Operation an Maintenance shall be jointly agreed by the System Operator and the appropriate Generator for each location where either an Operational Interface or joint

responsibilities exist. For those Generators connected at MV and having firm supply connections provided by more than one circuit, and where the Generator so requests the System Operator, these schedules shall identify those specified System Operator circuits for Planned Outages and the Generator shall be notified at least two(2) weeks in advance of the planned outage.
These specified circuits shall usually operate at the voltage level at which the supply is provided and shall have a significant effect on the security level of the Generator's s supply. These specified circuits shall be those where the System Operator and the Generator have agreed that during the outages of the specified circuits the Generator can introduce measures to manage critical processes or safety aspects. Those Generators connected at MV and not having firm interconnections provided by more than one circuit may seek to obtain outage planning information through established arrangements with the System Operator.

GC 11.2 Maintenance of Schedules and Diagrams

All schedules and diagrams shall be maintained by the System Operator and appropriate Generator and exchanged as necessary to ensure they reflect the current agreements and network configuration.

GC 12 TESTING AND MONITORING

GC 12.1 Procedures for Conducting Tests

The Generator shall provide to the System Operator a timetable and a list of all tests to be performed on the Generating Units, and such tests shall be subject to approval by the System Operator. The System Operator shall be given five (5) days' notice of any testing and shall reserve the right to have a representative present during any such tests.

GC 12.2 Standard Tests

This section addresses procedures for testing and monitoring of Generating Units for purposes of determining available Capacity and, if relevant, operating characteristics in accordance with the commercial and technical conditions of Power Purchase Agreements. An Independent Engineer shall be required for the commissioning of new Generating Facilities.

GC 12.2.1 Test Prior to First Synchronization

I. Mandatory Tests that may be carried out at the Factory prior to Equipment delivery at the Site of the New Generator Facility Automatic Voltage Regulator (AVR) setting up and adjusting with the Generator running at rated load;

a) prime mover governor control checks;
b) open and short circuit tests on the generator as per IEC 60034 or equivalent under the standard bodies of Sub-section GC 2.2.1; and

c) Governor tests for units not allowed to perform full load rejection tests under Sub-section GC 2.2.2 (viii)

In each instance, the Generator shall provide the System Operator with the results of all such tests, within a reasonable time of the test being completed.

II. Tests that shall be completed at the Site of New Generating Facility

a) Grounding test at the generator switchyard;
b) functional testing and timing of High Voltage switchgear in the Substation;
c) voltage phasing checks between the Substation to which the Generating Unit is connected and the System;
d) primary and/or secondary injection tests and functional tests to prove the calibration and function of all electrical protection schemes installed for the Generating Unit(s) and the Facility. Frequency Relaying Test to confirm that the plant relays are configured adequately and per frequency criteria Sub-section GC 2.3.2 of this Generation Code Relaying Requirements. This functionality test is required to ensure that the Generating Unit will not disconnect from the System during the specified frequency range and delay to trip times provided within Sub-section GC 2.3.2 of this Code.
e) There are no trend requirements for these tests. However, the necessary SCADA and Control equipment should be online and operational to be able to perform these tests as System Operator will need to confirm the position (Open/Close) of breakers during the test at the System Control Center.

Upon completion of each test the Generator shall within forty eight (48) hours provide the System Operator with two (2) copies of the results of such tests.

The System Operator shall have the right to request additional testing if, in its judgment verified by an Independent Engineer, any test results are not satisfactory for establishing the purpose for which the test was intended. Such additional testing shall be performed at the Generator's expense.

The Generator shall confirm to the System Operator the programme for any test as specified or advise of any adjustments thereto, not less than five (5) days prior to the commencement.

GC 12.2.2 Tests after First Synchronization

After the Pre-Synchronization tests as defined in Sub-section GC 12.2.1 and prior to the commissioning date, and under such subsequent conditions as defined by Power Purchase Agreements, Generator shall carry out the following tests at the Generator's expense:

I. **Dependable Capacity**

The Generator shall test the Dependable Capacity of the Generating Unit. The test shall be performed according to ASME, IEEE, ISO, and NEMA standards or

to equivalent standards of Sub-section GC 2.2.1. If any such standards are inconsistent in any respect, the test shall be performed in accordance with the most stringent standard.

II. Reliability Run

The Generator shall test the Reliability of the Generating Units in accordance with industry standards based on the type of plant and established international codes for the industry.

III. Automatic Voltage Regulator (AVR) Droop

The Generator shall test the AVR to demonstrate control of the Generating Unit voltage over the range of plus or minus five (±5) percent of rated voltage with a droop characteristic of plus or minus one half (±0.5) percent.

Voltage ride through tests

The Generator shall determine whether the Generating Units are capable of detecting and riding through voltage dips without tripping and to provide the necessary support to the System in terms of active power and reactive current injection as given in Sub-section GC 2.3.4 of this Code.

IV. Governor Operation

The Generator shall demonstrate that the speed governor for each Generating Unit operates over its range, the droop being adjustable from two (2) percent to five (5) percent.

Primary Frequency Response (PFR) Test

The PFR Test will be carried out by the Generator to assess the ability of the Generator controller to provide frequency support to the System Operator Transmission System. The PFR Test will be carried out by the Generator to verify that the Generator is capable to either increase output or decrease output in real-time when the system frequency is outside the 50 ±0.5 Hz range. The Generator shall conduct the test based on the procedures below and show compliance with Sub-section GC 2.3.3 of this Code.

V. Reactive Capacity

The Generator shall test each Generating Unit's capability to operate at rated voltage and frequency at power factors and under reactive conditions according to the technology used. Where synchronous generators are used, the minimum capabilities shall be as follows:

100% output: 0.80 lag; 0.99 lead.

vi) Short-term Load Capability

The Generator shall test each Generating Unit's capability to operate at a

maximum safe load of one hundred and ten percent (110%) of the Required Dependable Capacity for at least one (1) hour. Where the Generating Unit cannot undergo a "Rapid Start", this unit must also be able to operate at a minimum safe load of at least zero (0) percent of the Dependable Capacity (0 MW) for one (1) hour.

vii) Response of Unit to Step Load Changes

For prime mover technologies that allow controllable load changes, the Generator shall test the capability of each Generating Unit to increase load by steps.

viii) Full Load Rejection

The Generator shall test the capability of each Generating Unit and auxiliaries to withstand 'Partial Load Rejection,' while remaining in a safe condition and without initiating a trip of the Generating Unit. Where a Generating Unit cannot undergo a Rapid Start, the Generator shall also test and prove the capability for each Generating Unit to withstand 'Full Load Rejection' while remaining in a safe condition and without initiating a trip of the Generating Unit.

Where a Co-Generator may determine that a Full Load Rejection test may cause a severe disruption of the Co-Generator's process operations, then a Partial Load Rejection test at a load value capable of being managed by its process operations shall be conducted instead.

