UTILITY REGULATORY AUTHORITY

Mauritius National Grid Code

Generation Code

Version December 2022

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Mauritius
National Grid Code

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GENERATION CODE

GC 1 SCOPE

This **Generation Code** sets out the procedures and principles applicable to all interconnected **Generating Stations** and associated **Electrical Facilities**. The **Generation Code** deals with **Generators** connected to the **Transmission System**, while requirements for **Generators** connected to the **Distribution System** are established in the **Distribution Code.**

Generating Stations connected to the 22 kV **Transmission System** shall comply with the requirements of the **Distribution Code** applicable to MSDG 3.

GC 2 CONNECTION CONDITIONS

This section specifies the method of interconnection and the minimum technical, design and operational criteria which must be complied with by any existing and prospective **Generating Station** namely **Synchronous Generating Stations** and **Power Park Stations,** including **Variable Renewable Generating Stations** and **Energy Storage Units**.

Additional details specific to each **Generator's** interconnection may be set out in a separate **IA**, **PPA** or **ESPA**. The interconnection conditions set out in Section GC 2 of the **Generation Code** shall be read in conjunction with either or both of these agreements as relevant.

The provisions of the **Generation Code** fully apply to all **Generators** unless explicitly stated in the corresponding section of the **National Grid Code**, or exempted by the **Authority** in accordance with the provisions of the **Governance Code**.

All **IAs, ESPA** and/or **PPAs** shall be read in conjunction with the **Generation Code** in force at any material time and in accordance with Section GC 2.1.2 of this **Generation Code**.

GC 2.1 General Requirements

GC 2.1.1 Scope

Section GC 2.1 applies to all **Generating Stations**, including **Synchronous Generating Stations** and **Power Park Stations**.

GC 2.1.2 Data Provision

Generators shall submit the data specified in GC 16 to the **System Operator** to carry out the appropriate **System** planning and operational studies and also to execute **Dispatch Instructions**. The **System Operator** shall forward the relevant information to other **Licensees**, including **Single Buyer** where needed.

Generators shall also submit to the **System Operator** any additional information requested in other parts of the **National Grid Code**.

GC 2.1.3 Method of Interconnection

The method of **Interconnection** of a **Generating Station** to the **Transmission System** shall be as per Figure 11 and Figure 12 unless otherwise agreed with the **Transmission Licensee** on the grounds of **System** security, stability safety and compliance with the **National Grid Code**.

GC 2.1.4 Interconnection Boundary

The **Generating Unit**(s) shall be interconnected to a **Transmission System**

Substation. The **Interconnection Boundary** shall normally be:

a) on the cable termination of the **Low Voltage** side of the **Generating Unit** step-up transformer for **Generators** directly connected to **Transmission System Substations**, as schematically shown in Figure 1
b) on the **Generator** side of the **Circuit Breaker** of the **Electric Line** connecting the **Generator** to the **Transmission System Substation** for **Generators** connected to **Transmission System Substations** through an **Electric Line**, as schematically shown in Figure 2.

The definition of the **Interconnection Boundary** of a **Generating Station** shall be approved by the **Authority**.

The **Interconnection Boundary** shall demarcate the boundary of responsibility between the **Generator,** connected to a **Transmission System Substation** through an **Electric Line**, and the **Transmission Licensee**. Detailed drawings of the Interconnection Boundaries for air-insulated Switchgear (**AIS**) and gas insulated switchgear (**GIS**) substations are provided in GC 17.

The **Generator** shall be responsible for all costs related to its **Interconnection** to the **System**. The **Generator** shall own and be responsible for the operation, maintenance and repair of the **Electrical Facilities** at its side of the **Interconnection Boundary** as from the **Commercial Operation Date**.

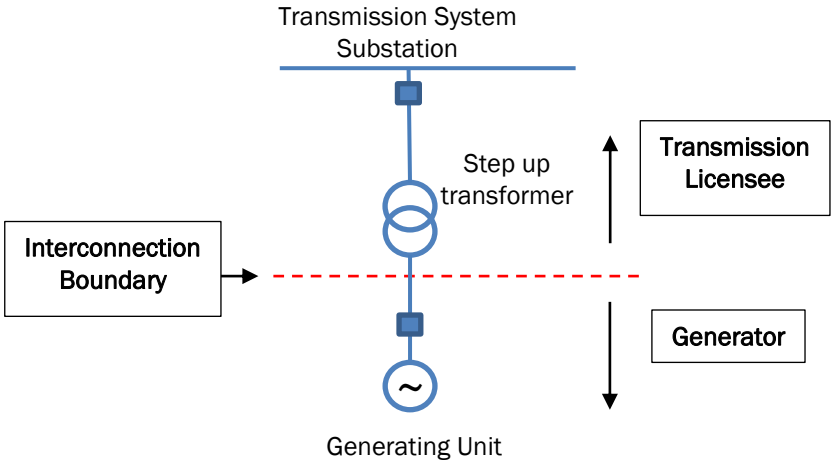

Figure 1. **Interconnection Boundary** of a **Generator** directly connected to a **Transmission System Substation**.

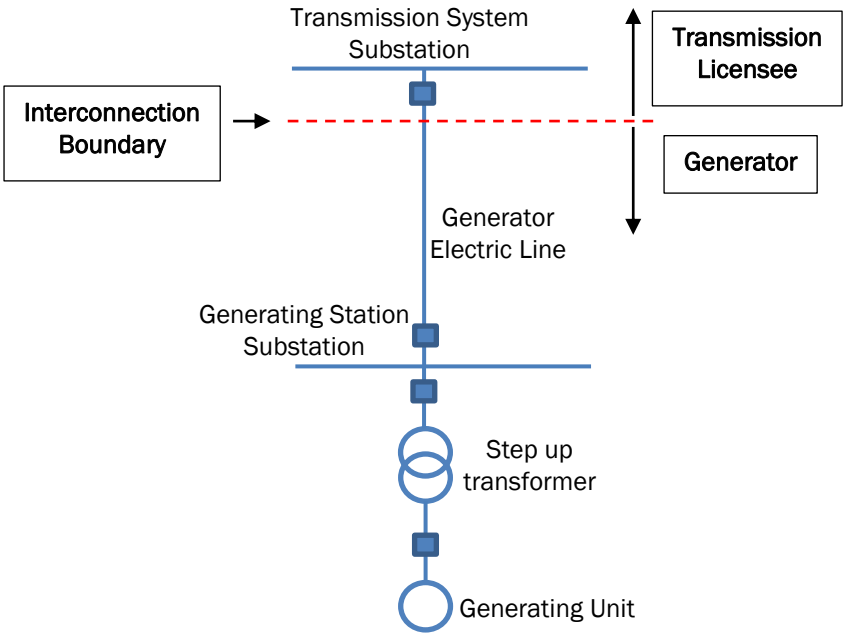

Figure 2. **Interconnection Boundary** of a **Generator** connected to a **Transmission System Substation** through an **Electric Line**.

The **Transmission Licensee** shall own and be responsible for the operation, maintenance and repair of the **Electrical Facilities** at its side of the **Interconnection Boundary** as from the **Commercial Operation Date**.

GC 2.1.5 **Supply Voltage**

The following criteria shall be applied for the definition of the voltage level at which the **Generating Stations** shall be **Interconnected** to the **System**:

a. **Generating Stations** with **Registered Capacity** not exceeding 50 kW shall normally be interconnected to the 230 V single-phase/400 V three-phase **Distribution System**.
b. **Generating Stations** with a **Registered Capacity** greater than 50 kW but not exceeding 10 MW shall be interconnected to the 22 kV **System**.
c. **Generating** Stations with a **Registered Capacity** above 10 MW shall be interconnected to the **Transmission System** at 66 kV or above.

Generating Units connected to the **Distribution System** shall comply with the provisions for **Distributed Generation** set forth in the **Distribution Code**.

GC 2.1.6 **Transformer Configuration**

Generating Stations shall have a step-up transformer with on-load tap-changer for connection to the **Transmission System**. The transformer configuration and tap changing steps shall be proposed by the **Generator** and approved by the **System Operator**. The tap step shall not alter the transformer voltage ratio by more than 1.5%.

GC 2.1.7 **Reliability**

All **Generating Station Substations** shall have the capability to disconnect or separate, from the **System**, any **Electric Line** and **Generating Unit** which is interconnected to the **Substation**.

Each **Generation Unit** shall be designed, where practicable, to mitigate the risk of common mode failure with other **Generation Units**. In particular each **Generation**

Unit shall be designed so that it can operate with its essential Auxiliaries supplied through a Unit Transformer which shall be connected between the Generation Unit Circuit Breaker and the generator transformer terminals, or from another secure source as agreed with the Transmission Licensee. Auxiliary supplies may, provided that they are in accordance with Prudent Utility Practice, be taken from an alternative source during Commissioning, testing, start-up or emergencies.

The Generating Station Substation shall be equipped with all requisite protection measures necessary to meet the Transmission Licensee's Protection System standards as set out in the Transmission Code and in GC 2.1.14.

GC 2.1.8 **Trip to house load**

All Generating Units built after the implementation of the Generation Code shall comply with GC 2.1.8 when required by the System Operator and approved by the Authority.

Where start-up time of Generation Units exceeds thirty minutes, Generating Units shall be designed to have the capability, when supply from the Transmission System is lost, to reduce their output to match its Auxiliaries' load and sustain operation for a maximum of 2 hours.

In a CCGT Generating Station, in the event of a loss of supply from the Transmission System, the gas turbine Generating Units shall remain in house load operation and the steam turbine Generating Units are allowed to trip.

GC 2.1.9 **Synchronization Facilities**

Each Generating Unit shall be equipped with Synchronization facilities at all Circuit Breakers that can connect the Generating Unit to the Grid to ensure Synchronization with the System. Two independent Synchronization 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:

i. System frequency within the limits 48.5 Hz to 51.5 Hz; and

ii. System voltages within the limits specified in the Transmission Code for Contingency Conditions.

Synchronization facilities shall be equipped with dead bus closing facilities.

GC 2.1.10 **Short Circuit Levels**

A Generating Station shall be designed to ensure symmetrical and asymmetrical short circuit currents do not exceed the declared manufacturers' ratings of the Transmission System Equipment, including switches, fuses, circuit breakers and other Protection devices, in terms of both Breaking Capacity and Making Capacity.

GC 2.1.11 **Voltage Control**

Each Generating Station, including Synchronous Generating Stations and Power Park Stations, must be capable of contributing to the Grid voltage control by changes to the Reactive Power supplied to the Transmission System or the User System in which it is embedded. The Generating Unit voltage and Reactive Power control mode and set point shall be specified by the System Operator.

GC 2.1.12 **Frequency response**

Each Generating Station, including Synchronous Generating Stations and Power Park Stations, must be capable of contributing to frequency control by continuous regulation of the Active Power supplied to the System when operating at or above Minimum Load.

Each **Generating Unit** or **Power Park Station** must be fitted with a fast-acting proportional frequency control device (or **Governor Control System**) and **Generating Unit** load controller or equivalent control device to provide frequency response under **Normal** and **Contingency Conditions**. In the case of a **Power Park Station** the frequency or speed control device(s) may be on the **Power Park Station** or on each individual **Power Park Station Generating Unit** or be a combination of both.

The frequency control device (or **Governor Control System**) in co-ordination with other control devices must control the **Generating Unit** or **Power Park Station Active Power** output with stability over the entire operating range of the **Generating Unit** or **Power Park Station.**

The frequency control device (or **Governor Control System**) must meet the following minimum requirements:

a) Non-synchronous **Generating Units** other than **Energy Storage Units** comprised in a **Power Park Station** shall also comply with the response for high **System** frequencies set forth in GC 2.3.3.
b) Where a **Generating Unit** or **Power Park Station** becomes isolated from the rest of the **Total System** but is still supplying **Customers**, the frequency control device (or **Governor Control System**) must also be able to control **System** frequency below 52 Hz unless this causes the **Generating Unit** or **Power Park Station** to operate below its **Designed Minimum Operating Level** when it is possible that it may trip after a time. For the avoidance of doubt the **Generating Unit,** or **Power Park Station** is only required to operate within the **System** frequency range 47 - 52 Hz as defined in GC 2.1.13.1.
c) The frequency control device (or **Governor Control System**) must be capable of being set so that it operates with an overall **Governor Droop** of:
    i. between 0% and 8% for hydro units; and
    ii. between 4% and 8% for other units.

    For the avoidance of doubt, in the case of a **Power Park Station** the **Governor Droop** shall be applied to each **Power Park Generating Unit** in service.
d) In the case of all **Generating Units** or **Power Park Station** other than coal-fired and bagasse-fired units the frequency control device (or **Governor Control System**) **Dead Band** should be no greater than 0.05 Hz (for the avoidance of doubt, ±0.025 Hz).
e) No time delays other than those necessarily inherent in the design of the frequency control device (or **Governor Control System**) shall be introduced. The **Generating Station** shall be capable of activating a power frequency response with an initial delay not greater than two seconds. The System Operator may require a shorter time delay based upon a frequency stability study approved by the **Authority.**
f) **Generating Units** shall comply with the following response times:
    i. High-frequency response: The response to high frequencies shall be fully achieved within 10 seconds and shall be sustained for the duration of the frequency excursion.
    ii. The response to low frequencies shall be fully achieved as per the set droop, within 10 seconds of a frequency drop as from the **Minimum Load**. The response time shall be sustained for the duration of the frequency excursion.
g) The **System Operator**, upon approval of the **Authority,** may accept delays or response times higher than the ones specified in e) and f) for **Generating Stations** commissioned before this **Generation Code** was published if the **Generator** provides technical evidence to justify it.
h) All **Generating Units** with **Registered Capacity** greater than 10 MW shall have the capability to connect to and participate on the Automatic Generation Control (**AGC**), unless otherwise agreed with the **System Operator**.

GC 2.1.13 Tolerance to frequency and voltage variations

GC 2.1.13.1 Tolerance to frequency variations

a) The frequency of the **System** shall be nominally 50 Hz and shall be controlled within 50 Hz ±0.75 Hz as per the frequency criteria set forth in the **Transmission System**, unless exceptional circumstances prevail. The **System** frequency could rise to 52.0 Hz or fall to 47.0 Hz in exceptional circumstances.
A **Generating Station** shall be capable of remaining connected to the **Transmission System** and operate within the frequency ranges and time periods specified in Table 1.

Table 1 Minimum time periods for which a **Generating Station** has to be capable of operating on different frequencies, deviating from a nominal value, without disconnecting from the **Transmission System**.

Frequency (F) range	Requirement
51.5 Hz < F≤ 52.0 Hz	Operation for a period of at least 15 seconds is required
51.0 Hz <F ≤ 51.5 Hz	Operation for a period of at least 90 minutes is required
49.0 Hz <F ≤ 51.0 Hz	Continuous operation is required
47.5 Hz <F ≤ 49.0 Hz	Operation for a period of at least 90 minutes is required
47.0 Hz < F ≤ 47.5Hz	Operation for a period of at least 20 seconds is required
F ≤ 47.0 Hz	Operation for a period of at 3 seconds is required

b) **Generating Stations** shall remain connected to the System during a rate of change of system frequency of values up to and including 2.5 Hz per second measured as a rolling average over 500ms.
c) Each **Generating Station** operating at **Registered Capacity** must be capable of:
    i) continuously maintaining constant **Active Power** output for **System** frequency changes within the range 50.75 to 49.25 Hz; and
    ii) maintaining its **Active Power** output at a level not lower than the figure determined by the linear relationship shown in Figure 3 for System frequency changes within the range 49.25 to 47 Hz, such that if the **System** frequency drops to 47 Hz the **Active Power** output does not decrease by more than 5%.