GC 12.2.3 Thermal Performance Tests

The Generator shall test the Heat Rate of each Generating Unit.

Heat Rate is computed by dividing the total British thermal unit (Btu) content of fuel consumed for electricity generation by the resulting net kilowatt-hour generation. The Basis of the value should always be expressed as either Lower Heating Value (LHV) or Higher Heating Value (HHV). The basis of the heating value provided shall be consistent with the relevant contractual arrangements and the capability of the generation technology employed.

The Heat Rate data for each Generating Unit is necessary to determine its variable fuel operating cost. All contracts for new generating capacity shall have a guaranteed Heat Rate curve or point.

The Heat Rate Tests for each Generating Unit, not having a guaranteed curve or point, shall normally be conducted at least twice annually or as stipulated by contract. The schedules for the Heat Rate Test for all dispatchable Generating Units shall be developed by the System Operator at least one Month before the

end of the preceding Year. The Heat Rate Test schedules may be adjusted within the Year to accommodate unforeseen circumstances, subject to agreement between the Generator and the System Operator. Such schedules for Heat Rate Test shall be submitted to the OUR by the System Operator.

The Heat Rate Test shall be conducted at a minimum of four (4) output levels from the minimum output level to the maximum output level for each Generating Unit.

The Heat Rate information obtained from Heat Rate Tests together with the guaranteed Heat Rates (for units to which this is applicable) shall be used as one of the inputs to the Generator Scheduling and Dispatch optimization process.

If the System Operator has sufficient reasons to believe that the Heat Rate of a Generating Unit which does not have a guaranteed curve or point, has changed significantly within the Month or since the last test (due to rehabilitation, damage etc.) the System Operator may request the Generator to conduct a Heat Rate Test in accordance with the System Operator Heat Rate Testing Policy (in the case of System Operator owned generators) or other approved policy (in the case of non-System Operator generators) and update the Heat Rate curve for such a Generating Unit. All cost associated with the Heat Rate test shall be the responsibility of the Generator.

The Generator may request a heat rate test of its own unit if it can provide information to substantiate that it has made improvements in the performance of its Unit(s). No more than two such requests will be accommodated within any calendar year.

Heat Rate Tests for all Generating Units, including those of the System Operator, shall be coordinated (mutually agreed date) by the System Control Engineer. The System Operator shall reserve the right to witness all such tests.

The OUR shall be advised and duly notified beforehand when such tests are contemplated and carried out and reserves the right to witness all such tests.

In the case of Independent Power Producers, the information on which the Generating Units will be ranked shall be based on the contractually agreed performance or such other criteria as established through the Power Purchase Agreement between the Generator and the System Operator.

The System Operator shall have the right to request additional testing if, in its judgment verified by an Independent Engineer, any test results are not satisfactory for establishing the purpose for which the test was intended. Such additional testing shall be performed at the Generator's expense. The results of the immediately prior test shall govern until the additional test is completed. The results of the additional test shall supersede the prior test for all purposes

commencing on the day following the additional test.

The Generator shall notify the System Operator of the proposed programme for any test specified in this Section, or advise of any adjustments thereto, not less than five (5) days prior to the proposed commencement of the relevant test. Upon receiving such notice, the System Operator shall have the right to reschedule the commencement of such test; provided that the rescheduled commencement shall not be more than three (3) days before the proposed commencement nor more than ten (10) days after the proposed commencement. The System Operator shall be entitled to have representatives present for the purpose of observing any such test. The OUR shall be notified beforehand by the Generator of all test programmes and shall have the right to have Officers present for the purpose of observing any such test.

Upon completion of each test specified in this Section, The Generator shall promptly provide the System Operator with two (2) copies of the results of such test, which shall be copied to the OUR; provided that the Generator shall submit all such test results to the System Operator no later than ninety (90) days after the commissioned date of the relevant Generating Unit or Facility.

GC 12.3 Co-Generators

Co-Generators Generating Units shall be required to perform all tests as listed Sub-section GC 12.2

GC 12.4 Variable Renewable Power Plant Connected to the System

VRPPs connected to either the Transmission or Distribution network, section shall be required to perform all tests as listed in Sub-section GC 12.2, where applicable. In addition to the following tests listed below.

Meteorological Data, applies to photo voltaic plants and wind plants:

a. Wind Speed
b. Wind Direction
c. Air Temperature
d. Air Pressure
e. Solar Irradiance

GC 12.4.1 Maximum Reactive Power Capability Test

The purpose of this test is to confirm the ability of the VRPP to operate to the limits of the reactive power capability curve for VRPPs as indicated in Figure GC 2.2.5 of Sub-section GC 2.2.5 and also to establish the limits of the VRPP reactive power capability at the High Voltage bus. The test shall be completed for both the export of reactive power from the VRPP as well as the import of reactive power to the VRPP. The point of measurement for compliance will be the VRPP Interconnection Point. This test should be undertaken at different levels of active

power to confirm that the range is within the capability characteristic at the given level of power. This test will be carried out at a time when the actual MW Output of the VRPP is greater than 80% of Registered Capacity and 95% of the VRPP Generating Units are in service.

The test should be carried out to determine both:

a. The Maximum Lagging Reactive (Exporting) capability of the VRPP and
b. The Maximum Leading Reactive (importing) capability of the VRPP

GC 12.4.2 Voltage Flicker Measurements

The purpose of this test is to confirm the ability of the VRPP to operate within the limits in Sub-section GC 2.2.5. Voltage Flicker during normal system operation. This test shall take place for a period of one week after all generating units have been individually commissioned. During the period of measurement, there shall be some period of time, if not all the time, during which 100% of the VRPP Generating Units are in service and providing active power.

GC 12.4.3 Harmonic Distortion Measurements

The purpose of this test is to confirm the ability of the VRPP to operate within the Harmonics limits specified in table GC 2.2.5 of Sub-section GC 2.2.5 for normal system operation. This test shall take place for a period of xx days after all generating units have been individually commissioned and it may be run at the same period of the voltage flicker measurements. During the period of measurement, there shall be some period of time, if not all the time, during which 100% of the VRPPs are in service and providing active power.

GC 12.4.4 Testing of Metering System

These testing procedures are outlined in Section GC 3 of this Code.

GC 12.5 Parameters Monitoring

For modeling of the System, Generators shall be required to periodically (5-10 years) submit the Generator operating parameters to determine if there is any decay which should be modeled.

Generators shall carryout routine and prototype response tests on excitation systems and governor systems (unit frequency response) for new power stations coming on-line or power stations at which major refurbishment or upgrades of these systems have taken place. Routine review is required of all power stations at least once every five (5) years.

GC 13 MONITORING AND CONTROL

This section outline the means and methods by which system operators and System participants will be able monitor and control individual generating plant and the power system on a whole. It sets out the responsibilities of each of the parties, and

the communication systems requirements through which the necessary information and dataset will be provided.

GC 13.1 Remote Monitoring

(a)The System Operator may require the generator to, within a reasonable time of notice being given in writing:

I. install remote monitoring equipment ("RME") adequate to enable the System Operator to remotely monitor performance of a generator (including its dynamic performance) where this is reasonably necessary in real time or with small delay for control, planning or security of the power system; and (2) upgrade, modify or replace any RME already installed in a power station provided that the existing RME is, in the reasonable opinion of the System Operator, no longer fit for the intended purpose.

(b) Input Information to RME may include, (without limitation) the following:

1. Status Indications
   i. generator circuit breaker open/closed;
   ii. remote generator control on/off;
   iii. remote generator control high limit reached;
   iv. remote generator control low limit reached; andgenerator operating mode;
2. Alarms
   i. generator circuit breaker tripped by protection;
   ii. urgent and non-urgent alarms
   iii. Measured Values
   iv. Generator active power;
   v. Generator reactive power;
   vi. Generator stator/terminal voltage;
   vii. Generator remote generation control high limit value;
   viii. Generator remote generation control low limit value;
   ix. and Generator remote generation control rate limit value.

Such other input information reasonably required by the System Operator.

GC 13.2 Remote Control

The System Operator may require the generator to, within a reasonable time after giving notice in writing: (a) install remote control equipment ("RCE") that is adequate to enable the System Operator to remotely control:

i. the active power output of any generator; and
ii. the reactive power output of any generator; and

Any RCE already installed in a power station to be upgraded, modified or replaced, by notice in writing to the relevant generator provided that the existing RCE is, in

the reasonable opinion of the System Operator, no longer fit for its intended purpose.

Unless agreed otherwise, the relevant generator will be responsible for the following actions at the request of the System Operator:

i. activating and de-activating RCE installed in relation to any generator; and
ii. setting the minimum and maximum levels to which, and a maximum rate at which, the System Operator will be able to adjust the performance of any generator using RCE.

GC 13.2.1 Communications Equipment

Generator shall provide electricity supplies for RME and RCE installed in relation to his generators capable of keeping such equipment available for at least eight hours following total loss of supply at the Point of Common Coupling for the relevant generator.

Generator shall provide communications paths (with appropriate redundancy) from the RME or RCE installed at any of his generators to a communications interface in a location reasonably acceptable to System Operator at the relevant power station or generation control centre.

The Generator shall provide, the telecommunications equipment as specified in Schedule 5 of the Generation Code. The selection and installation of items to be provided by the Generator in accordance with the prior written approval of System Operator, which approval shall not be unreasonably conditioned, withheld or delayed.

GC 13.2.2 Governor System

Each generator shall have a governor system which includes facilities for both speed and load control except where approved by the System Operator.

Generator shall normally operate each generator in a mode (e.g. “boiler-follow” or “load control” mode for thermal units) in which it will respond with a change in loading for changes in power system frequency according to the performance requirements set out in the following paragraphs.
The generator shall notify the System Operator whenever any Generator is operated in a mode (e.g. “turbine-follow” mode) where the generator is unable to respond as set out in the following paragraphs.

Overall response of a generator for system frequency excursions shall be settable and be capable of achieving an increase in the Generator's active power output of 2 % per 0.1 Hz reduction in system frequency for any initial output up to 85% of rated output and a reduction in the generator's active power output of 2% per 0.1 Hz increase in system frequency provided the latter does not require operation below technical minimum. For initial outputs above 85% of rated output response

capability shall be able to achieve a linear reduction in response down to zero response at rated output, and the generator shall use reasonable endeavours to ensure that the generator responds in accordance with this requirement.

The Generators shall be capable of achieving an increase in output of at least 5% of their rating for operation below 85% of output. For operation above 85% of rated load, the required increase will be reduced linearly with generator output from 5% to zero at rated load. The generator will not be required to increase output above rated load. Generators shall be capable of achieving a decrease in output of at least 10% of their rating for operation at all levels above their technical minimum loading level as advised in the registered bid and offer data.

The dead band of a generator (being the sum of the increase and the decrease in system frequency before a measurable change in the generator's active power output occurs) shall be less than 0.1 Hz.

The frequency response and dead band values may be varied by the generator with the approval of the System Operator under the interconnection agreement.

When a generator is operating in a mode such that it is insensitive to frequency variations (including pressure control or turbine follower for a thermal generator), the generator shall apply a dead band of not greater than 0.25 Hz to ensure that the generator will respond for frequency excursions outside the normal operating frequency band.

Generator shall adjust the governor system of a Generator to ensure stable performance under all operating conditions with adequate damping. The criterion for adequate damping is that following a step change in the governor speed feedback signal the load transient oscillations have a minimum damping ratio of 0.4 and the steady state response is within plus or minus 20 per cent of the ideal response having regard to loading rates and dead band.

The Generator shall advise System Operator of data regarding the structure and parameter settings of all components of the governor control equipment, including the speed/load operator, actuators (for example hydraulic valve positioning systems), valve flow characteristics, limiters, valve operating sequences and steam tables for steam turbine (as appropriate) in sufficient detail to enable the System Operator to characterize the dynamic response of these components for short and long term simulation studies. These data shall include a control block diagram in suitable form and proposed settings for the governor system for all expected modes of governor operation.

These parameter settings shall not be varied without prior approval of the System Operator.

GC 13.2.3 Voltage Support

System Operator has the responsibility to monitor and control the system voltages. Therefore, System Operator may issue a new voltage set-point to the Generator concerning scheduled voltage support requests. System Operator will maintain a performance log for all Generators acknowledgments of such requests and a response is deemed provided that it is completed within five (5) minutes of the issuance of such request.

Generating unit shall ensure that the excitation control system of a synchronous generating unit is capable of:

a. limiting generating unit operation at all load levels to within generating unit capabilities for continuous operation;
b. controlling generating unit excitation to maintain the short-time average generating unit stator voltage at highest rated level which shall be at least 5% above the nominal stator voltage (and is usually 10% above the nominal stator voltage);
c. maintaining adequate generating unit stability under all operating conditions including providing power system stabilizing action if fitted with a power system stabilizer;
providing five second ceiling excitation voltage at least twice the excitation voltage required to achieve maximum continuous rating at nominal voltage; and
d. unless otherwise agreed by the System Operator, providing reactive current compensation settable for boost or droop. generating unit shall ensure that each new synchronous generating unit is fitted with a fast acting excitation control system utilising modern technology. Each excitation control system shall provide voltage regulation to within 0.5% of the selected setpoint value.

Each synchronous generating unit shall incorporate a power system stabilizer circuit which modulates generating unit field voltage in response to changes in power output and/or shaft speed and/or any other equivalent input signal approved by the System Operator except where specifically advised by the System Operator that a power system stabilizer is not required. The stabilizing circuit shall be responsive and adjustable over a frequency range which shall include frequencies from 0.1 Hz to 2.5 Hz.