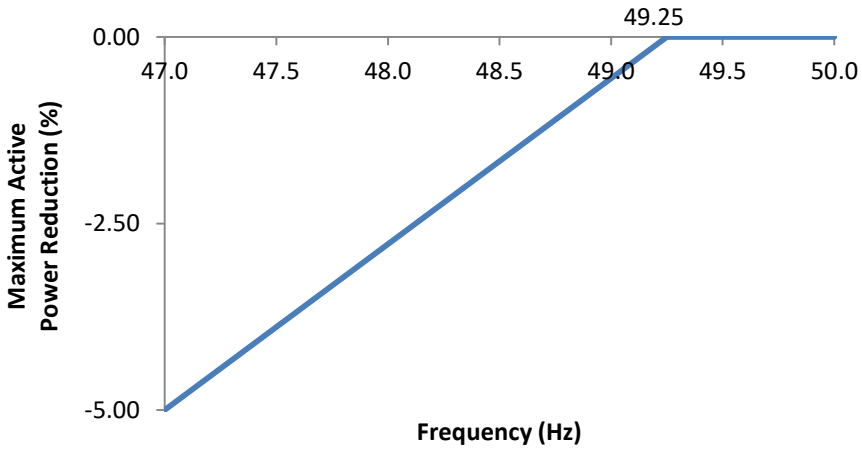

Figure 3. Maximum **Active Power** capability reduction with falling frequency required for all **Generating Stations** operating at **Registered Capacity**.

GC 2.1.13.2 Tolerance to voltage variations

Generating Units shall be designed to operate under **Normal** and **Contingency Conditions** with terminal voltages at least within ± 5 % of the nominal value.

A **Synchronous Generating Station** shall be able to operate continuously at full **Registered Capacity** within the frequency ranges and time durations defined in GC 2.1.13.1 and at **Transmission System** voltages defined in the **Transmission Code** for **Normal** and **Contingency Conditions**.

A **Power Park Station** shall remain continuously connected to the **Transmission System** at its **Available Active Power** or curtailed **Active Power** output for frequencies within the ranges and time durations defined in GC 2.1.13.1 and at **System** voltages defined in the **Transmission Code** for **Normal** and **Contingency Conditions.**

Generating Station shall avoid introducing undue resonance leading to over voltage at the **Interconnection Boundary**.

GC 2.1.14 Protection Requirements

GC 2.1.14.1 General provisions

Protection systems shall be provided in accordance with **Prudent Utility Practice** and comply with the relevant requirements set forth in the Protection Requirements section of the **Transmission Code**.

A **Generating Station** transformer, **Generating Unit Transformer**, associated busbar, **Auxiliaries** and switchgear shall be equipped with well-maintained **Protection** functions, to rapidly disconnect appropriate **Generating Station** section(s) should a **Fault** occur on the **Generator** side of the **Interconnection Boundary** that may affect the **Transmission System.**

The following requirements apply to **Protection Systems** of **Generating Stations**:

a) Should **System** conditions dictate it, the **System Operator** shall determine other capital **Protection** requirements in consultation with the **Generator**. This **Equipment** may be installed at the relevant **Generating Station**, and be maintained by the relevant **Generator**.
b) Where **Generating Station Circuit Breakers** are provided on the **primary** or **secondary** side of the **Substation** transformer, tripping and **Fault Clearance Times**, including **Circuit Breaker** interruption time, shall not exceed the corresponding **Critical Fault Clearing Time**.

c) The **Generator** in consultation with both the **System Operator** and **Transmission Licensee** shall co-ordinate all protection interfaces between the **Generating Unit, Generating Station Substation** and the **Transmission System**.
d) The settings of all the **Protection** tripping functions on the **Generating Station Substation Protection's** system, relevant to the **System** performance and as agreed with each **Generator** in writing, shall be co-ordinated with the **Transmission System Protection** settings. These settings shall be agreed between the **Transmission Licensee, System Operator** and each **Generator**, and shall be documented and updated to reflect the actual plant status at all time.
e) A **Generating Station** may be disconnected from the **Transmission System** in response to conditions on the Transmission System side of the **Interconnection Boundary** that will result in damage of the **Generating Station Plant** and **Apparatus**. **Protection** setting documents shall illustrate **Generating Station** and **Generating Station Substation** capabilities and the relevant P**rotection** operations.
f) **Parties** shall ensure that competent persons shall carry out testing, commissioning and configuration of **protection** systems.
g) **Generators** shall communicate any work on the **protection** circuits interfacing with **Transmission** P**rotection** systems (e.g. bus zone, differential protection) to the **System Operator** before commencing the work. This includes work done during a unit outage.

GC 2.1.14.2 Synchronous Generating Stations

The **Protection** of **Generating Units** of **Synchronous Generating Station** shall follow the guidelines of IEEE C37.102-2006 "IEEE Guide for AC Generator Protection", and have at least the following **Protection** relays:

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. Overcurrent **Protection**
f. Reverse power protection;
g. Over- and under-frequency **Protection**;
h. Over- and under-voltage **Protection**;
i. Thermal over-load **Protection**;
j. Rotor (or field) ground fault **Protection**.

GC 2.1.14.3 Generating Unit transformers

Generating Unit transformers shall follow the guidelines of C37.91-2008, "IEEE Guide for Protecting Power Transformers", and have at least the following **Protection** relays:

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. Over-temperature protection (winding and oil).

GC 2.1.14.4 Interconnection Boundary

At least the following **Protection** relays shall be installed on each side of the **Interconnection Boundary:**

a. Differential and impedance **Protections,** as main **Protections,** for phase and earth faults.

b. Backup interconnection **Protection** for phase and earth faults.
c. Backup **Protection** in the event of **Circuit Breaker** failure to operate.

The following **Protection** requirements shall be met at **Interconnection Boundary:**

a. The **Protection** requirements for the **Interconnection** with the **Transmission System** will depend on the interconnection voltage and the **Substation** configuration. The detailed arrangements for each **Generating Station** shall be set out in the respective **IA**, **PPA** or **ESPA**. In all cases it should be ensured that each **Generating Unit** or **Generating Station** can be separated from the **System** as rapidly as possible in the event of a sustained electrical fault on either side of the **Interconnection Boundary**.
b. At the **Transmission System** side of the **Interconnection Boundary** a directional **Protection** shall be installed so that for **Faults** on the **Transmission System** side of the **Interconnection Boundary** the **Circuit Breaker** connecting the **Generating Station** to the **Substation** will only trip as a backup of other **Circuit Breakers** in meshed areas of the **Transmission System**.
c. The **Generator** shall provide, install, own, and maintain relays, circuit breakers, and all other devices necessary to remove promptly any fault or contribution of the **Generating Station** to any short circuit occurring on the **System** not otherwise isolated by the relevant **Transmission** or **Distribution System Equipment**. Such **Protection Equipment** shall include a disconnecting device or switch with load interrupting capability to be located between the **Generating Station** and the **System**. The **Generator** shall be responsible for the **Protection** of the **Generating Station** and **Generator's** other **Equipment** on the **Generator** side of the **Interconnection Boundary** from such conditions but not limited to the ones in GC 2.1.14.2. The **Generator** shall be solely responsible for the provision of **Equipment** to disconnect the **Generating Station** and **Generator's** other **Equipment** when any of the above-described disturbances occur on the **System**.
d. The **Protection** relay systems shall provide the levels of sensitivity, speed and reliability required by the **System Operator** and the **Transmission Licensee**. The operation of all **Protection** schemes shall be coordinated with the operation of the **Transmission Licensee's Equipment**.
e. The **Generator** shall take full responsibility for **Protection** settings and commissioning of the interconnection between the **Generating Station** and the **Transmission System**, and any changes to settings for **Transmission System Equipment** affected by the **Protection** settings of the **Generator's Protection Equipment** shall be agreed by the **Parties**.
f. The **Generator** shall submit the following design data for approval by the **Transmission Licensee**:
    i. **Protection** and Metering single line diagrams;
    ii. Tripping logic diagrams;
    iii. **AC** and **DC** schematic diagrams for the **Interconnection** and **Generating Unit Protection** schemes;
    iv. Setting calculations and setting lists for the **Interconnection** and **Generating Unit Protection** schemes including opening/closing time for main **Circuit Breakers**;
    v. **Generating Station Substation Equipment** single line diagram; and
    vi. Any other information that may be required.

GC 2.1.15 Power Oscillations Damping Control

a) To allow the **Generating Unit** to maintain second and subsequent swing stability and also to ensure an adequate damping of electromechanical

oscillations, the **Automatic Voltage Regulator** shall include a **Power System Stabiliser** (**PSS**) as a means of supplementary control.

b) Whatever supplementary control signal is employed; it shall be of the type which operates into the **Automatic Voltage Regulator** to cause the field voltage to act in a manner which results in the damping power being improved while maintaining adequate synchronising power.
c) The arrangements for the supplementary control signal shall ensure that the **Power System Stabiliser** output signal relates only to changes in the supplementary control signal and not the steady state level of the signal. Additionally, the **Power System Stabiliser** should not react to mechanical power changes in isolation for example during rapid changes in steady state load or when providing frequency response.
d) The output signal from the **Power System Stabiliser** shall be limited to not more than ±10% of the Generating Unit terminal voltage signal at the **Automatic Voltage Regulator** input. The gain of the **Power System Stabiliser** shall be such that an increase in the gain by a factor of 3 shall not cause instability.
e) The **Power System Stabiliser** shall include elements that limit the bandwidth of the output signal. The bandwidth limiting must ensure that the highest frequency of response cannot excite torsional oscillations on other plant connected to the network. A bandwidth of 0-5Hz would be judged to be acceptable for this application.
f) The **Power System Stabiliser** must be active, if required, within the excitation system at all times when synchronised including when the under-excitation limiter or over excitation limiter are active. When operating at low load when Synchronising or de-synchronising a **Generating Unit**, the **Power System Stabiliser** may be out of service.

GC 2.1.16 Power Quality

Generator's Plant and **Apparatus** shall not introduce excessive distortion to the sinusoidal voltage and current waves and shall comply with the requirements of the Power Quality section of the **Transmission Code**. **Generating Stations** shall meet the following requirements:

a) Harmonic Distortion: The electrical output of a **Generating Station** shall not contain harmonic content causing unacceptable disturbances on or damage its own **Electrical Facilities** or **Electrical Facilities** of other **Users**, such as but not limited to computer, telephone, communication and other sensitive electronic or control systems.
b) Phase Unbalance: **Generating Units** of **Synchronous Generating Stations** shall remain synchronised to the **Transmission System** during a negative phase sequence load unbalance in accordance with IEC 60034-1.
c) Voltage excursions**: Generator's Plant** and **Apparatus** shall not cause excessive voltage excursions nor cause the voltage to permanently drop below or rise above the statutory ranges set forth in the **Transmission Code** for **Normal** and **Contingency Conditions**.

All Generators shall comply with the power quality requirements established in TC 6 Power Quality Standards

GC 2.1.17 Safety Requirements

The **Generator** shall comply with the provisions of its **License**, Applicable Laws, the **System Operator** and the **Transmission Licensee Safety Rules**, any relevant **IA**, **PPA** or **ESPA**, and conform to **Good Industry Practice** for securing the safety of its employees, other persons living/ working close to the **User Site**.

Requirements to be followed by Generators for Safety Coordination are included in

section SOC 15 of the **System Operations Code**.

GC 2.2 Requirements for Synchronous Generating Stations

GC 2.2.1 General Provisions

Synchronous Generating Stations shall comply with the requirements of GC 2.1, in addition to the requirements in GC 2.2.

GC 2.2.2 Operating characteristics

Each **Generating Unit** shall be operated within its technical capabilities at all times and shall, as a minimum, have the following capabilities:

a) **Minimum Load** not greater than
   a. 35% of **Registered Capacity** for bagasse and/or coal cogeneration **Generating Stations** for crop and inter-crop season;
   b. 50% of **Registered Capacity** for GT **Generating Stations**;
   c. 80% of **Registered Capacity** for Diesel **Generating Stations**; and,
   d. 35% of **Registered Capacity** for all other **Generating Units**.

   For CCGT **Generating Stations** whilst operating in Open Cycle Mode as a result of combined cycle plant capability being unavailable, the **Minimum Load** of each Combustion Turbine Unit must not be greater than 35% of the Registered Capacity divided by the number of Combustion Turbine Units.
b) Ramp up capability not less than 1.5% of **Registered Capacity** per minute when the **Generating Unit** is in the Normal Dispatch Condition.
c) Ramp down capability not less than 1.5% of **Registered Capacity** per minute when the **Generating Unit** is in the Normal Dispatch Condition.
d) **Minimum Up Time** not greater than 4 hours for Thermal Units.
e) **Minimum Down Time** not greater than 4 hours for Thermal Units.
f) Hydroelectric **Generating Units** shall not have more than 2 **Forbidden Zones** of width greater than 10% of **Registered Capacity** within the range between 105 % **Minimum Load** and 90 % **Registered Capacity**.
g) **Block Load** not greater than 15% of **Registered Capacity**.
h) Time to **Synchronise** from instruction for:
   a. **Hot Start**: not greater than 3 hours
   b. **Warm Start**: not greater than 8 hours
   c. **Cold Start**: not greater than 12 hours
i) Time to deload from Minimum Load to de-synchronising not greater than 40 minutes, except where agreed with the System Operator.
j) **Operating Reserve**: A **Generating Unit** shall provide the amount of **Operating Reserve** defined by the **System Operator** in the Dispatch Procedures in the range from **Minimum Load** to 95% **Registered Capacity**.

Notwithstanding the abovementioned requirements in GC 2.2.2, combustion turbine, hydro, or other technology based **Generation Units** shall as appropriate, register and perform to **Operating Characteristics** giving maximum flexibility of operation, consistent with their type and model of generation plant, in accordance with **Prudent Utility Practice**. Where appropriate, **Operating Characteristics** and in particular start times, should be registered separately for normal (planned) starts, and for starts required under conditions of system stress, such as following the loss of a **Generation Unit**. The **Generator** will maintain operational procedures and practices, which ensure that there are no unnecessary delays in responding to Dispatch instructions in accordance with the technical capabilities of the **Generation Plant**.

Where the **System Operator** approaches a **Generator**, the **Generator** will co-operate with the **System Operator** in the development of procedures and facilities to improve the response of each **Generation Unit** during conditions of system stress, including,

for example, automatic start-up of fast-start **Generation Units** following a loss of **Generation Unit(s)** or in advance of an anticipated loss of **Generation Unit(s)**. This shall be subject to the agreement of the **Generator** that the procedures are consistent with secure operation of the **Generator's Plant**, such agreement not to be unreasonably withheld.

GC 2.2.3 Governor Control System

Each **Generating Unit** must be fitted with a fast-acting proportional **Governor Control System** or equivalent control device to provide frequency response under **Normal** and **Contingency** conditions subject to the provisions of GC 2.1.12.