A minimum performance requirement that shall be establish by System Operator for each for generating units which have an a.c. exciter, rotating rectifier or static excitation system, in accordance with acceptable international standards such as the IEEE and IEC, with consideration given to:

1. One per unit is that field voltage required to produce nominal voltage on the air gap line of the generating unit open circuit characteristic (Refer IEEE Standard 115-1983 - Test Procedures for Synchronous Machines).

2. Rated field voltage is that voltage required to give nominal generating unit terminal voltage when the generating unit is operating at its maximum continuous rating. Rise time is defined as the time taken for the field voltage to rise from 10% to 90% of the increment value.
3. Negative field current is not required.

The generating unit shall obtain the prior approval of the System Operator for the structure and parameter settings of all components of the generating unit excitation control system, including the voltage regulator, power system stabilizer, power amplifiers and all excitation limiters.

The generating unit shall not change, corrector adjust the structure and settings of the excitation control system in any manner without prior written notification to System Operator. The System Operator may then require the generating unit to conduct generating unit tests to ensure compliance with previous test and standards. System Operator shall have the opportunity to witness these test, if wishes to do so.

The System Operator may require the generating unit to alter generating unit excitation control system settings from time to time. The cost of altering the settings and verifying subsequent performance shall be borne by the generating unit, provided alterations are not made more than once in each 18 months for each generating unit. If more frequent changes are requested the person making that request shall pay all costs on that occasion.

Excitation limiters shall be provided by the generating unit on each generating unit for under excitation and over excitation where the generating unit has over or under excitation protection which can trip the generating unit and may be provided for voltage to frequency ratio. Each generating unit shall be capable of stable operation for indefinite periods while under the control of any excitation limiter. The generating unit shall ensure that excitation limiters do not detract from the performance of any stabilizing circuits and that they have settings applied which are co-ordinated with all protection systems.

GC 13.2.4 LVRT/HVRT

LVRT and HVRT monitoring at the Interconnection Point shall be enforced by the System Operator through on site disturbance recording. For verification of the behaviour of the VRPP plant with installed Active Power equal to or above 10 MW in the case of real voltage dips or voltage swells, a disturbance recorder must be installed at the Interconnection Point of the VRPP plant. The aim of this monitoring/recording is to ensure that the VRPP units behave in the same manner as shown in the VRPP simulations and/or tests, and meet the Transmission Code for LVRT and HVRT.

After a real event (voltage dip or voltage swell), the behaviour of the VRPP plant may be checked by System Operator for compliance based on the measurements available from the recording unit.

GC 13.2.5 Generation Dispatch and Shutdown Signal

System Operator reserves the right to send dispatch instructions to VRPPs, via phone or SCADA as per the VRPP's SCADA signals list, to reduce its output due to system reliability.

In the event that System Operator is required to shut down and disconnect a VRPP from the System Operator Transmission System:
On-Line VRPPs must be able to commence their shutdown sequence within five (5) minutes of receipt of a Dispatch Instruction from System Operator. The shutdown sequence shall be completed as soon as practical, but no longer than ten (10) minutes from the receipt of a Dispatch Instruction from System Operator.

If the System Operator Transmission System condition requires breaker or switch operations to disconnect a non-MW producing VRPP from the system, the disconnection shall be completed as soon as practical, but no longer than ten (10) minutes from the receipt of a Dispatch Instruction from System Operator. Once disconnected from the System Operator Transmission System, a VRPP shall wait for instructions from System Control Center before reconnecting the system to the network. The VRPP shall complete as soon as practical, but no longer than ten (10) minutes, the required switching to return the system to a normal configuration after receiving the new Dispatch Signal from System Operator to do so.

After providing prior notice to System Operator, a VRPP plant may disconnect from the Transmission System at any time, if reasonable and practical, in the case that the condition or manner of operation of the System Operator Transmission System poses an immediate threat of injury or material damage to any person or equipment of the VRPP Units and/or project substation.

GC 13.2.6 Additional Monitoring and Control Requirements for VRPPs

In addition to the above where applicable, the following meteorological data will be required for wind and solar PV plants:

a. Wind Speed
b. Wind Direction
c. Air Temperature
d. Air Pressure
e. Solar Irradiance

GC 14 UNFORESEEN CIRCUMSTANCES, SYSTEM EMERGENCIES

GC 14.1 Unforeseen Circumstances

If circumstances arise which are not addressed by the Code, the System Operator, shall, to the extent practicable in the circumstances, consult promptly and in good faith with all affected Parties in an effort to reach agreement as to the required course of action. If such agreement cannot be reached in the time available the System Operator shall refer the matter to the OUR with a view to determining the course of action to be taken.

Whenever the OUR makes a determination, it shall do so having regard, wherever possible, to the views expressed by the Generators and the System Operator, in any event, to what is reasonable in the circumstances. Each Generator and the System Operator shall comply with the instructions given to it by the OUR as a consequence of such a determination, provided that the instructions are consistent with the technical parameters set out in the Code, the respective Licences and PPAs. The OUR shall promptly refer all unforeseen circumstances and any determinations to the Generation Code Review Panel for consideration.

GC 14.2 Force Majeure

All Parties should note that the provisions of the Code may be suspended in whole, or in part, pursuant to any directions or orders given by the OUR in situations of Force Majeure.

GC 15 GENERATION INTERCONNECTION STUDIES

Power system analysis studies shall be conducted by System Operator or third party consultant pre-approved by System Operator, according to the Study Guidelines outlined in the Transmission Code and using a suitable power system software such as PSS/E and DIgSILENT or equivalent. The final results and the used models, including the validated user model have to be handed over to the System. The studies must demonstrate the capability of the plant to meet all the System code requirements outlined in this chapter. The Plant model shall comprise all facilities necessary for the generation of power from the generating unit(s) to be integrated in the system model.

The following power system studies are to be conducted:

1. Load Flow Studies
2. Short Circuit Studies
3. Transient Stability Studies
4. Steady-State Stability Analysis

5. Voltage Stability Analysis

In addition to the above and due to the intermittent nature of the VRPP, additional power system studies as outline below but not limited to should be done:

Voltage Flicker
Harmonic Analysis
Phase Imbalance
Medium and Long Term Stability Study or Quasi Dynamic analysis

GC 15.1 Generator Dataset

The dataset that will be required to carry out the appropriate system studies and also to execute Dispatch Instructions can be found in sections of the Transmission, Distribution and Dispatch Codes as follow:

Transmission Code

Section TC 18 Transmission Data Registration

Schedules I
Schedules VI
Schedules VIII and
TC APPENDIX - Site Responsibility Schedules

Distribution Code

Section DC 19 Distribution System Data Registration

Dispatch Code

DSC 16. Data to be Exchanged between the System Operator and Generators

GC 16 NOTICES

Notices and Communique relating to the Code should be directed to the following contact details:

Entity	Contact	Address	Phone	Fax	Email
OUR					
System Operator					
JEP					
JPPC					
Jamalco					
Wigton Windfarm					
Jamaica Broilers					
West Kingston Power Partners					
Small Generator Nominee (<15 MW)					

APPENDIX A
Schedules to Generation Code

SCHEDULE A: REQUIRED COMMUNICATION EQUIPMENT

The Communication Systems used for System Operations are in two basic forms –VHF Radio for general operational communications (including mobile units), and a point-to-point telephone system for Substations and Generating Stations operation. For switching operations, the primary form of communication is radio while the secondary communication is telephone. For all other operations, telephone is the primary form of communication and radio is the secondary form. Proper use of these facilities is described in detail in the System Operator's Policies and Procedures Manual for System Operation. However the following principles are especially noteworthy:

The VHF radio system should be operated in accordance with stipulated protocols.