Synchronous Generating Stations shall operate at all times under the control of a **Governor Control System**, unless otherwise specified by the **System Operator**.

GC 2.2.4 Voltage Control

A **Synchronous Generating Station**, must be capable of contributing to voltage control by changes to the **Reactive Power** supplied to the **Transmission System** subject to the provisions of GC 2.1.11.

A **Generating Unit** shall have a continuously acting **Automatic Voltage Regulator** (**AVR**). The **AVR** shall provide constant terminal voltage control of the **Generating Unit** over the entire **P-Q Capability diagram** of the **Generating Unit**. Excitation control systems shall comply with the requirements specified in IEC 60034, IEEE 421 or any other standard agreed to by the **System Operator**.

Generators shall comply with the following requirements:

a) The excitation system of each **Generating Unit** shall normally be operated under the control of a continuously acting **AVR**, which shall be set so as to maintain a constant terminal voltage. The **Generator** may not disable or restrict the operation of the **AVR**, unless the **System Operator** is informed.
b) The excitation control system shall be equipped with under and over-excitation limiters and a flux limiter except for installed **AVR** equipment up to and including analogue electronic technology.
c) The excitation system shall have a minimum excitation ceiling limit of 1.6 PU rotor current, where 1 PU is the rotor current required to operate the unit at rated load and at rated power factor as defined in IEC 60034, IEEE 421 or any other standard agreed to by the **System Operator**.
d) The excitation system of each **Generating Unit** shall comply with the following minimum requirements:
    i) Steady State Voltage Control: An accurate steady state control of the **Generating Unit** pre-set terminal voltage is required. As a measure of the accuracy of the steady-state voltage control, the **Automatic Voltage Regulator** shall have static zero frequency gain, sufficient to limit the change in terminal voltage to a drop not exceeding 0.5% of rated terminal voltage, when the **Generating Unit** output is gradually changed from zero to rated **MVA** output at rated voltage, **Active Power** and frequency.
    ii) Transient Voltage Control: For a step change from 90% to 100% of the nominal **Generating Unit** terminal voltage, with the **Generating Unit** on open circuit, the excitation system response shall have a damped oscillatory characteristic. For this characteristic, the time for the **Generating Unit** terminal voltage to first reach 100% shall be less than 0.6 seconds. Also, the time to settle within 5% of the voltage change shall be less than 3 seconds.
e) The **Generator** shall obtain the 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 based on the outcome of the Generation Interconnection Studies defined in GC 15.

f) The unit shall be able to operate anywhere within its effective **P-Q Capability Diagram**.

g) **Generating Units** shall be capable of delivering constant **Active Power** output under steady state conditions for **Transmission System** voltage changes in the range for **Normal** and **Contingency Conditions** specified in the **Transmission Code**.

h) All **Generating Units** shall be equipped, if required by the **System Operator**, with power system stabilisers as defined in IEC 60034, IEEE 421 or any other standard agreed to by the **System Operator**. The requirements for other excitation control facilities and **AVR** refurbishment shall be determined in conjunction with the **System Operator**.

i) The **Generator** shall not change, correct or 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 **Generator** to conduct **Generating Un**it tests to ensure compliance with the **Generation Code**.

GC 2.2.5 Reactive Power Capability

Each **Generation Unit** shall be at least capable of operating at any point within the **P-Q Capability Diagram** schematically shown in Figure 4 and defined below, as measured at their alternator terminals:

a) At **Registered Capacity** between 0.85 power factor leading to 0.80 power factor lagging;

b) At 50% of **Registered Capacity** between 0.60 power factor leading to 0.50 power factor lagging;

c) At between **Registered Capacity** and 50% **Registered Capacity**, MVAR capability to be not less than the indicated by a straight line drawn between the two points derived from the above, on a plot of **MVAR** capability against **MW** output;

d) At below 50% **Registered Capacity**:

   i. The lagging MVAR capability shall not be less than that at 50% **Registered Capacity**.

   ii. The leading MVAR capability shall not be less than the indicated by a straight line drawn between the value at 50% Registered Capacity and the minimum value for lagging power factor at zero MW output multiplied by -0.60.

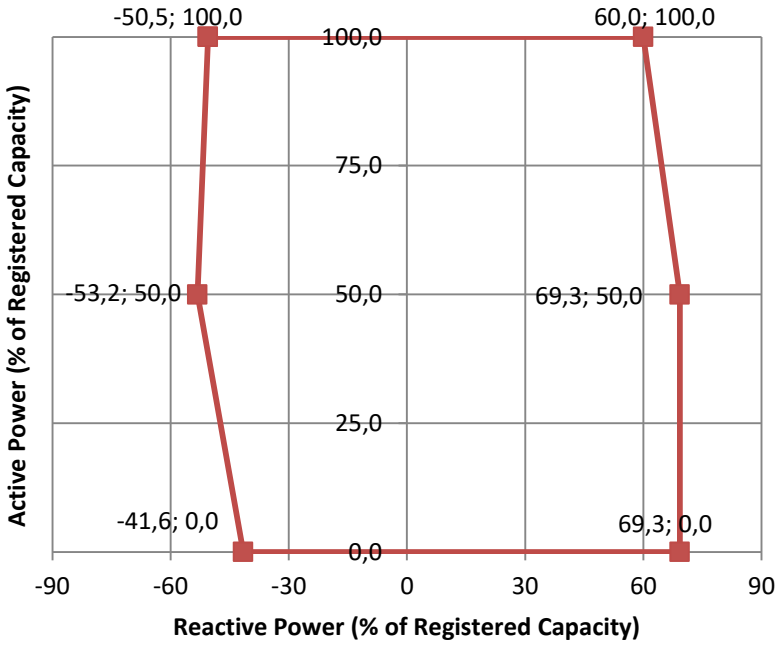

Figure 4. P-Q Capability Diagram for Generating Units of Synchronous Generating Stations.

The Generating Unit transformer shall be designed such that the required Reactive Power capability is possible over the full range of Transmission System voltages specified in the Transmission Code for Normal and Contingency Conditions.

The System Operator and the Generator will liaise on matters related to GC 2.2.5 at the design stage.

GC 2.2.6 Fault ride through

GC 2.2.6.1 Low Voltage Ride Through

Each Generating Unit shall remain synchronised during and following any Fault Disturbance anywhere on the System which could result in voltage dips at the Interconnection Boundary of magnitude and duration up to and including the curve in Figure 5.

Following the Fault clearance, the Generating Unit should return to pre-fault conditions subject to its normal Governor Control System and Automatic Voltage Regulator response.

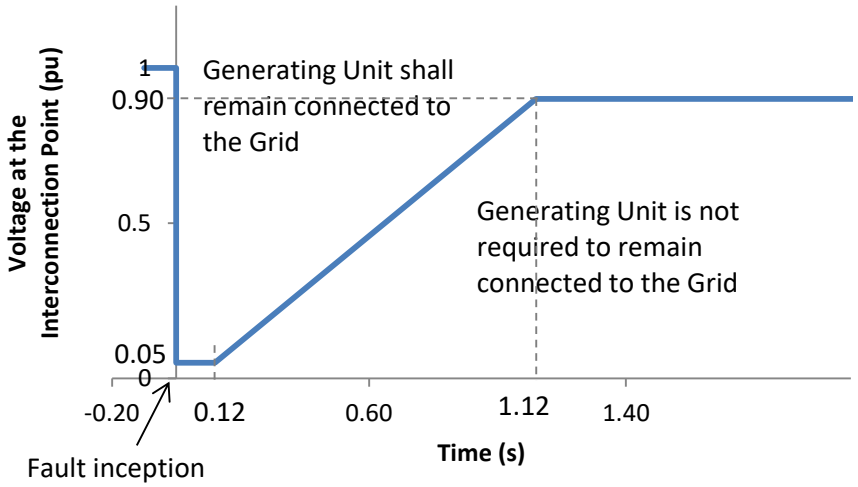

Figure 5. Low Voltage Ride Through Capability for Synchronous Generating Stations.

GC 2.2.6.2 High Voltage Ride Through

Each **Generating Unit** shall remain synchronised during and following any **Fault Disturbance** anywhere on the **System** which could result in a voltage rise at the **Interconnection Boundary** of magnitude and duration up to and including the curve in Figure 6.

Exceeding the solid border line in Figure 6 shall trigger the immediate disconnection of the **Generating Unit**. **Generating Units** must be capable of remaining connected at or below the limit in Figure 6 during and immediately after any **System** condition. These are minimum requirements and the **Transmission Licensee** may require **Equipment** that is capable of riding through higher voltage and longer duration to deploy their full capability in coordination with the **System Operator**.

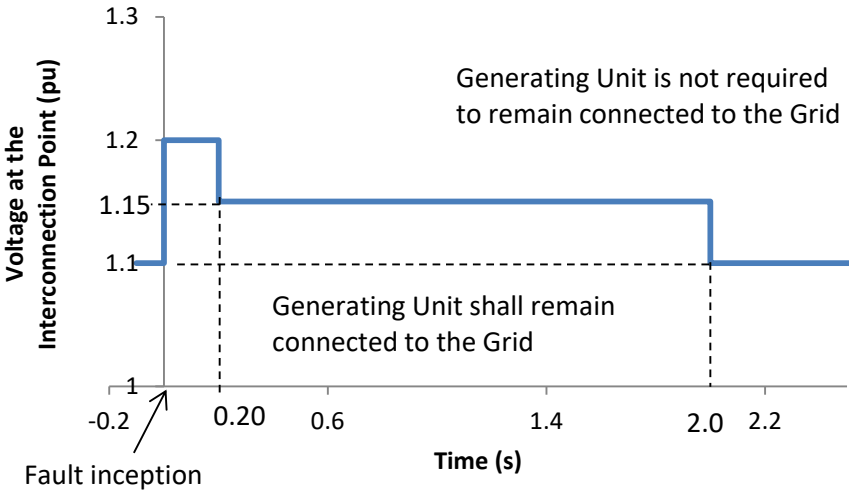

Figure 6. High Voltage Ride Through Capability for Synchronous Generating Stations.

GC 2.2.7 Black Start and Dead Bus Control Capability

Some **Generating Units** shall be designated by the **System Operator** to have **Black Start Capability** primarily considering their type and location on the **System**. This

shall enable **Generators** to restart their **Generating Units** without incoming supply from the **System**, perform the **Dead Bus Control**, and supply load as necessary. Once online, **Generating Units** shall control the system frequency through the variation of their **Active Power** output with load changes. In the event of the **Generator** participating in the **System Black Start** procedure, 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 **IA**, **PPA** or **ESPA** .

Bagasse and coal-fired **Generating Units** are exempted from providing **Black Start** and **Dead Bus Control Capability**. Where a **Generator** has a facility with a capacity of 30 MW or greater, at least one source of **Black Start** supply shall be located at the site subject to the **Authority's** decision based on the **System Operator**'s **System Restoration Procedure**.

Plant and **Apparatus** used for **Black Start** 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** and to the **Authority** once a year, detailing the results of the **Black Start** generator test. Black start test reports shall be submitted to the **System Operator** before the cyclone season starts.

A failed **Black Start Generator** test shall automatically trigger the reporting of that **Black Start** test results by the relevant **Generator** to the **System Operator**. A further report is also to be immediately submitted by the **Generator** to the **System Operator** and to the **Authority** upon subsequent successful maintenance and operation of said **Black Start Generator**.

GC 2.2.8 Fuel Supply Capability (Thermal Plants only)

The Generator shall at its own expense construct and maintain fuel supply infrastructure sufficient to store at least the number of days of fuel requirement at normal rated output subject to the provisions of section GC 7 of this Generation Code.

The minimum required fuel storage capacity of waste-to-energy **Generating Stations** shall be determined by the **Authority** after requesting the **System Operator** for a recommendation.

GC 2.3 Requirements for Power Park Stations

GC 2.3.1 General Provisions

Power Park Stations shall comply with the requirements of GC 2.1 in addition to the requirements of GC 2.3.

GC 2.3.2 Active Power Constraint Functions of Variable Renewable Generating Stations

For **System** security reasons it may be necessary for the **System Operator** to curtail the **Variable Renewable Generating Station (VRGS) Active Power** output.

The **VRGS** shall be capable of:

(a) operating the **VRGS** at a reduced level if active power has been curtailed by the **System Operator** for **System** security reasons,

(b) receiving a telemetered MW curtailment set-point sent from the **System Operator**.

The **VRGS** shall be equipped with constraint functions, i.e. supplementary active power control functions. The constraint functions are used to avoid imbalances in the **Total System** or overloading of the **Transmission** and **Distribution Systems** in

connection with the reconfiguration of the **Transmission** and **Distribution Systems** in critical or unstable.

Activation of the **Active Power** constraint functions shall be agreed with the **System Operator**. The required constraint functions are as follows:

(a) Absolute production constraint

(b) Power gradient constraint.

The required constraint functions are described in the following sections.

GC 2.3.2.1 Absolute Production Constraint

An Absolute Production Constraint is used to constrain the output active power from the **VRGS** to a predefined power MW limit at the **Interconnection Boundary** measured at the **Point of Delivery**.

If the set point for the Absolute Production Constraint is to be changed, the **VRGS** shall commence such change within two seconds and the change shall be completed no later than 30 seconds after receipt of an order to change the set point unless otherwise agreed with the **System Operator**.

The accuracy of the control performed and of the set point shall not deviate by more than ±2% of the set point value or by ±0.5% of the **Registered Capacity**, whichever yields the highest tolerance.

GC 2.3.2.2 Power gradient constraint

The **VRGS** control system shall be capable of controlling the ramp rate of its **Active Power** output with a maximum **MW** per minute ramp rate set by the **System Operator** based on the results of the transient and frequency stability studies performed according to the Planning Studies section of the **Transmission Code**.

These ramp rate settings shall be applicable for all ranges of operation including positive ramp rate during start up, positive ramp rate only during normal operation and negative ramp rate during controlled shut down. They shall not apply to frequency regulation.

GC 2.3.3 Automatic frequency response

Each **Generating Unit** must be fitted with a fast-acting proportional **Governor Control System** or equivalent control device to provide frequency response subject to the provisions of GC 2.1.12.

The **Power Park Station** shall perform frequency response control function unless otherwise instructed by the **System Operator**.

The **Generating Units** of a **Power Park Station,** excluding **Energy Storage Units,** shall be able to provide at least the **Active Power** output response to frequency changes displayed in Figure 7. The **Active Power** output shall be only allowed to increase again as soon as the frequency is only 50.05 Hz. Above 52 Hz and below 47 Hz, the **Power Park Station** shall be disconnected from the **Grid**.

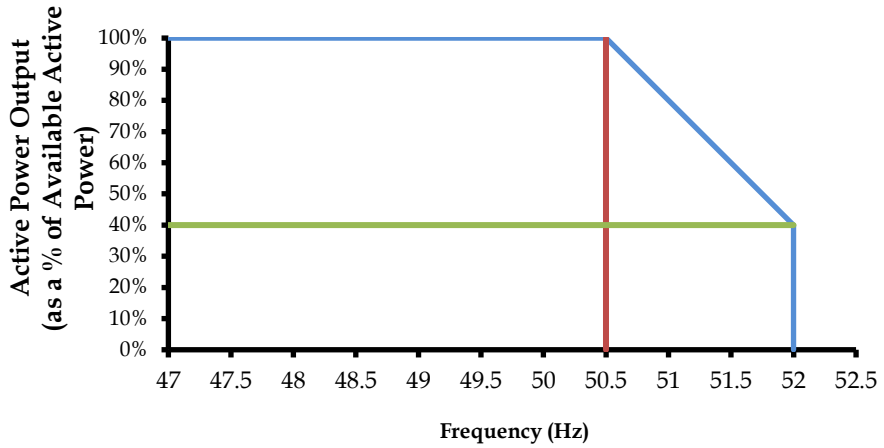

Figure 7. Required frequency response for **Power Park Stations** (excluding **Energy Storage Units**).

GC 2.3.4 **Reactive Power and Voltage Control Functions**

A **Power Park Station**, must be capable of contributing to voltage control by continuous changes to the **Reactive Power** supplied to the **Transmission System** subject to the provisions of GC 2.1.11.

The **Power Park Station** shall be equipped with **Reactive Power** control functions capable of controlling the **Reactive Power** supplied by the **Power Park Station** at the **Interconnection Boundary,** measured at the **Point of Delivery,** as well as voltage control function capable of controlling the voltage at the **Interconnection Boundary,** measured at the **Point of Delivery,** via orders using set points and gradients.

The **Reactive Power** and voltage control functions shall be mutually exclusive, which means that only one of the 3 (three) functions mentioned below can be activated at a time:

a) Voltage Control;

b) Power Factor Control; and

c) **Reactive Power** Control

The **Power Park Station** shall control the voltage at its side of the **Generating Station** step up transformer with a set-point of 1.00 PU unless otherwise specified by the **System Operator**. The **Generator** shall not change the functional mode and set-point of the **Power Park Station** unless instructed by the **System Operator** as provided under the **System Operator's** operating procedures.

GC 2.3.4.1 **Reactive Power Control**

Reactive Power control is a control function controlling the **Reactive Power** supply and absorption at the **Interconnection Boundary** independently of the **Active Power** and the voltage.

If the **Reactive Power** control set point is to be changed by the **System Operator**, the **Power Park Station** shall update its set point value in response to the new value within two seconds. The **Power Park Station** shall respond to the new set point within 30 seconds after receipt of an order to change the set point unless otherwise agreed with the **System Operator**.

The controlled **Reactive Power** set point by more shall not deviate from the given set point by more than ±2% of the set point value or by ±0.5% of maximum **Reactive Power** after stabilization following a change of setpoint, whichever which yields the

highest tolerance.

The **Power Park Station** shall be able to receive a **Reactive Power** set point with an accuracy of at least 1 kVAR.

GC 2.3.4.2 Power Factor Control

Power Factor Control is a control function controlling the **reactive power** proportionally to the **active power** at the **Interconnection Boundary**.

If the power factor set point is to be changed by the **System Operator**, the **Power Park Station** shall update its echo analog set point value to in response to the new value within 2 seconds. The **Power Park Station** shall respond to the new set point within 30 seconds after receipt of an order to change the set point unless otherwise agreed with the **System Operator**.

The power factor at the **Interconnection Boundary,** measured at the **Point of Delivery,** shall not deviate by more than ±0.02 of the set point.

GC 2.3.4.3 Voltage Control

Voltage control is a control function controlling the voltage at the **Interconnection Boundary** or at either side of the **Substation** step up transformer on the **Generator** side of the **Interconnection Boundary**.

If the voltage set point is to be changed, such change shall be commenced within 2 seconds and completed no later than 30 seconds after receipt of an order to change the set point unless otherwise agreed with the **System Operator**.

The controlled voltage shall not deviate from the set point by more than ±0.5% of the nominal voltage. The control droop, defined as the voltage change (PU) caused by a change in reactive power (PU), shall be set accordingly.

When the voltage control has reached the **Power Park Station**'s design limits, the control function shall await possible overall control from the transformer on load tap changer or other voltage control functions.

The overall voltage control coordination shall be handled by the **System Operator**.

GC 2.3.5 Reactive Power Capability

The **Power Park Station** shall be at least capable of operating at any point within the **P-Q Capability Diagram** schematically shown in Figure 8 and defined below, as measured at the **Point of Delivery** on the **System Operator** side of the **Interconnection Boundary**:

a) At **Registered Capacity** between: 0.95 power factor leading to 0.95 power factor lagging; available from 20% of **Registered Capacity**
b) At between 20% **Registered Capacity** and 5% **Registered Capacity**, MVAR capability to be not less than indicated by straight lines drawn between the requirement at 20% **Registered Capacity** and the origin of the plot of **MVAR** capability against **MW** output.
c) When operating below 5% **Registered Capacity**, there is no **Reactive Power** capability requirement, however the **Power Park Station** can only operate within the **Reactive Power** tolerance range not exceeding +/-5% of **Registered Capacity**; that is within the box in dashed lines in Figure 8.

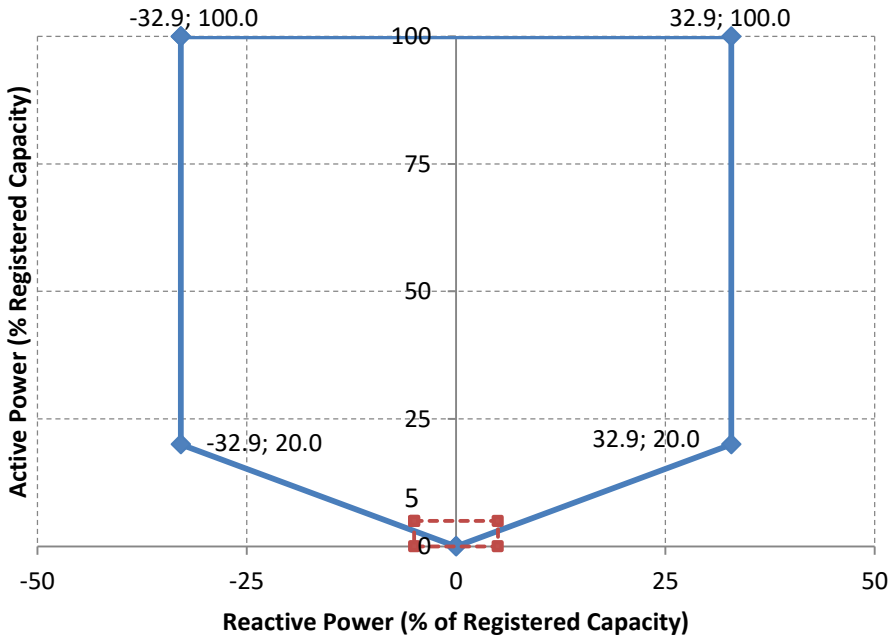

Figure 8. P-Q Capability Diagram of Power Park Stations.

The **Power Park Station** Substation transformer shall be designed such that the **Power Park Station** capability is possible over the full range of **Transmission System** voltages specified in the **Transmission Code** for **Normal** and **Contingency Conditions**.

GC 2.3.6 Fault ride through

GC 2.3.6.1 Low Voltage Ride Through

Each **Generating Unit** shall remain synchronised during and following any **Fault Disturbance** anywhere on the **System** which could result in voltage dips at the **Interconnection Boundary** of magnitude and duration up to and including the curve in Figure 9.

Following the fault clearance, the **Generating Unit** should return to pre-fault conditions subject to its normal power-frequency and automatic voltage regulator response.

The **Power Park Generating Station** shall have the technical capability to provide the following:

a) During the **Transmission System** voltage dip, the **Generating Units** shall provide active power in proportion to retained voltage and maximise reactive current to the transmission system without exceeding the Generating Unit limit. The maximisation of reactive current shall continue for at least 625 (six hundred and twenty-five) ms or until the Transmission **System** voltage recovers to within the range for **Normal Conditions** of the **Transmission System** whichever is the sooner.

b) The **Generating Units** shall provide at least 90% of their maximum available **Active Power** as fast as the technology allows and in any event within 1 (one) second of the **Transmission System** voltage recovering to the range for **Normal Conditions**.

c) A higher or lower **Fault Clearance Time** for the **Generating Unit** shall be agreed to with the **Transmission Licensee**.

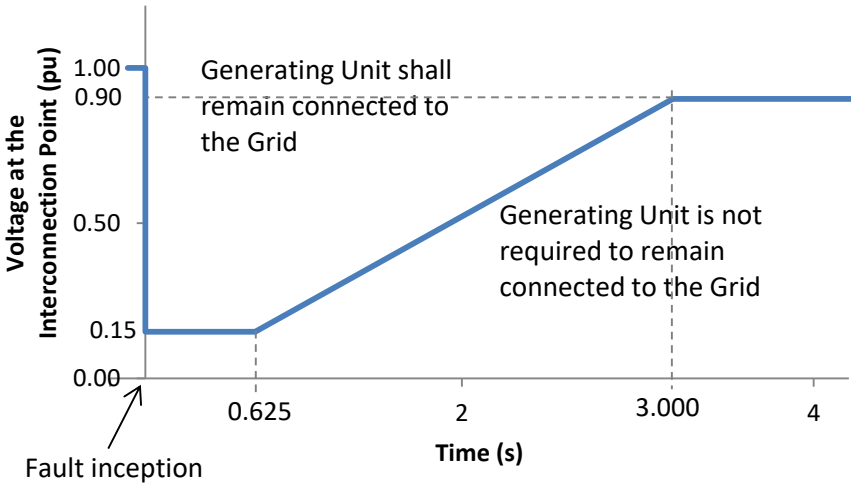

Figure 9. Low Voltage Ride Through Capability for **Power Park Stations**.

GC 2.3.6.2 High Voltage Ride Through

Each **Generating Unit** shall remain synchronised during and following any **Fault Disturbance** anywhere on the **System** which could result in a voltage rise at the **Interconnection Boundary** of magnitude and duration up to and including the curve in Figure 10.

Exceeding the solid border line in Figure 10 shall trigger the immediate disconnection of the **Generating Unit**. **Generating Units** must be capable of remaining connected at or below the limit in Figure 6 during and immediately after any **System** condition.

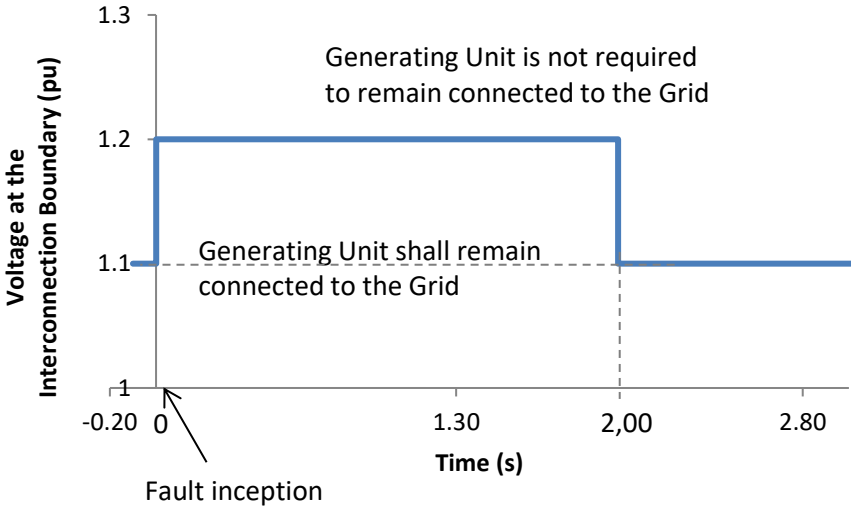

Figure 10. High Voltage Ride Through Capability for **Power Park Stations**.

GC 2.3.7 Particular Requirements for Energy Storage Units

ESUs shall comply with general requirements for **Generating Stations** in GC 2.1 and particular requirements for **Power Park Modules** in GC 2.3. **ESUs** shall also comply

with the relevant provisions of the operational planning and dispatch sections of the System Operations Code.

The System Operator shall be able to fully exploit the technical capabilities of ESUs according to the installed capacity and the duration ranges of the continuous charging and discharging of the ESUs in order to minimize operation costs and satisfy operational reliability requirements of the System.

Whenever technically feasible and under the provisions of the IA, PPA or ESPA, the System Operator shall be able to operate and control the ESU to provide the following services:

1) Voltage control
2) Active Power reserve for System frequency regulation
3) Black Start
4) Energy arbitrage to avoid high electricity production costs by transferring load from high demand to low demand periods.

GC 2.4 Rights of the System Operator

GC 2.4.1 Inspection of Generating Station

The System Operator, the Single Buyer and the Transmission Licensee have the right to inspect any aspect of the Generator's Electrical Facilities 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, Protection relays (and relay settings), metering and telemetering. Prior to exercising its right to inspect the Generator's Electrical Facilities and Metering System, the System Operator shall give the Generator 1-week notice and provide reasons for the inspection. The reasons of such inspection shall be duly justified by the System Operator's notice to avoid unnecessary impact on the daily operation of the Generating Station.

The Generator shall keep records to provide verification of tests and maintenance, in accordance with the IA, PPA or ESPA by the System Operator.

GC 2.4.2 Disconnection of Generator by the System Operator

The System Operator retains the right to disconnect any Generating Station from the System thereby isolating its Equipment without prior notice under the following circumstances:

a. in cases of System Emergency;

b. during System restoration following partial or complete loss of power;

c. if at any time the Generator's Electrical Facilities are being operated outside acceptable operating parameters in a manner which violates the provisions of GC 2 or which is likely to cause any of the following:

i. A safety risk to personnel;

ii. Jeopardize the stability or security of the System or other Generating Units;

iii. Any behaviour causing sustained operation outside the System operating frequency and voltages as stated in GC 2.1.13.

Notwithstanding the forgoing in the event of any material breach of the provisions of Section GC 2 which prevents the System Operator from meeting its License obligations, the System Operator may disconnect the Generator after using its best efforts to give notice to the Generator.

GC 3 METERING

GC 3.1 Purpose

This section of the **Generation Code** sets out the way in which power and energy flows shall be measured at the **Point of Delivery** on the **System Operator** side of the **Interconnection Boundary**

This section of the **Generation Code**:

- Establishes the requirements for metering the **Active and Reactive Energy** entering and leaving the **Transmission System**;
- Sets out appropriate procedures for meter reading; and
- Ensures that procedures are in place to manage disputed readings.

Adequate Metering Systems consistent with the technical specifications of the Generation Code shall be installed by the **Transmission Licensee**. The **Metering System** shall comprise a **Main** and **Backup Metering System** and shall be designed and installed by the **Transmission Licensee** at the cost of the **Single Buyer**. The **Transmission Licensee** shall maintain the **Main Metering System** and the **Backup Metering System** in a manner reasonably acceptable to the **Single Buyer**.

The **Generator** may install at his own expense a backup electric metering device (**Generator Back-Up Meter**) in addition to the **Single Buyer's** meters, which installation and maintenance shall be performed in a manner reasonably acceptable to the **System Operator**. **Generator Back-Up Metering System** shall be totally separate from the **System Operator's** meters

GC 3.2 Scope

This section applies to:

a. The **System Operator.**

b. **Generators**.

GC 3.3 Metering Requirements

GC 3.3.1 Overall Accuracy

Both **Main** and **Backup Metering Systems** will have an accuracy class of 0.2 and shall measure the electrical energy delivered to **Transmission System,** measured at the **Point of Delivery,** by the **Generator** as well as energy imported by the **Generator** from the **Transmission System**.