Transmitter/receiver sets are located at all District offices, Power Stations, major Substations and in the Generator's Operating vehicles

Communication equipment should be properly maintained and any malfunction of such equipment be reported to System control promptly

In the event of loss of communication (including Public Telephone facilities) between a generating station and System Control, the Generator's management must assume full direction and control of the Station. All actions taken and their corresponding times must be logged and reported to system control as soon as communication is restored. In any such event the first priority is safety and then system integrity. The Generator shall not change the operations and shall maintain the last dispatch while maintaining safety.

Supervisory Control and Data Acquisition

The Supervisory Control And Data Acquisition (SCADA) System is currently used to monitor and record status and analogue values at relevant data collection points throughout the system. Required points for monitoring include circuit breakers, switches, potential transformers and current transformers.

The SCADA system performs constant scanning of all data points and logs a status update every two seconds, unless a significant non-transient change occurs that results in a monitored value exceeding its predefined limits, in which case the resolution of the data recorded is in milliseconds. It is therefore necessary that the monitoring/control devices installed at the Generating Station be capable of sub second response to a degree equal to or better than that of the System's SCADA equipment.

Required Communication Equipment

Each Generator shall install and maintain at each Generating Station at its sole cost and expense:

i) Compatible Remote Terminal Units ("RTUs") to allow interfacing of SCADA status and analog signals from the generating station to the centralized SCADA system at system control, specifically transmitting:

   a) Three phase values of watts, vars, voltage, and current as well as busbar frequency
   b) Status (open, closed) of the relevant circuit breakers

ii) Adequate Power Line Carrier Channels to System Control Centre for the purpose of tele-metering, protection and telecommunications.

iii) An extension of System Control Centre PBX System in the Generating Units control room to facilitate (hotline) voice communication between the Generator control room and System Control Centre.

iv) Telecommunications facilities such as Internet and landline telephones in the Generating Units control room to transmit and receive telecopies/facsimiles and electronic mail to and from System Control Centre respectively.

v) UHF and VHF radio equipment to permit voice communication between the Generating Unit control room and System Control Centre.

vi) Microwave equipment to transmit data to System Control Centre.

vii) A synchronized digital GPS Clock to allow time stamping of all analog and status communications especially those logged by the Sequence of Events recorder.

SCHEDULE B: LOAD SHEDDING SCHEME

Setting of Under-frequency Relays

The Under-frequency Relay set points as at the date of this document are as follows:

Stage	Under-frequency Relay Setting
0	49.35
1	49.2
2	48.9
3	48.5
4	48.1

SCHEDULE C: RESERVE MARGIN POLICY

Spinning Reserve Policy

SYSTEM OPERATION POLICIES AND PROCEDURES

CLIENT: JAMAICA PUBLIC SERVICE COMPANY LIMITED Ref. No. 8 Page: 1 of 1

SUBJECT: OPERATING SPINNING RESERVE POLICY Effective Date:_____

	Responsibility	Reference
The following details the company's spinning reserve policy.		
A minimum spinning reserve capacity of 30 MW should be planned to meet the daily system demand.	Operation Planning Engineer	
Consistent with the above policy, the following measures should be adopted:		
a) The Old Harbour units (OH2, OH3, OH4) and Hunts Bay B6 steam unit are to be limited to a maximum of 85% of their Maximum Continuous Rating (MCR). The difference between the reserve allocated by the above restrictions and the stipulated 30 MW operating spinning reserve is to be allocated across the system by means of an economic optimization process.	System Control Engineer	
b) Under normal circumstances a gas turbine should not be started with the spinning reserve above 30 MW. However, if the margin should fall below 30 MW, a gas turbine can be used to assist in maintaining a margin of spare plant.	System Control Engineer	Section 7.2
c) Gas Turbines should be used for quick load restoration following operation of under frequency relays. (At least two of the aeroderivative GTs (GTs 6, 7, 8, 9, 11) should be on remote standby for this purpose, unless they are required to meet the demand.	System Control Engineer/Bogue Operations Manager	
d) No single generator should be allowed to carry more than 27.7% of the total demand. This is in keeping with the system overload protection of 38%. Provisions for this is made in the ELD programme.	Operations Planning Engineer/System Control Engineer	

Approved By	Status	First Effective	Supercedes	Reviewed By
	Active	Dec 2006	Apr 03	Ricardo Case

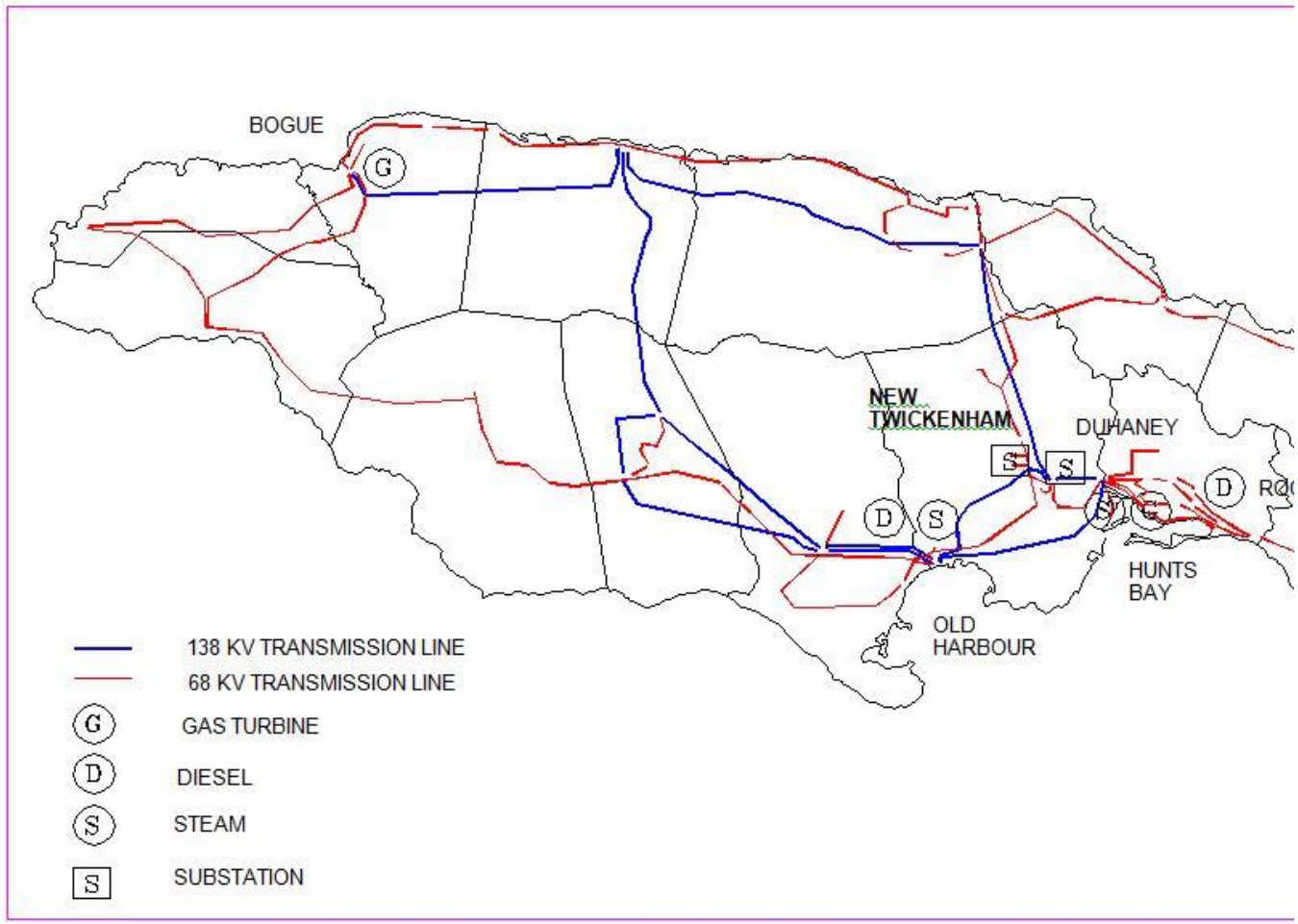
4/09/05

SCHEDULE D: EXISTING GENERATING SYSTEM

Unit	Capacity (MW)	Technology	Fuel Type	Location	Remarks
RF#1	20.0	Slow Speed Diesel	HFO	Rockfort	
RF#2	20.0	Slow Speed Diesel	HFO	Rockfort	
OH#1	30.0	Steam	HFO	Old Harbour	Out of service
OH#2	60.0	Steam	HFO	Old Harbour	
OH#3	65.0	Steam	HFO	Old Harbour	
OH#4	68.5	Steam	HFO	Old Harbour	
HB#B6	68.5	Steam	HFO	Hunt's Bay	
GT#5	21.5	ADO Fired Gas Turbine	ADO	Hunt's Bay	
GT#10	32.5	ADO Fired Gas Turbine	ADO	Hunt's Bay	
GT#3	21.5	ADO Fired Gas Turbine	ADO	Bogue	
GT#6	14.0	ADO Fired Gas Turbine	ADO	Bogue	
GT#7	14.0	ADO Fired Gas Turbine	ADO	Bogue	
GT#8	14.0	ADO Fired Gas Turbine	ADO	Bogue	
GT#9	20.0	ADO Fired Gas Turbine	ADO	Bogue	
GT#11	20.0	ADO Fired Gas Turbine	ADO	Bogue	
Bogue Combined Cycle	114.0	ADO-CCGT	ADO	Bogue	
Maggotty	6.0	Run of River Hydro		Maggotty	
Lower White River	4.75	Run of River Hydro		White River	
Upper White River	3.19	Run of River Hydro		White River	
Roaring River	4.05	Run of River Hydro		Roaring River	
Rio Bueno "A"	2.5	Run of River Hydro		Rio Bueno	
Rio Bueno "B"	1.1	Run of River Hydro		Rio Bueno	
Constant Spring Hydro	0.75	Run of River Hydro		Constant Spring	
JPPC - IPP	60.0	Slow Speed Diesel	HFO	Rockfort	
JEP - IPP	124.2	Medium Speed Diesel	HFO	Old Harbour	
WKPP - IPP	65.5	Medium Speed Diesel	HFO	Hunts Bay	
Wigton Wind Farm I	20.7	Wind Turbines		Wigton	Energy only
Wigton Wind Farm II	18.0	Wind Turbines		Wigton	Energy only
Munro College	0.25	Wind Turbine		Munro	
System Operator Munro Wind	3.0	Wind Turbines		Munro	
Jamaica Broilers	as-available	Slow Speed Diesel	HFO	Spring Village	
JAMALCO	11.0	Steam - Cogen	HFO	May Pen	
JAMALCO	as-available	Alternative		St Jago, Clarendon	

ADO Automotive Diesel Oil
GT Gas Turbine
HB Hunts Bay
HFO Heavy Fuel Oil
IPP Independent Power Producer
JEP Jamaica Energy Partners
JPPC Jamaica Private Power Company
OH Old Harbour
RF Rockfort
WKPP West Kingston Power Partners

LAYOUT OF JAMAICA'S GENERATION AND TRANSMISSION SYSTEM



SCHEDULE E: SYSTEM OPERATOR INTERCONNECTION CRITERIA

Generating Unit(s) Connected to the Jamaican Transmission System

	Category	System Operations Criteria/Parameters	Plant/generating unit Design Criteria	Comments
Transmission System Security	Interconnection Voltage	Generating Unit(s) at rated capacity >10MW shall be connected to the Transmission system at 69kV or 138kV.		The System Operator on basis of System Security Stability and Safety should determine the interconnection voltage
	Reliability of Generating Unit(s) System Interconnection Points	All substations shall have the capability to disconnect or separate, from the System, any transmission line and/or generating unit that is interinterconnected to the substation.	Substations (including Generation substations) with more than three (3) Transmission Lines or generating units shall be of a “breaker and a half configuration”.	
	Loss of Generation	For the loss of one transmission element there shall be no loss of generation > 60MW.	The loss of any single transmission element interconnecting a generating unit(s) shall not result in a loss of generation greater than 60MW. Therefore generation greater than 60MW shall be designed on the N-1 principle.	