The overall accuracy of Generator metering is to be designed to give a tolerance of ±0.5% on an ongoing basis.

GC 3.3.2 Relevant Metering Policies, Standards and Specifications

Both **Main** and **Backup Metering Systems** shall be installed at the **Point of Delivery** on the **System Operator** side of the Interconnection Boundary to accumulate the outputs and/or inputs at the **High Voltage**.

Each meter shall have its own **Current Transformer** (CT) or separate CT's core and **Voltage Transformer** (VT) or separate VT's core and necessary independent systems to function effectively.

Instrument transformers shall have an accuracy class of 0.2 and shall conform to the standard IEC 61869.

The **Transmission Licensee** in collaboration with the **Single Buyer** shall inspect both **Main** and **Backup Metering Systems** upon installation and at least once every year thereafter, and shall also check the certification of these meters through an

accuracy test at least once every 4 (four) years thereafter or at any time the readings of these meters and the **Generator Back-up Meter** (if applicable) differ by an amount greater than 0.5%.

The **Generator** shall inspect the **Generator Back-up Meter** (if applicable) both upon installation and at least once every year thereafter, and shall also check the certification of these meters through an accuracy test at least once every 4 (four) years thereafter or at any time the readings of this meter and both the **Main** and **Backup Metering Systems** differ by an amount greater than 0.5%.

The **Generator Back-Up Meter** (if applicable) shall be installed on the **System Operator** side of the **Interconnection Boundary** and shall be connected to a dedicated CT Core and VT Core with necessary independent systems to function effectively.

The **Generator** may also install meters at the **Generator** terminals (LV side of the step-up transformer) to meter the energy generated from the power plant for recording purposes.

GC 3.4 Parameters for Meter Reading

The **Main and Backup Metering Systems** shall make a continuous recording on appropriate magnetic media or equivalent of the import and export of **Net Energy Output** of the **Generating Unit(s)**.

The parameters to be metered shall be subject to the **IA** (or **ESPA or PPA**), and shall consist of but are not limited to any or all of the following parameters:

a. Active Energy (Wh) OUT;

b. Active Energy (Wh) IN;

c. Reactive Energy (VARh) First Quadrant;

d. Reactive Energy (VARh) Fourth Quadrant;

e. Active Power Demand (W) OUT;

f. Active Power Demand (W) IN;

g. Reactive Power Demand (VAR) First Quadrant; and

h. Reactive Power Demand (VAR) Fourth Quadrant.

All units shall be expressed at appropriate multiples determined by the maximum expected demand.

GC 3.5 Frequency of Reading

The Demand Interval shall be fifteen (15) minutes, unless otherwise mentioned in the CA, ESPA or PPA, and shall be set to start at the beginning of the hour. Demand shall be calculated by averaging the respective parameters over the stated Demand Interval.

The **Main and Backup Metering Systems** and the **Generator Back-up Meter** (if applicable) will be configured to measure output at 5 (five) minute intervals.

All **Metering Systems** internal clocks shall be synchronized with the GPS clock at least once every month or at any time the readings of the clock of each meter differ by an amount greater than 1 (one) minute with the GPS time.

GC 3.6 Metering Responsibility

The **Transmission Licensee** and the **Single Buyer** shall ensure that all **Interconnection Boundaries** with **Generators** are metered in accordance with this Code.

It is the responsibility of **Generators** to cooperate with the **Transmission Licensee** and **Single Buyer** in the execution of their responsibilities under this Code.

The costs for installation and replacement of **Main** and **Back Up Meters** shall be borne by the **Single Buyer** and also set out in the **Generator's ESPA**.

GC 3.7 Point of Delivery

The **Point of Delivery** should be as close as possible to the **Interconnection Boundary**.

GC 3.8 CT Metering

The **Point of Delivery,** on the **System Operator** side of the **Interconnection Boundary,** shall be at the position of the **Current Transformers (CT)** used for the metering System. This should be designed to be as close as possible to the **Interconnection Boundary**.

Current Transformers should be installed as shown in Figure 11 of this Generation Grid Code

Where the **Interconnection Boundary** is declared on the outgoing side of a high voltage circuit breaker the metering transformers may be accommodated in that circuit breaker unit.

Where appropriate the **Point of Delivery** should be at the same voltage as the **Interconnection Boundary**.

Where the **Point of Delivery** is at a lower voltage than the **Interconnection Boundary** then appropriate loss factors should be calculated to ensure any additional loss is appropriately accounted for.

GC 3.9 Meter Reading and Collection Systems

It is the responsibility of the **Single Buyer** to ensure that meters are read in accordance with the requirements of the **Single Buyer License**. Meter reading and recording shall be undertaken by a suitable authorized representative of the **Single Buyer**.

It is the responsibility of **Generators** to cooperate with the System Operator in the execution of its responsibilities under this Code.

GC 3.10 Approval of Meters

Only meters that have received pattern approval from the Mauritius Bureau of Standards (MSB) in accordance with "Electricity Meter Testing in Mauritius - Protocol on Administrative and Testing Procedures", may be used on the **System Operator's Transmission System**, unless indicated otherwise by the Authority.

GC 3.11 Calibration and Sealing

GC 3.11.1 Calibration

All meters should be calibrated at the factory to ensure they comply with published accuracy specifications.

The **Meter Laboratory** will only perform calibration of electro-mechanical meters and accuracy test for electronic meters. Calibration of electronic meters (if required) will be done only at the factory.

Electronic meters should be certified by the manufacturer for a guaranteed calibration period over the operational life of the meter. However, in case that a

meter experiences an accuracy drift over time due to environmental or other unknown factors, it shall be sent back to the factory for re-calibration and certification.

In case a meter has exceeded the guaranteed calibration period given by the manufacturer, it should be sent for accuracy test as soon as practical. In case the accuracy test is not within standard limits, the meter shall be sent for calibration.

All laboratory calibration shall be undertaken in laboratories accredited by the Mauritius Accreditation Service (MAURITAS), unless indicated otherwise by the Authority.

GC 3.11.2 Traceability

The kilowatt hour standard used to calibrate electricity meters shall be traceable to a recognized national or international standard.

GC 3.11.3 Sealing

All meters shall be constructed to enable the meter unit to be sealed to prevent unauthorized access or interference with the operation of the meter or the input terminals of the meter.

Seals applied on a meter after calibration shall be marked with the date of recalibration and serial number.

GC 3.11.4 Testing Facilities

The **Main and Back Up Metering Systems** and the **Generator Back up Metering System** shall have test facilities for testing on site.

GC 3.12 Metering Disputes

GC 3.12.1 Meter Inaccuracy

If the **Metering System** is found to be inaccurate more than the allowable error, as indicated in GC 3.3.1 and the **Single Buyer** and the **Generator** fail to agree upon an estimate for the correct reading within a reasonable time (as specified in the relevant **ESPA or PPA**) of the **Dispute** being raised, then the matter may be referred for arbitration by either party in accordance with the relevant **ESPA or PPA**.

GC 3.12.2 Meter Accuracy Check

The **Generator** has a right to request a meter accuracy check when they consider that the meter may be reading incorrectly, in accordance with the meter testing protocol.

Should a **Generator** request more than one accuracy check in a single calendar year and the accuracy is within the allowable error then the **Single Buyer** may charge for the additional checks.

GC 3.13 Inspection and Testing

GC 3.13.1 Maintenance Policy

The **Transmission Licensee** and the **Single Buyer** shall put in place and implement policy for the inspection and testing of all metering equipment. This policy shall be in accordance with the procedures set out in sub-section GC 3.3.2.

GC 3.13.2 Maintenance Records

The **Transmission Licensee** shall keep all test results, maintenance program records and sealing records.

GC 4 MERIT ORDER SYSTEM

The **System Operator,** with the support of the Single Buyer, shall establish, with the approval of the **Authority**, a **Merit Order,** to be used by the **System Operator,** based on the real or contracted **Variable Operating Cost** component of each **Generating Unit** or **Generating Station**, whichever is applicable.

The Variable Cost of each **Generating Unit** or **Generating Station** is the sum of the Variable Operating & Maintenance Cost (VOM) and the Fuel Cost. In mathematical form:

> Merit Order Cost (MUR/MWh) = Fuel Cost[1] (MUR/MBTU) x Optimal Load Heat Rate (MBTU/MWh) + VOM (MUR/MWh)

This information allows the **System Operator** to rank the **Generating Units** or **Generating Station** in the order of their Full Load Point cost of operation, however; other technical considerations shall be taken by the **System Operator** when deciding the final dispatch, as described in the **System Operations Code**.

Refer to section SOC 4.5 of the **System Operations Code** for details of the **Merit Order System**.

GC 5 SCADA INTERFACING

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

GC 5.1 General Requirements

A **SCADA** system shall be installed onsite to enable the remote control and data acquisition of the **Generating Station Equipment**.

The **Generator** shall implement the **SCADA** system for data acquisition, visualization, alarms and logs. Data shall be stored on site in a 3-month or higher buffer database. The **Generating Station** shall be equipped with local **SCADA** system and interfaced to the **System Operator** via the **RTU** in order to provide the **System Operator** with the remote control and signals specified in GC 13.2

The **SCADA** hardware shall at least include:

a) **SCADA Servers**: runs the **SCADA** software and a buffer database
b) Switch: enables data exchange between every connected **Equipment**
c) Ethernet-Optic Fibre Converters: enables communication with the **Transmission System Substation**)
d) HMI: performs configuration, monitoring, control and operation of the system.

The **System Operator** may require additional **SCADA** hardware if duly justified in a case by case basis.

In all cases signals shall be arranged such that the level of electrical interference does not exceed those defined in IEC 60870-2-1: "Telecontrol Equipment and Systems - Operating Conditions - Power Supply and Electromagnetic Compatibility" and IEC 60870-3: "Telecontrol Equipment and Systems - Specification for Interfaces (Electrical Characteristics)".

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[1] The units for the energy contained in the fuel for both the fuel cost (cost per unit of energy contained in the fuel) and the heat rate (energy in the fuel needed to generate one MWh) must be consistent. That is, both must be expressed either in BTU, kcal or any other selected energy units, and also must be both referred to the same fuel calorific value methodology, that is LHV (low heating value) or HHV (high heating value)

GC 6 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 **Operations Engineer** in charge of operation and control of each **Generating Unit**.

GC 6.2 System Control Centre Record of Dispatch

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

a. all instructions regarding switching, voltage control and Generating Unit operation;
b. deviations in frequency outside the normal range;
c. each operation or sequence of operations of circuit breakers, disconnectors and earthing switches under the control of the **System Control Engineer** or a designated operator and, where appropriate, alarms and protection indications; Transformer tap changers instructed or operated by the **System Control Engineer** or a designated operator.
d. the synchronization or taking off-line of **Generating Units**;
e. details of the application and removal of all groundings and other safety precautions, including the issue and cancellation of safety procedures and permits to work, by the **System Control Engineer** or his designate as required by the **Transmission Licensee's** safety rules;
f. 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;
g. the failure, or change of state, of **Plant** or **Apparatus** on the **System** together with relevant details;
h. the failure of plant or apparatus affecting the availability of **Generating Unit**(s), together with relevant details;
i. the location and identification of switchgear for which a risk of trip is expected;
j. **Generating Units** which are not operating in the frequency sensitive mode;
k. any significant abnormal or dangerous occurrence in operation including incidents involving the use of emergency public service;
l. any interruption and restoration of supply together with relevant details;
m. details of the **System Operator's System** load reductions, restorations and **Demand** control;

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:

a. **Dispatching Instructions** and times of receipt of such instructions from the **System Control Engineer** or a designated operator;

b. Time of implementation of instructions;

c. Any request from the **Generator** to the **System Control Engineer** which includes:

i. Scheduled outages;

ii. Forced outages;

iii. Load adjustments;

iv. Maintenance Outages;

v. Emergencies of any kind affecting the operation of the Generating Station and Daily available Capacity.

vi. Names and status of all personnel on each shift;

vii. Daily midnight readings of the fuel used and in stock, were applicable;

d. Statements relating to abnormal running conditions of **Generating Unit**(s) and **Auxiliaries**;

e. All **Active** and **Reactive Power** at half hour intervals or lower, frequency and voltage, at the 66 kV bus bar and 132 kV bus bar at half hour intervals or lower, unit **Auxiliaries** and station bus bar voltage and **Active** and **Reactive Power**.

f. **Generating Stations** operating on an energy-only basis 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**.

g. Time of trip-out or removal of **Generating Units** from service and the time of return to service; and

h. Visits by factory inspectors to the **Generating Station**.

GC 7 FUEL SUPPLY AGREEMENT

The **Fuel Supply Agreement** shall at a minimum:

a) demonstrate a dependable and sufficient fuel supply;
b) detail the infrastructure installed for delivery of the fuel from the central storage point to the plant gate;
c) provide details of any applicable fuel transportation agreement; and
d) detail alternative fuel supply arrangements (if applicable) 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 that will depend on the technology and typical dispatch thereof according to the following:
    i. Coal: 60 days on site and 30 days on port
    ii. Fuel-Oil: 30 days
    iii. Jet Fuel (for Gas Turbines): 15 days for peaking purpose
    [values to be confirmed by a study considering costs and risks]
b) 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 **Authority** to trigger an emergency plan.

c) provide the **System Operator** not later than December 31st of each year a **Fuel Supply Plan** covering at least two full calendar years, based on the expected dispatch program for years Y1 through Y3 (see SOC 4.3.3.1 Generation Outage Planning Timescale); as duly approved by the **Authority**, in consultation with the **System Operator**. The **System Operator** and the **Authority** may consult the **Single Buyer** as deemed necessary and inform **Single Buyer** of approved plan.

d) only enter into fuel supply arrangements consistent with the **Fuel Supply Plan**. The **Fuel Supply Plan** shall be revised by the Generator when expected significant variations in the load forecast could occur as informed by the **System Operator**.

GC 8 GENERATOR SCHEDULING AND DISPATCH

The procedures for scheduling and dispatch of **Generators** as well as requirements for information exchange are described in the **System Operations Code** sections SOC 4 and SOC 5.

Generators shall comply with all the applicable requirements established in the **System Operations Code**.

GC 9 NEW TECHNOLOGIES

New **Generation** technologies that have features not covered in this **Generation Code** shall be given consideration for inclusion to the **System**. The **Authority**, in full consultation with the **Licensees**, shall first provide written approval of the technical compatibility of the technology with the **System**, before the new technology can be interconnected. Accordingly, and as necessary, as soon as possible thereafter, the respective parts of the **National Grid Code** shall be updated as per Section 9 of the **Governance Code**.

GC 10 GENERATOR MAINTENANCE PLANNING

The procedures for the elaboration of the **Generation Outage Planning** as well as requirements for information exchange are described in the **System Operations Code** sections SOC 4.3

Generators shall comply with all the applicable requirements established in the **System Operations Code**.

GC 11 SCHEDULES OF RESPONSIBILITY

GC 11.1 Ownership, Operation and Maintenance Schedules

Schedules specifying the ownership and the responsibilities for Operation and 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.

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 COMPLIANCE MONITORING

GC 12.1 Introduction

Section GC 12 defines procedures for testing and monitoring of **Generating Stations** for the purpose of determining the compliance with the **Generation Code**

requirements and, if relevant, the operating characteristics in accordance with the commercial and technical conditions of the **PPA** or **ESPA**.