	Category	Operations Mode	Unit	System Operations Criteria/ Parameters	Plant/generating unit Design Criteria	Comments
Plant Performance	frequency	Nominal	Hz	50	Generating plant and auxiliary apparatus shall be designed to operate at this nominal frequency (continuous operation).	Intermittent and type generating maintain active p per the turbine/ power curve cha
		Normal Operating Band	Hz	49.5 – 50.5	Maintain constant Active Power output at any load point. Generating plant and auxiliary apparatus shall be designed to operate in this range.	
		Abnormal	Hz	48.5 – 49.5 50.5 – 52.5	Maintain constant Active Power output at any load point. Plant and Apparatus shall be designed to operate in this range (continuous operation)	Intermittent and type generating define the limitat generating unit(s criteria for revie by the System Oper
			Hz	48.0 – 48.5	Maintain, for at least one (1) second, Active Power within 95% and 100% of output loading levels before abnormal frequencies occurred. Generating plant and auxiliary apparatus shall be designed to operate in this range.	
			Hz	<48.0	generating unit trip settings shall be as agreed with the System Operator.	
	Voltage	Nominal	KV	69kV or 138kV	Reactive power output shall be fully available under steady state conditions.	
		Normal Operating Band (± nominal kV)	%	± 5%	Reactive power output shall be fully available under steady state conditions (continuous operation). The Generating Unit shall not be affected by voltage changes in this operating band.	Generating plant reactive power s induction genera provide their full power

						compensation w specified voltage bands (normal a
		Abnormal	%	± 10%	Reactive power output shall be fully available under steady state conditions	

	Category	Operations Mode	Unit	System Operations Criteria/ Parameters	Plant/generating unit Design Criteria	Comments
				(continuous operation) as per the capability curve of the plant. The Unit(s) and auxiliaries shall not lose synchronism or trip by voltage changes in this operating band.		
Voltage Dips (Fault Ride Through Capability)	Abnormal	% of nominal bus kV	10% to 90%	**VOLTAGE DIPS OF DURATION ≤ 120ms** The generating unit(s) shall remain stable and interconnected to the system without tripping or losing synchronism for transmission voltage dips less than or equal to 120ms in duration. VOLTAGE DIPS OF DURATION > 120ms For transmission voltage dips occurring due to system disturbances greater than 120ms (6 cycles) in duration the generating unit(s) shall: **During Voltage Dip** 1. Remain transiently stable and interconnected to the system for at least 1 second without tripping/losing synchronism. 2. Provide Active Power output during voltage dips at least in proportion to the retained balanced voltage at the Interinterconnection Point. **Immediately After Voltage Dip** 3. Restore Active Power output at the Interinterconnection Point to 90% of nominal levels (available immediately before the occurrence of the dip) within 1 second of	See FIGURE A for Ride Through (L	

	restoration of steady state voltage conditions. That is, within the normal voltage operating band of 69kV ± 5%

	Category	Operations Mode	Unit	System Operations Criteria/ Parameters	Plant/generating unit Design Criteria	Comments
	Negative Phase - Sequence Component of phase voltage	Normal	%	<1%	Sustained operation at any load (continuous operation)	
	(Unbalance loading withstand capability)	abnormal	%	≤2%	Sustained operation at any load (continuous operation)	
	Negative Phase - Sequence Component of phase voltage cont'd (Unbalance loading withstand capability)	faults			Generating unit shall withstand, without tripping, the negative phase sequence loading incurred by clearance of a close-up phase-to-phase fault by system back-up protection on the Transmission System.	The System Operato relay settings up
	Plant Output	Normal	MW	Rated Generating Unit output shall be provided in the Interinterconnection or Power Purchase Agreement.	Supply rated Active Power (MW) at any point between limits 0.85 pf lagging and 0.95 pf leading at generating unit terminals. Reactive power output shall be fully variable between these limits.	Intermittent and type generating maintain Active output as per the turbine/generat characteristics.
	Synchronisation	Normal			1. Synchronise and parallel/load transfer with System without causing voltage fluctuation at Interinterconnection Point >±5% of voltage at Interinterconnection Point. 2. Synchronise to System within voltage ±5% of nominal and	

					frequency 50±0.5Hz	
		Abnormal			Synchronise to System within voltage	

	Category	Operations Mode	Unit	System Operations Criteria/ Parameters	Plant/generating unit Design Criteria	Comments
					±10% of nominal and frequency 50±0.5Hz	
Controls	frequency Control	Normal			Each generating unit shall be capable of contributing to frequency control by continuous modulation of Active Power supplied to the Transmission system. The unit shall be fitted with a fast-acting speed governing system that shall have an overall speed droop characteristic of five (5) percent or less. The speed governor deadband shall be no greater than 0.1 Hz.	Applicable on a C basis for intermi renewable type g plant. The droop settin
	Voltage Control	Normal			Each generating unit shall be capable of contributing to voltage control by continuous changes to the Reactive Power supplied to the Transmission system. Automatic Voltage Regulator: Deadband: not exceeding 0.5% Controls: Capability to control voltage continuously between 90% and upper limit of rated voltage of the generating unit from no load to full load. This range shall be covered linearly in approximately 1 minute.	Applicable on a C basis for intermi renewable type g plant.
	Excitation Control Excitation Control (cont'd)	Normal Normal			Provide Constant Terminal voltage control of the synchronous generating unit without instability over the entire operating range of the unit Excitation System (Large Signal response): Voltage response Time: less than 0.1	Applicable on a C basis for intermi renewable type g plant.

	Category	Operations Mode	Unit	System Operations Criteria/ Parameters	Plant/generating unit Design Criteria	Comments
					second for a voltage step change not to exceed 5% in terminal voltage Ceiling Voltage: minimum 160% of generating unit rated load field voltage.	
Protection	generating unit Protection	Abnormal		Protect against: - Loss of Excitation - Under Excitation - Unbalanced Load Operation - Stator Phase Faults and Earth Faults - Reverse Power - Unit Over and Underfrequency - Thermal Overload: Stator Over Temperature, - generating unit Overspeed - Restricted Earth Fault	Meet system protection requirements for all synchronous generating units.	Protection requi asynchronous ge reviewed and ap System Operator.
	Generating Unit Step Up Transformer (GSU)			Protect against: - Phase and earth faults (HV and LV) within the GSU zone - Transformer Tank Sudden pressure, - Differential Current - Backup	Meet system protection requirements for all GSU.	

				protection if		

	Category	Operations Mode	Unit	System Operations Criteria/ Parameters	Plant/generating unit Design Criteria	Comments
				failure of the plant local breaker to operate ○ The plant owner to provide breaker fail signal to System Operator switchyard		
	Interinterconnection Protection	Abnormal		Protect against: Phase and Earth Faults (tie-lines, bus) Failure of System Operator (System Operator) remote protection to clear System phase and earth faults (b/up protection) ○ Grid Operator (System Operator) to provide breaker fail signal to generating unit	Meet system protection requirements at Interinterconnection Point.	Protective syste at the Interconne shall be designed and tested to ach sensitivity and se fault clearing. Re approved by the (System Operator).

owner switchyard

- Failure of plant local breaker to operate (breaker fail

	Category	Operations Mode	Unit	System Operations Criteria/ Parameters	Plant/generating unit Design Criteria	Comments
				protection) ○The generating unit owner to provide breaker fail signal to System Operator (System Operator) switchyard		
Fault Clearing Times	Transmission bus (point of System interinterconnect-ion)	Maximum time	Milli-seconds (ms)	To be provided in Power Purchase Agreement (PPA) documents. In the absence of the requirement in PPA documents, fault clearing time (from fault inception to arc extinction) shall not be slower than: 69kV – 120ms 138kV – 100 ms	Meet or exceed system fault clearing times. The generating unit shall remain transiently stable and interconnected to the system without tripping for a close-up solid three phase fault or any unbalanced short circuit fault on the Transmission System up to the maximum total fault clearance time. During the period of the fault the generating unit shall generate maximum reactive current without exceeding the transient rating limit of the generating unit.	
Fault Levels	Transmission bus (point of System interinterconnect-ion)		Amps (A)	To be provided in Power Purchase Agreement (PPA) documents.	The maximum fault levels at the System Interinterconnection Point shall be below 80% of the interrupting capacity of substation and plant apparatus determined using generating unit transient impedances.	