GC 12.2 Independent Engineer

An **Independent Engineer** shall be required to certify compliance with the **Generation Code** and **Transmission Code** of new **Generating Stations** and **Generating Stations** after a major refurbishment that may affect the **Generating Station** performance and functionalities. This requirement shall also apply to the **Interconnection Facilities** of the **Generation Station**.

The process for the appointment of **Independent Engineer** shall be the following:

(a) **System Operator** and the **Single Buyer** shall jointly draw a panel of reputable consulting engineering firms or bodies corporate to be the independent consultant under this **Generation Code** within a maximum of 2 (two) months from date of signature of the **ESPA, IA or PPA**.

(c) The **System Operator** and **Single Buyer** shall then seek offers and evaluate offers from the firms or bodies corporate.

(d) The **System Operator** and **Single Buyer** shall then identify and rank the firms and/or bodies corporate. The highest ranked substantially responsive firm or body corporate shall be appointed by the **System Operator** and **Single Buyer** as the Independent Engineer.

(e) The appointment shall be made no later than the effective date and shall be valid till the **Independent Engineer** discharges all of his functions as per the **ESPA, IA or PPA** and under GC 12.

and

Notwithstanding the above, the **Generator** can also proceed with an open advised bidding exercise for the appointment of an **Independent Engineer**.

GC 12.3 General Provisions

Generators shall demonstrate compliance to all applicable requirements specified in this **Generation Code** and any other applicable codes or standards approved by the **Authority**, as applicable, before being allowed to connect to the **Transmission System** and operate commercially.

A **Generator** shall keep records relating to the compliance by each of its **Generating Units** with each section of this code applicable to that **Generating Unit**, setting out such information that the **System Operator** reasonably requires for assessing **System** performance (including actual **Generating Unit** performance during abnormal conditions).

A **Generator** shall review, and confirm to the **System Operator**, compliance by the **Generating Station** or each of that **Generator's** units with every **Generation Code** requirement.

A **Generator** shall conduct tests or studies to demonstrate that each **Generating Station** and each **Generating Unit** complies with each of the requirements of the **Generation Code**. Tests shall be carried out on new **Generating Units**, after every outage where the integrity of any **Grid Code** requirement may have been compromised, to demonstrate the compliance of the **Generating Unit** with the relevant **Grid Code** requirements. The **Generator** shall continuously monitor its compliance in all material respects with all the **Interconnection** conditions of the **Generation Code**.

Each **Generator** shall submit to the **System Operator** and **Single Buyer** a detailed test procedure, emphasizing the **System** impact, for each relevant part of the **Generation Code** prior to every test. All request for any test made to the **System Operator** shall also be communicated to the **Authority**.

If a **Generator** determines, from tests or otherwise, that one of its **Generating Units** or **Generating Stations** is not complying in any material respect with one or more sections of this **Generation Code**, then the **Generator** shall

a. promptly notify the **System Operator** and **Single Buyer** of that fact
b. promptly advise the **System Operator** and **Single Buyer** of the remedial steps it proposes to take to ensure that the relevant Generating Unit or **Generating Station** (as applicable) can comply with the **Generation Code** and the proposed timetable for implementing those steps
c. diligently take such remedial action as will ensure that the relevant **Generating Unit** or **Generating Station** (as applicable) can comply with the **Generation Code**; the **Generator** shall regularly report in writing to the **System Operator** and **Single Buyer** on its progress in implementing the remedial action, and
d. after taking remedial action as described above, demonstrate to the reasonable satisfaction of the **System Operator** that the relevant **Generating Unit** or **Generating Station** (as applicable) is then complying with the **Generation Code**.

The **System Operator** may issue an instruction requiring a **Generator** to carry out a test to demonstrate that the relevant **Generating Station** complies with the **Generation Code** requirements. A **Generator** shall not refuse such an instruction, provided it is issued timeously and there are reasonable grounds for suspecting non-compliance.

Generating Units of **Co-Generators** shall comply with the requirements of GC 12.

GC 12.4 Test Conditions

During all testing, all **Plant** and **Apparatus** of the **Generating Station** shall be operated within their operational/design limits and in a manner consistent with **Good Utility Practice** for continuous long-term operation, and the operational temperatures and pressures shall not exceed manufacturers' recommendations for continuous long-term operation.

During all tests, all **Generating Station Electrical Facilities** must be ready for normal and continuous operation. The use of temporary equipment shall not be allowed except with the **System Operator**'s prior approval. Each **Generating Unit** of the **Generating Station** shall be run in a normal manner with no equipment shutdown to reduce auxiliary load. Where redundant capacity is provided, only **Equipment** required for normal operation must be in operation.

Subject to the test periods allocated in GC 12 and except as otherwise specified, testing of the **Generating Station** may be carried out on **Active Power** output and **System** frequency control modes as required by the **System Operator**.

The tests for all types of **Generating Units** shall fall into the following categories:

(a) Pre-Commissioning Tests (to be carried out and successfully completed prior to the first synchronisation of any **Generating Unit** with the **System**);

(b) Demonstration Tests (required to demonstrate inter alia compliance with the requirements of the **Generation Code** and other relevant parts of the **National Grid Code**);

(c) Reliability Tests: Additionally, **Synchronous Generating Stations** shall perform Performance Tests, required to establish the Net **Dependable**

Capacity of each **Generating Unit**

During the Demonstration Tests, the Reliability Test and Performance Tests, the **Generating Station** (or **Generating Unit**, as the case may be) shall be operated from the **Generating Station** control room with all systems operated normally in automatic mode.

Testing will be coordinated between the **System Operator** and the **Generator**. The **System Operator** will use reasonable endeavours to accommodate the **Generator's** requests and to agree with **Generator** the times at which verification and testing may be carried out but shall have the ultimate authority to determine such times.

GC 12.5 Test Reports

The **Generator** shall provide a certified true copy of the test results to the **System Operator, Single Buyer** and the **Independent Engineer**, upon successful completion of the tests. The **Independent Engineer** shall prepare and submit a written report of the results of each of the relevant tests referred to in this Section GC 12. These reports shall include, as a minimum, the following information:

(a) date and time of the test start and finish;

(b) date of the report;

(c) summary of instrument calibration data, including signed and approved instrument calibration forms, and laboratory fuel analysis, if applicable;

(d) names of people recording data;

(e) where applicable, a description of the conditions under which the tests were performed, including meteorological information, and a listing of emissions throughout the test period;

(f) summary of all test data and results, including for each **Generating Unit** the daily maximum and average electrical output;

(g) listing of **Dispatch Instructions**, **Transmission System** events, **Generating Station** problem events; and

(h) conclusions from the test results.

Other test requirements may be imposed by the **Transmission Licensee** or the **Authority** and the **System Operator** shall reasonably cooperate in the issue of **Dispatch Instructions** to suit these requirements also when such tests are carried out outside the time periods being used to conduct the tests required by the **System Operator**. **Single Buyer** will also be informed of these tests.

The **Single Buyer** shall be forwarded a copy of the **Independent Engineer** report and be informed of any additional tests imposed by the **Transmission Licensee** and the **Authority**

GC 12.6 Pre-Commissioning Tests

Pre-Commissioning Tests comprise functional tests done under no load conditions to prevent the creation of disturbances in the **System** during this relatively unreliable phase. The **Pre-Commissioning Tests** shall be performed individually for each **Generating Unit**.

The **Independent Engineer** shall issue to the **System Operator, the Singe Buyer** and the **Generator** documentation and test reports that demonstrates the following tests have been satisfactorily performed prior to initial synchronisation with the **Grid** of any **Generating Unit** comprised in the **Generating Station**:

a) Verification of the settings of all the **Protection** relays/systems;

b) Checking/proving of all safety **Equipment**;
c) Functional testing and timing of **High Voltage** switchgear in the **Substation**;
d) Voltage phasing checks between the **Generating Unit** and the **Substation** to which it is connected, and the **Grid**;
e) Proving of all inter-tripping circuits between the **Generating Unit** or **Generating Station Substation** and the **Transmission System Equipment**.
f) Earthing test at the **Generating Station** and **Generating Station Substation**;
g) Primary and/or secondary injection tests and functional tests to prove the calibration and function of all electrical **Protection** schemes installed for the **Generating Station, Generation Station Substation** and its **Generating Unit**(s).
h) Test to confirm that the frequency relays are configured adequately and per frequency criteria in GC 2.1.13.1 of this **Generation Code**.
i) There is no need to record signals in the tests a) to h) above. However, the **Generating Station SCADA** and control **Equipment** should be online and operational to enable the **System Operator** to confirm the position (Open/Close) of **Circuit Breakers** and switches, if required, during the test at the **System Control Centre**.
j) **Synchronous Generating Station**:
    a. Automatic Voltage Regulator (AVR) setting and adjusting in both stand-still condition and with the generator running at full speed no load condition;
    b. Turbine governor control checks, including a 10% (or the percentage as specified by the manufacturer) over-speed test;

Pre-commissioning Tests shall be conducted at the **Generating Station** pursuant to a request made by the **Generator** to the **System Operator** no later than 30 days prior to the date that **Generator** intends to achieve the initial synchronisation with the **Grid** of each **Generating Unit** comprised in the **Generating Station**. Subsequent requests for initial verification, if needed, shall require 5 business days' advance notice.

The **Generator** shall maintain an **Operations Log** throughout testing performed pursuant to Section GC 12 in accordance with the provisions of GC 6.3.

Upon completion of each test the **Generator** shall within forty-eight (48) hours provide the **System Operator** and **Single Buyer** with two (2) copies each 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) calendar days prior to the commencement.

GC 12.7 Demonstration Tests

After performing the Pre-Commissioning Tests as defined in GC 12.6 and prior to the commissioning date, and under such subsequent conditions as defined by **PPAs, IAs or ESPs**, **Generator** shall carry out the Demonstration Tests described in this section at the **Generator's** expense:

GC 12.7.1 Scope

The Demonstration Tests shall test the ability of a **Generating Unit** to achieve the operating characteristics and the minimum technical requirements set forth in GC

2. A **Generating Unit** or the **Generating Station,** as the case may be, shall be considered to have failed a Demonstration Test, and the **Generating Unit** or the **Generating Station,** as the case may be, shall therefore not be entitled to reach commercial operation if the minimum acceptable limit value is demonstrated by a Demonstration Test not to have been satisfied.

The Demonstration Tests shall consist of the tests in GC 12.7.2 for **Synchronous Generating Stations** and in GC 12.7.3 for **Power Park Stations** in order to demonstrate compliance with the required functional capabilities specified in GC 2.

Each of the tests described in this section shall be carried out prior to the **Commercial Operation Date.**

GC 12.7.2 Synchronous Generating Stations

Each of the tests described in this section shall be carried out on whatever Fuel the **Generating Unit** or **Generating Station** is being operated on at that time subject to the relevant provisions of the **IA, PPA** or **ESPA**:

a. Automatic Voltage Regulator (**AVR**)
The **Generator** shall demonstrate the **AVR** set point is adjustable over the agreed range or otherwise over a range of 95% to 105% of rated voltage with a droop characteristic of 0% to 6%.

b. Governor Operation
The **Generator** shall verify the compliance of the **Governor Control System** of each **Generating Unit** to GC 2.2.3 and verify that each **Generating Unit** is fully responsive to frequency deviations from 50 Hz.

The **Synchronous Generating Station** shall demonstrate its capability to participate in the **Automatic Generation Control**.

c. Reactive Power Capability
The **Generator** shall test each **Generating Unit**'s capability to operate at rated voltage and frequency under the following conditions:

i) Operating at **Full Load Point** and maximum leading **Reactive Power** in accordance with the **Generating Unit P-Q Capability Diagram**;
ii) Operating at **Full Load Point** and maximum lagging **Reactive Power** in accordance with the **Generating Unit P-Q Capability Diagram**;
iii) Operating at **Minimum Load** and maximum leading **Reactive Power** in accordance with the **Generating Unit P-Q Capability Diagram**;
iv) Operating at **Minimum Load** and maximum lagging **Reactive Power** in accordance with the **Generating Unit P-Q Capability Diagram**.

d. Full Load Rejection Test
The **Full Load Rejection** test shall be undertaken by the **Generator** to demonstrate the ability of each **Generating Unit** and the **Auxiliaries** comprised in the **Generating Station** to withstand the instantaneous disconnection from the grid in a controlled manner when operating at the **Full Load Point** (or a lower load level if deemed appropriate by the **System Operator**).
The purpose of this test is to demonstrate compliance with GC 2.1.8.
After the **Full Load Rejection** test, each **Generating Unit** comprised in the **Generating Station** must
i. successfully resynchronise to the **System** within 30 minutes; or
ii. not trip and must otherwise remain operating in a safe condition throughout the test and remain in island operation and supplying its own **Auxiliary** load consumptions for a maximum of 30 minutes.
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.

e. Minimum stable load test
Each **Generating Unit** comprised in the **Generating Station** shall be demonstrated to be able to operate continuously at the **Minimum Load** on the applicable fuel over a period of 2 hours.

f. Start-Up Sequence Time
These tests shall determine the time required to bring each **Generating Unit** comprised in the **Generating Station** from a shut-down condition to **Minimum Load**.

g. Minimum Run Time
This test shall determine the **Minimum Run Time** for each **Generating Unit**.

h. Minimum Load Acceptance Rate
The test shall determine the **Minimum Load Acceptance Rate** for each **Generating Unit** comprised in the **Generating Station**.

i. Response 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 and decrease load by steps.

The ability of the **Generating Unit** being tested to accept a step load increase of 10% of the **Generating Unit** Net **Dependable Capacity** at any load above **Minimum Load** of the Relevant Unit Net Dependable Capacity. It must also be demonstrated its ability to accept a step load reduction of 10% of the Relevant Unit Net Dependable Capacity from any load in the range 100% to (Minimum Load + 10%) of the Relevant Unit Net Dependable Capacity.
During these tests the **Generating Unit** must not Trip and must safely and stably absorb the transient event occurring in a reasonable time.

j. **Cold** and **Warm Starts** of thermal units
The **Generator** shall conduct tests to demonstrate that each **Generating Unit** has completed 2 consecutive successful **Cold Starts** and **Warm Starts** in accordance with **Good Utility Practice**.

k. Minimum time for synchronization
Tests shall be conducted in respect of each **Generating Unit** to determine the minimum time required for each **Generating Unit** to synchronise to the **Grid**.

l. Frequency Allowance
This test shall be conducted in respect of each **Generating Unit** to demonstrate the ability of each **Generating Unit** to compensate for frequency deviations around the **System** nominal frequency larger than the **Dead Band** of the **Governor Control System** specified in GC 2.1.12.

m. Maximum Ramp Rate
This test shall determine the maximum load changes in respect of **Dispatch Instructions** of each **Generating Unit.**

n. Fuel Changeover Modes
Where applicable, this test shall demonstrate the ability of each **Generating Unit** to successfully change the fuel and continuously operate in a safe and reliable manner.

Manufacturer's data and design calculations shall be submitted by the **Generator** to the **System Operator** to verify the value of the constant of inertia of the complete mechanical shaft of each **Generating Unit** of the **Generating Station**.

The net electrical energy and **Active Power** delivered to the **System** at the **Point of Delivery** shall be continuously recorded in all the above-mentioned tests with a time stamp of sufficient resolution for remuneration, if applicable, and technical analysis purposes. Measurements for remuneration shall be carried out in accordance with

GC 3.

GC 12.7.3 Power Park Generating Stations

Power Park Generating Stations connected to the **Transmission** shall at least perform the following tests:

a. Reactive Power and Voltage Control Functions

The Generator shall demonstrate compliance with GC 2.3.4 for the set points specified by the **System Operator** at extreme points within the **P-Q Capability Diagram**. The operating points shall be chosen so as to demonstrate the satisfactory operation of the **Generating Station** step-up transformer tap changer and the **Reactive Power** compensation equipment, where applicable.

b. Active power control function and operational range

The **Generator** shall verify the compliance of the **Power Park Station** with the frequency response and active power constraint requirements in GC 2.3.

1. **Power Park Stations** will be required to regulate the **Active Power** to a set of specific set points within the design margins.
2. **Power Park Stations** will be required to obtain a set of **Active Power** set points within the design margins with minimum two different gradients for ramping up and two different gradients for ramping down.
3. **Power Park Stations** with **Energy Storage Units** will be required to:
   a. maintain as a minimum two different set levels of spinning reserve within the design margins.
   b. verify operation according to as a minimum two different parameter sets for a frequency response curve within the design margins.
4. **Power Park Stations** will be required to operate as a minimum to limit active power output according to two different absolute power constraint set levels within the design margins.
5. **Power Park Stations** will be required to demonstrate their capability to participate in the **Automatic Generation Control**.

In **Power Park Stations** the abovementioned tests shall be performed for **Active Power** levels of at least 20% of the **Registered Capacity**.

c. Maximum Reactive Power Capability Test

The purpose of this test is to confirm the ability of the **Power Park Station** to operate to the limits of the **P-Q Capability Curve** for defined in GC 2.3.5. The test shall be completed for both the injection and absorption of **Reactive Power** from the **System**.

Measurements shall be undertaken at different levels of **Active Power** output to confirm that the range is within the capability characteristic at the given level of **Active Power**.

In **Variable Renewable Generating Stations**, this test will be carried out at a time when the actual **Active Power** output of the **Power Park Station** is greater than 80% of its **Registered Capacity** and 95% of the **Generating Units** comprised in the **Power Park Station** are in service.

GC 12.7.4 Power Quality Measurements

Generating Stations of all types shall perform the power quality measurements defined in this section.

GC 12.7.4.1 Voltage Flicker Measurements

The purpose of this test is to confirm the ability of the **Generating Station** to operate within the limits in GC 2.1.16. 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 all the **Generating Units** of the **Power Park Station** are in service and injecting **Active Power**. In carrying out the measurements the appropriate standard such as IEEE 1453 or equivalent should be applied.

GC 12.7.4.2 Harmonic Distortion Measurements

The purpose of this test is to confirm the ability of the **Generating Station** to operate within the **Harmonic Distortion** limits specified in GC 2.1.16 for **Normal Conditions**. This test shall take place for a period of 24 hours after all **Generating Units** have been individually commissioned and it may be run at the same period of the voltage flicker measurements.

In **Variable Renewable Generating Stations**, during the period of measurement, there shall be some period of time, if not all the time, during which all the **Generating Units** are in service and injecting **Active Power**.

GC 12.8 Reliability Test

The **Generator** shall test the reliability of its **Generating Units** in accordance with industry standards based on the type of plant and **Prudent Utility Practice** and shall be conducted prior to the **Generating Unit** reaching **Commercial Operation Date**.

The procedure to perform and acceptance criteria of the Reliability Tests shall be agreed between the Generator and the System Operator. The **Generator** shall prepare a report on each phase of the Reliability Test comprising observations and recordings of the various test parameters measured. This report shall record all details of interruptions that occurred, adjustments made and any minor repairs carried out during the test, and shall be submitted to the **System Operator**.

The Reliability Test will be completed if the following is satisfied:

(a) the transmission of all signals as required by the **National Grid Code** is established;

(b) the **Generating Station** operates in accordance with the **Active** and **Reactive Power** set point values:

(c) the **Generating Station** as a whole operates continuously under the following conditions:

1. In Reliability Tests of **Synchronous Generating Stations** each **Generating Unit** comprised in the **Generating Station** shall operate at its Full **Load Point**.
2. In Reliability Tests of **Power Park Stations**:
    i) **Variable Renewable Generating Stations** shall continuously operate with all its **Generating Units** in service and delivering their **Available Active Power**.
    ii) **Generating Stations** with **Energy Storage Units** shall continuously operate the **Energy Storage Units** according to the **Dispatch Instructions** specified by the **System Operator**.

The duration of the Reliability Test for each **Generating Unit** in **Synchronous Generating Stations** and for the whole **Generating Station** in **Power Park Stations** shall be as agreed or otherwise 30 Days and in the latter case shall comprise 4 discrete phases each of 7, 7, 8 and 8 Days.

If an interruption occurs which is caused by the **Generating Station** operating as a whole (and which not does not auto re-start), then the Reliability Test will be deemed to have failed and the **Generator** must restart the **Reliability Test** after making good such defect. If an interruption occurs which is not caused by the **Generating Station** operating as a whole, the **Reliability Test** will continue without being paused. In the event that the Reliability Test is interrupted due to a **Transmission** or **Distribution System** constraints or an instruction to curtail by the System Operator, then the Reliability Test will be paused, and once the System conditions have been rectified, the **Reliability Test** will continue.

GC 12.9 Testing of Metering System

These testing procedures are outlined in section GC 3.13 of this **Generation Code**.

GC 12.10 Additional tests for Synchronous Generating Stations

GC 12.10.1 Performance Test of Synchronous Generating Stations

The **Generator** shall test the **Dependable Capacity** of each **Generating Unit** for all fuels on which the **Generating Unit** is prepared to operate.

Prior to carrying out any Performance Test, the **Generator** shall check and adjust for continuous operation of all **Plant** and **Apparatus** of the **Generating Unit** being tested. Before starting the official programme test, the **Generator** may perform the **Pre-Commissioning Tests** in GC 12.6 to confirm all **Generating Station** functions are in correct working order.

Prior to the carrying out of any **Performance Tests**, tests shall be carried out to demonstrate the **Rated Capacity** and **Net Electrical Output** of each Generating Unit. These tests shall be to ASME or an equivalent internationally acceptable standard and the net achieved kW output level shall be corrected to the reference conditions as listed under the design conditions set out below.

The **Generator** shall conduct the Performance Tests for each **Generating Unit** with respect to (i) **Rated Capacity**, fuel consumption, **Net Electrical Output**, air emissions and noise with respect to Environmental Standards.

Data for each test shall consist of instrument readings taken at 15-minute intervals over a one-hour time span after steady state-conditions have been established. Two tests each of one hour shall be conducted and the final tested **Rated Capacity** and **Net Electrical Output** level of each **Generating Unit** shall be the average of the test results for each one-hour period.

Before starting the test, the **Generating Unit**, shall be run until steady state conditions have been established. Steady state is achieved when key variables associated with the test objectives have been stabilised. Stability is achieved when all the following readings have been kept within the maximum permissible variation for a 15-minute period before the test start and throughout the one-hour test period:

(a) **Active Power** output at the **Point of Delivery:** +/– 2%

(b) Barometric Pressure: +/– 5 mbar

(c) Ambient Air Temperature: +/– 2.5°C

(d) **System** frequency: +/– 0.1Hz

(e) **Power Factor:** +/– 2%

(f) **Grid** voltage: +/– 1%

The instruments required to ensure the proper determination of the electrical outputs shall have been calibrated at a reputable establishment to be agreed with

System Operator.

GC 12.11 Parameters Monitoring

To produce and maintain the **Model** of the **System**, **Generators** shall periodically submit the **Generating Station** operating parameters to determine if there is any decay which should be modelled.

Generators shall carry out routine and prototype response tests on voltage and power-frequency controls for new **Generating Stations** synchronized to the **System** or **Generating Stations** at which major refurbishment or upgrades have taken place. Routine review is required of all **Generating Stations** at least once every five (5) years.

GC 13 MONITORING AND CONTROL

This section outlines the means and methods by which the **System Operator** shall monitor and control individual **Generating Stations** and the **System** as a whole. It sets out the responsibilities of the **Parties**, and the communication system requirements through which the necessary information and dataset shall be provided.

GC 13.1 Remote Monitoring

a. The Generator shall:

   i. install remote monitoring equipment (**RME**), on both sides of the **Interconnection Boundary**, adequate to enable the **System Operator** to remotely monitor performance of a **Generating Unit** (including its dynamic performance) where this is reasonably necessary in real time or with small delay for control, planning or security of the **System**; and

   ii. upgrade, modify or replace any **RME** already installed in a **Generating Station** and the **Transmission Licensee Substation** to which it is connected provided that the existing **RMEs** are, in the reasonable opinion of the **System Operator**, no longer fit for the intended purpose.

b. At least the following information shall be made available to the **RME** at the **Transmission Licensee Substation** to which it is connected via the fibre-optic link:

   i. Status Indications
      a. **Generating Unit** circuit breaker open/closed;
      b. Remote **Generating Unit** control on/off;
      c. Remote **Generating Unit** control high limit reached;
      d. Remote **Generating Unit** control low limit reached; and
      e. **Generating Unit** frequency and voltage control modes of operation;
      f. **Protection** relay auxiliary supply fault; and
      g. **Generating Unit** step up transformer status:
         1. Oil temperature alarm
         2. Buchholz trip;
         3. Winding temperature alarm
         4. Standby earth fault
         5. Buchholz alarm
         6. Tap changer high
         7. Oil temperature trip;
         8. Tap changer low
         9. Winding temperature trip
         10. Tap changer faulty

      The above signals can be combined in series as a single signal to the **SCADA** of the **System Control Centre**

   ii. Alarms

a. **Generating Unit Circuit Breaker** tripped by **Protection**;
b. Urgent alarms requiring an immediate automatic or manual action
c. Non-urgent alarms triggered for information only

iii. **Generating Unit** measured values
i. active power;
ii. reactive power;
iii. terminal voltage;
iv. remote generation control high limit value;
v. remote generation control low limit value; and
vi. remote generation control rate limit value.

iv. In the case of an **Energy Storage Unit**, additional input signals (e.g. state of charge, and system availability) may be specified by the **System Operator**.

v. Any other input information reasonably required by the **System Operator**.

GC 13.1.1 LVRT/HVRT Monitoring

LVRT and **HVRT** monitoring at the **Interconnection Boundary** shall be enforced by the **System Operator** through on-site disturbance recording. For verification of the behaviour of **Generating Stations** with **Registered Capacity** equal to or above 10 MW in the case of voltage dips or voltage swells, a disturbance recorder must be installed at the **System Operator** side of the **Interconnection Boundary** of the **Generating Station**. The aim of this monitoring/recording is to ensure that the **Generating Station Generating Units** behave in the same manner as shown in the **Generating Station** simulations and/or tests, and meet the **Generation Code** for **LVRT** and **HVRT** set forth in **GC 2**.

After a real event (voltage dip or voltage swell), the behaviour of the **Generating Station** may be checked by **System Operator** for compliance based on the measurements available from the recording unit. If a non-compliance is detected, required evidence to be supplied by the **System Operator** to the **Generator** for investigation.

GC 13.2 Remote Control

The **System Operator** may require **Generators** with **Generating Stations** with **Registered Capacity** above 10 MW to, within a reasonable time after giving notice in writing, install remote control equipment (**RCE**) that is adequate to enable the **System Operator** to remotely control:

a. the **Active Power** and **Reactive Power** output of any **Generating Unit or Power Park Module** through the **AGC**; and

b. the **Circuit Breaker** of any **Generating Unit** or its step-up transformer

Any **RCE** already installed in a **Generating Station** and the **Transmission Licensee Substation** to which it is connected shall be upgraded, modified or replaced, by notice in writing to the relevant **Generator** provided that the existing **RCEs** are, 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**:

a. activating and de-activating **RCE** installed in relation to any **Generating Unit**; and

b. setting the minimum and maximum levels to which, and a maximum rate at which, the **System Operator** will be able to adjust the operation of any generator using **RCE**.

GC 13.2.1 Power-frequency control system

The **System Operator** has the responsibility to monitor and control the **System**

frequency, and shall issue the necessary dispatch instructions to the **Generating Units**.

Each **Generating Unit** shall have a power-frequency control system which includes facilities for both **System** frequency and **Active Power** output control whether in manual or closed loop automatic generation control except where approved by the **System Operator**. The method of control must be mutually agreed and approved by the **System Operator** and **Generator**. The **Generator** shall adjust the power-frequency control system of a **Generating Unit** to ensure compliance with the **Generation Code** and stable performance under all operating conditions with adequate damping.

By default, **Synchronous Generating Stations** and **Power Park Stations** with **Energy Storage System** shall operate in frequency control mode and **Variable Renewable Generating Stations** shall deliver their **Available Active Power**, unless otherwise instructed by the **System Operator**.

GC 13.2.2 Voltage Support

The **System Operator** has the responsibility to monitor and control the **System** voltages. Therefore, **System Operator** may issue a new voltage set-point to the **Generating Units** concerning scheduled voltage support requests.

The **System Operator** shall maintain a log of all **Generators** acknowledgments of such requests and of their related fulfilment.

GC 13.2.3 Generation Dispatch and Shutdown Signals

GC 13.2.3.1 Generation dispatch signals

The **System Operator** shall have the right to send **Dispatch Instructions** to **Generating Stations**, via telephone, radio, **AGC** or **SCADA**, to reduce its output due to **System** reliability.

GC 13.2.3.2 Normal shutdown

In the event that **System Operator** requires to shut down and disconnect a **Generating Station** from the **System,** on-line **Generating Stations** must be able to commence their shutdown sequence within five (5) minutes of receipt of a **Dispatch Instruction** from the **System Operator**. The shutdown sequence shall be completed as soon as practical, but no longer than

a) thirty (30) minutes for coal and bagasse fired **Generating Stations**; and

b) twenty (20) minutes for all other types **Generating Stations**

from the receipt of a **Dispatch Instruction** from **System Operator**.

After providing prior notice to **System Operator**, a **Generating Station** may disconnect from the **System**, if reasonable and practical, in the case that the condition or manner of **Operation** of the **System** poses an immediate threat of injury or material damage to any person or **Equipment** of the **Generating Station, Generating Units** and/or **Substation**.

GC 13.2.3.3 Forced shutdown

If, in the reasonable opinion of **Generator**, there exists an Emergency at its **Generating Station**, the **Generator's Plant** and **Apparatus** which warrant shut-down of the whole or any part of the **Generating Station**, the **Generator** shall be entitled to shut down the whole or any part of its **Generating Station** for so long as such Emergency and the consequences thereof warrant; provided that particulars of such Emergency shall be notified by the **Generator** to the **System Operator** promptly without undue delay, and the **Generator** shall diligently carry out and abide by any reasonable directions that the **System Operator** may give for dealing with such Emergency.

The **Generator** shall re-synchronise its **Generating Station** or the affected part thereof as soon as practicable after the circumstances leading to its shut-down and the shut-down have ceased to exist or have so abated as to enable the **Generator** to re-synchronise its **Generating Station** and the **Generator** shall notify **System Operator** of the same without any delay.