The owner of the Generating Unit(s) is required to submit to the System Operator all Generating Unit and G Up (GSU) transformer parameters upon completion of plant, apparatus and equipment designs.

SCHEDULE F LOW VOLTAGE RIDE THROUGH CHARACTERISTIC

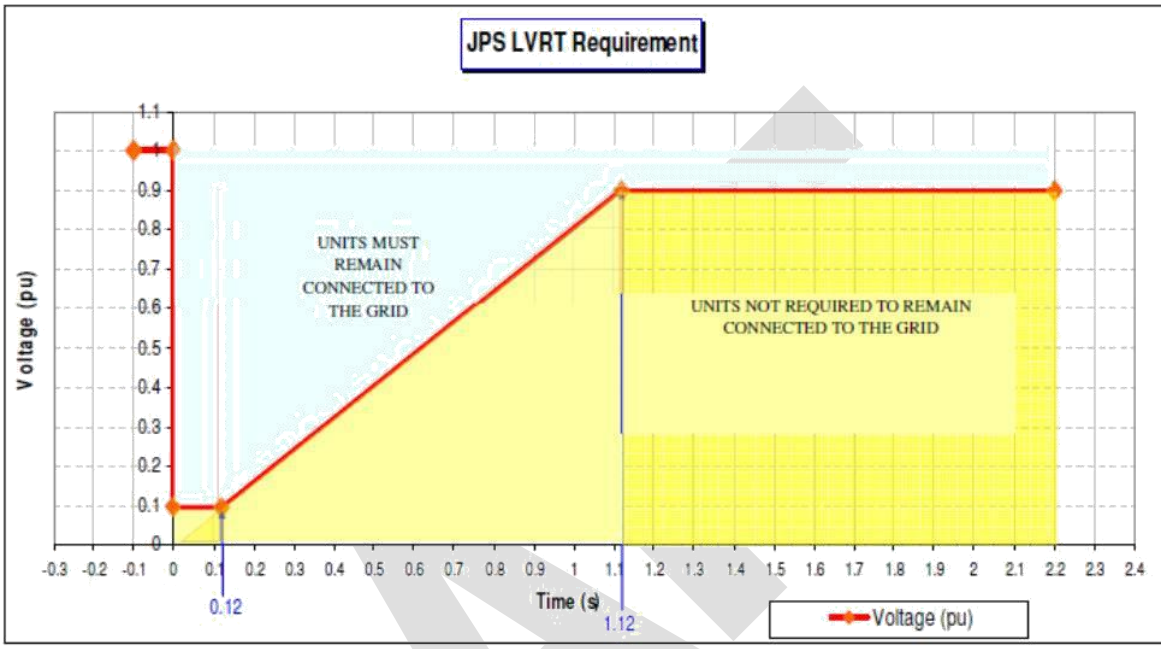


Figure GC - S1 Low Voltage Ride Through Characteristics

SCHEDULE G HIGH VOLTAGE RIDE THROUGH CHARACTERISTICS

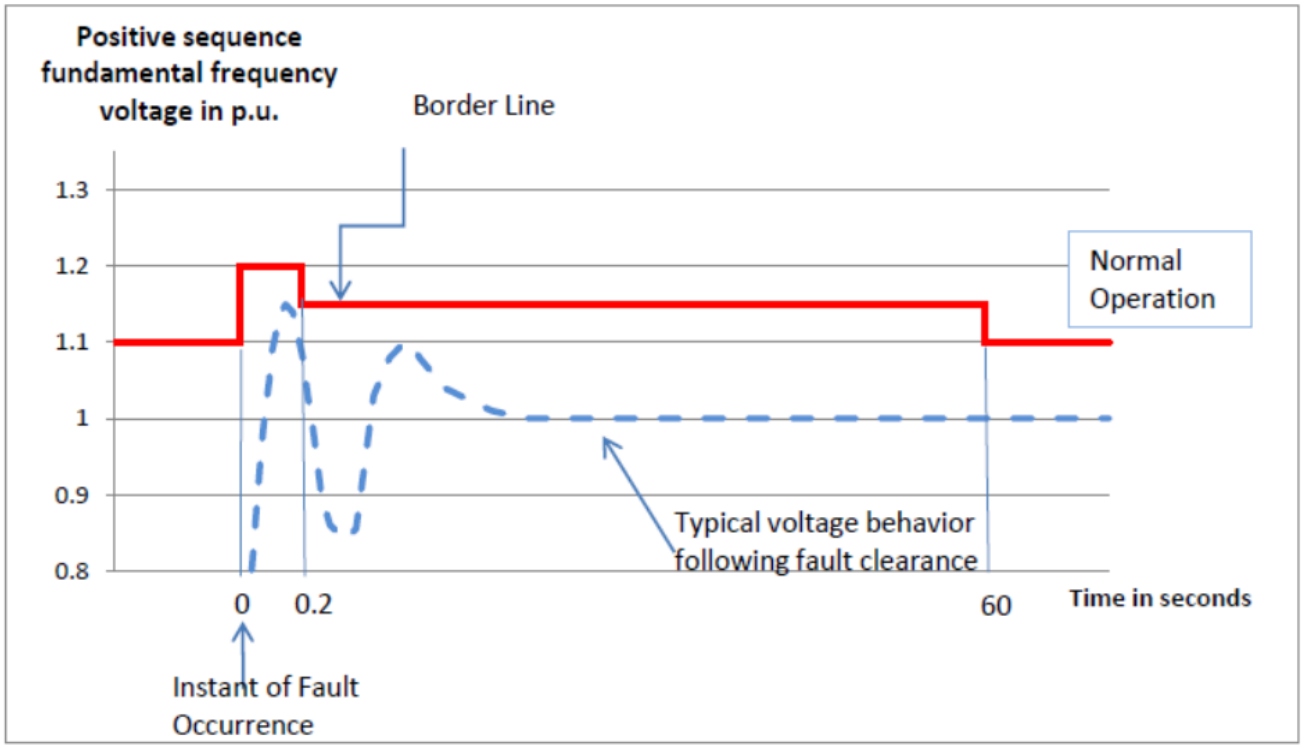


Figure GC – S2 High Voltage Ride Through Characteristics