GC 13.3 Communication Requirements

GC 13.3.1 General requirements

The **Generator** shall provide electricity supply to the **RME** and **RCE** installed in relation to its **Generating Units** and be able to keep such **Equipment** available for at least eight (8) hours following total loss of supply for the relevant **Generator**.

The **Generator** shall provide, where applicable, redundant communication paths from the **RME** or **RCE** installed at any of its **Generating Stations** to a communications interface located in the closest **Substation** of the **Transmission System** to which it is connected.

The telecommunication interface to the **Transmission System** may vary from **Substation** to **Substation** of the **System**. The **Generator** shall provide the **Equipment** to interface with the **System** telecommunication infrastructure which shall be agreed upon by the **Parties**. The selection and installation of items shall be provided by the **Generator** in accordance with the prior written approval of **System Operator.** Such approval shall not be unreasonably conditioned, withheld or delayed.

The communication link from the **Generating Station** up to the **Transmission System** telecommunication interface, including the associated equipment to interface with existing communication system at the **Substation**, shall be owned and maintained by the **Generator**. The energy consumption of the equipment installed in the **Substation** of the **Transmission System** shall be at the expense of the **Generator**.

GC 13.3.2 Communication Equipment

Each **Generator** shall install and maintain at each **Generating Station** and the **Transmission Licensee Substation** to which it is connected at its sole cost and expense:

1. Compatible communication equipment to allow interfacing of status and signals from the **Generating Station** to the centralized **SCADA** system at system control, specifically transmitting the signals listed in GC 13.1.

2. Adequate fibre optic communication between each **Generating Station** and the **Interconnection Substation** of the **Transmission System** for the purpose of telemetering, protection and telecommunications.

3. An extension of PABX System in the **Generating Units** control room to facilitate (hotline) voice communication between the **Generator** control room and **System Control Centre**, where applicable.

4. 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.

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

7. A synchronized digital GPS clock to allow time stamping of all analogue and status communications especially those logged by the sequence of events recorder.

GC 13.3.3 Electronic Messaging System

The **Generator** shall install the necessary **Equipment** to implement and use the **System Operator's** Electronic Messaging System. Messages shall be recorded for eventual use to help monitor/implement contractual conditions.

The **Generator** shall acquire its own computer, bear the cost of the communication charges and pay the software user licence fee, (if any) in relation to its use of the Electronic Messaging System.

GC 13.3.4 Radio and telephone systems

The **Generator** shall install a Communication System for **System Operations** comprising a VHF Radio system 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 shall be telephone while the secondary communication shall be radio. For all other operations, telephone shall be the primary form of communication and radio shall be the secondary form.

Communication equipment within the **Generating Station** shall be properly maintained by the **Generator** and any malfunction of such **Equipment** be reported to the **System Operator** promptly.

In the event of loss of communication (including public telephone facilities) between a **Generating Station** and the **System Control Centre**, the **Generator's** must assume full direction and control of the **Generating Station**. All actions taken and their corresponding times must be logged and reported to **System Control Centre** 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.

GC 13.3.5 Additional Monitoring and Control Requirements for Power Park Stations

The following meteorological data will be required for wind and solar PV **Power Park Stations**:

a. wind speed
b. wind direction
c. air temperature
d. air pressure
e. relative air humidity
f. solar irradiance

For **Energy Storage Units** the state of charge shall be available for the **SCADA** system

GC 13.4 Unattended Generating Stations

The minimum monitoring, control and communication requirements and exemptions from the provisions of GC 13.1, GC 13.2 and GC 13.3 for unattended **Generating Stations** shall be specified by the **System Operator** and approved by the **Authority**.

GC 14 UNFORESEEN CIRCUMSTANCES AND SYSTEM EMERGENCIES

GC 14.1 Unforeseen Circumstances

If circumstances arise which are not addressed by the **Generation 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 **Authority** with a view to determining

the course of action to be taken.

Whenever the **Authority** 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 **Authority** as a consequence of such a determination, provided that the instructions are consistent with the technical parameters set out in the **Generation Code**, the respective **Licences, ESPAs** and **PPAs**. The **Authority** shall promptly refer all unforeseen circumstances and any determinations to the **Generation Code Review Panel** for consideration.

GC 14.2 Force Majeure

The provisions of the **Generation Code** may be suspended in whole, or in part, pursuant to any directions or orders given by the **Authority** in situations of **Force Majeure**

GC 15 GENERATION INTERCONNECTION STUDIES

GC 15.1 General

Generation Interconnection studies shall be conducted by the **System Operator,** with the support of the Single Buyer, or third-party consultant pre-approved by the **System Operator** and **Single Buyer**, according to the studies outlined in the Planning Procedures of the **System Operations Code**.

The studies shall demonstrate the feasibility of connecting the **Generating Station** to the **System** without causing any adverse effect on the rest of the **System** while complying with the relevant requirements of the **National Grid Code**.

GC 15.2 Model and software

The **Generation Interconnection** studies shall be carried out using power system simulation and calculation software compatible with the ones used by the **System Operator** and **Single Buyer**

The final results and the used models, including the validated **Generating Station** user model shall be handed over to the **System Operator** and **Single Buyer**.

The **Generating Station** model shall comprise all **Electrical Facilities** necessary for the generation of electrical power from the **Generating Unit(s)** to be integrated in the **System** model.

GC 16 GENERATOR DATA REQUIREMENTS

GC 16.1 Generator Basic Data Schedule

All **Generating Stations** directly connected to the **Transmission** shall submit the information in the following table as requested by the **System Operator, Single Buyer** or **Transmission Licensee**.

Generating Station Name:

Data	Unit	Value
Rated Terminal Voltage	kV	
Rated Active Power	kW	
Rated Reactive Power	kVAR	

Capability MW/MVAR curve at rated terminal voltage	Chart	
Type of Generating Station (synchronous/asynchronous, conventional/renewable, etc.)	Text	
Type of prime mover, if applicable;	Text	
Primary energy resource or fuel or type of storage	Text	
Anticipated operating regime of generation (e.g. continuous, intermittent, peak lopping;)	Text	
Method of voltage/reactive power/power factor control	Text	

GC 16.2 Modelling requirements

Modelling requirements for **Generating Units** are processed on the identification by the **Generator** of the relevant **Model** available in the library of the simulation software and the provision of the applicable data parameters. Where there is no suitable library of **Models** available, user-written **Models** shall be supplied.

All **Generators** connected to, or applying for a connection to, the **Transmission System** shall provide suitable and accurate dynamic **Models** to the **System Operator** and **Single Buyer** in order to assess the impact of the **Generator's** proposed installation on the dynamic performance and security and stability of the **System**.

GC 16.2.1 Requirement to Provide a Dynamic Model

A **Generator** shall provide to the **System Operator** and the **Single Buyer** a validated dynamic **Model**, or shall provide an unambiguous reference to a dynamic model previously provided to the **System Operator** and the **Single Buyer**, appropriate for the **Generating Station**. If all the **Generating Units** in the **Generating Station** are not identical, the **Model** shall incorporate separate modules to represent each type of **Generating Unit**. Appropriate data and parameter values must be provided for each **Model**.

The **Models** for **Power Park Stations** must be able to calculate how quantities such as **Active Power** output, **Reactive Power** output, primary resource (e.g. wind speed, solar radiation, etc.) vary as factors such as the voltage at the **Interconnection Boundary** measured at the **Point of Delivery** change. They must take account of the inherent dynamic characteristics of the machines and the actions of their control and protection systems, including the **LVRT** and **HVRT** capabilities.

GC 16.2.2 Computer Environment

The **Generating Station Model** shall be provided in a format compatible with the software used by the **System Operator** and the **Single Buyer** to perform electrical studies and calculations. They must not require a simulation time step of less than 5 ms. Details of the software version shall be provided by the **System Operator** and/or **Single Buyer** upon request.

The **System Operator** may request that the **Models** be updated to be compatible with changes in the **Single Buyer's** and **System Operator's** computing environment. Each **Generator** shall ensure that such updated models are provided without undue delay.

GC 16.2.3 Features to be Represented in the Dynamic Model

The dynamic **Generating Station Model** must represent the features and phenomena likely to be relevant to angular, frequency and voltage stability. These features include but may not be limited to:

a. The electrical characteristics of each **Generating Unit**;
b. The mechanical characteristics of the whole mechanical shaft;

c. Variation of electrical power output with the primary resource availability in **Variable Renewable Generating Stations**;
d. **AVR**, power system stabilizer, excitation system and its limiters, prime mover and **Governor Control System** in **Synchronous Generating Stations**
e. Converter **Active** and **Reactive Power** controls and limiters in **Power Park Stations**;
f. Power plant controller
g. **Reactive Power** compensation **Equipment**;
h. **Protection** relays.
i. Saturation curves of power transformers and CTs
j. Damage curves of power transformers
k. Harmonic current injections
l. Any features required by the **System Operator** and **Single Buyer**

GC 16.2.4 **Model Aggregation**

For computational reasons, it is essential that the **Models** of individual **Generating Units** comprised in a **Power Park Station** can be aggregated into a smaller number of **Models**, each representing a number of **Generating Units** at the same site. A representation of the collector network may be included in the aggregate model of the **Generating Units**.

GC 16.2.5 **Model Documentation**

The **Generating Station Model** should be fully documented. The documentation should describe in detail the **Model** structure, inputs, outputs and how to set up and use the model in the simulation software environment.

The **System Operator** and **Single Buyer** may, when necessary to ensure the proper running of its complete **System** representation or to facilitate its understanding of the results of a dynamic simulation, request additional information concerning the **Model**, including the source code of one or more routines in the model. The **Generator** shall comply with any such request without delay. Where the **Generator** or any other party (acting reasonably) designates such information as confidential on the basis that it incorporates trade secrets, the **System Operator** and **Single Buyer** shall not disclose the information so designated to any third party.

GC 16.2.6 **Model Validation**

All **Generating Station Models** provided to the **System Operator** and **Single Buyer** for use in dynamic simulations must be validated against site measurements. The **System Operator** and the **Single Buyer** must verify that the behaviour shown by the **Model** under simulated conditions is representative of the behaviour of the real **Equipment** under equivalent conditions.

For validation purposes the **Generator** shall ensure that appropriate tests are performed and measurements are taken to assess the validity of the dynamic **Generating Station Model**.

The **Generator** shall provide to the **System Operator** and **Single Buyer** all available information showing how the predicted behaviour of the dynamic **Model** to be verified compares with the actual observed behaviour of a prototype or production **Generating Unit** under laboratory conditions and / or actual observed behaviour of the real **Generating Unit** as installed and connected to a **Transmission System**.

If the on-site measurements or other information provided indicate that the dynamic **Model** is not valid in one or more respects, the **Generator** shall provide a revised **Model** whose behaviour corresponds to the observed on-site behaviour as soon as reasonably practicable.

The conditions validated should as far as possible be similar to those of interest,

e.g. low short circuit level at **Interconnection Boundary**, large frequency and voltage excursions, primary resource variations.

GC 16.3 Generating Station Interconnection Data Schedules

Generating Stations connected to the **Transmission System** shall submit to the **System Operator** and **Single Buyer** the relevant information requested in the Transmission System Data Registration Schedules of the **Transmission Code**.

GC 16.4 Generation Data Schedules

Unless otherwise indicated, the following information shall be provided to the **System Operator** and **Single Buyer** prior to connection and then updated as and when changes occur.

GC 16.5 Generating Station Data

Parameter	Value
Generator name	
Power station name	
Number of units	
Primary fuel type/prime mover	For example, gas, hydro, fossil, nuclear, wind, solar, etc.
Secondary fuel type	For example, oil (if applicable)
Capacity requirement	Generation sent-out connection capacity required (MW)
"Restart after station blackout" capacity	Provide a document containing the following: Start-up time for the first unit (time from restart initiation to synchronise) and each of the following units assuming that restarting of units will be staggered
Black starting capacity	A document stating the number of units that can be black started at the same time, preparation time for the first unit black starting, restarting time for the first unit, and restarting time for the rest of the units
Partial load rejection capability	A description of the amount of load the unit can automatically govern back, without any restrictions, as a function of the load at the point of governing initiation

GC 16.6 Unit data

Unit number		
Capacity		
Parameter	**Unit**	**Value**
Maximum continuous generation capacity:	MW	
Unit auxiliary Active Power load	MW	
Unit auxiliary Reactive Power load	MVAR	
Minimum continuous generating capacity	MW	
Minimum continuous sent out capacity	MW	
Generator rating	MVA	
Maximum lagging power factor	-	
Maximum leading power factor	-	
Governor droop		
Forbidden loading zones	MW	
Terminal voltage adjustment range	KV	
Short-circuit ratio		
Rated stator current	Amp	
Time to **Synchronise** from warm	Hour	
Time to **Synchronise** from cold	Hour	
Minimum up-time	Hour	
Minimum down-time	Hour	
Loading rate	MW/min	
Deloading rate	MW/min	
Can the generator start on each fuel?		
Ability to change fuels on-load		
Available modes (lean burn etc.)		
Time to change modes on-load		
Control range for AGC operation	MW	
Partial load rejection capability	% MW name plate rating	
Minimum time unit operates in island mode	Hour	
Maximum time unit operates in island mode	Hour	

Additional data	Type
P-Q Capability Diagram showing full range of operating capability of the generator, including thermal and excitation limits	Diagram
Systems that are common and can cause a multiple unit trip	Description
Open-circuit magnetisation curves	Graph
Short-circuit characteristic	Graph
V curves	Diagram

GC 16.7 Documents

GC 16.7.1 Protection settings document

A document signed by the **Generator** and to be revised and approved by the **System Operator** containing the following:

a. A section defining the base values and per unit values to be used
b. A single line diagram showing all the **Protection** functions and sources of current and voltage signals
c. Protection tripping diagram(s) showing all the protection functions and associated tripping logic and tripping functions
d. A detailed description of setting calculation for each **Protection** setting relevant to the **Transmission System** connection, discussion on **Protection** function stability calculations, and detailed dial settings on the **Protection** relay in order to achieve the required setting
e. A section containing a summary of all **Protection** settings on a per unit basis
f. A section containing a summary for each of the **Protection** relay dial settings/programming details
g. An annex containing plant information data on which the settings are based

GC 16.7.2 Voltage control system setting document

A document signed by the **Generator** and to be revised and approved by the **System Operator** and the **Single Buyer** containing the following:

a. A section defining the base values and per unit values to be used
b. A single line diagram showing all the voltage control system functions and all the related protection tripping functions
c. Voltage control system transfer function block diagram, including the excitation system of synchronous machines.
d. A detailed description of setting calculation for each of the voltage control system functions, discussion on function stability calculations, and detailed dial settings on the excitation system in order to achieve the required setting
e. A section containing a summary of all settings on a per unit basis
f. A section containing a summary for each of the voltage control system dial settings/programming details.
g. Plant test data from which the **Model** was derived

GC 16.7.3 Unit model document

The document shall include **Models** as per GC 16.2, which together can be used by the **System Operator** and the **Single Buyer** to simulate the dynamic performance of the **Generating Unit**, specifically voltage control, load ramping and frequency support within the design operating range of the **Generating Unit**.

The document signed by the **Generator** and to be revised and approved by the **System Operator** and **Single Buyer**, will contain the following:

a. The operating parameters on which the **Model** is based, with the per unit and corresponding base values
b. A **Model** for the dynamic response of the unit in block diagram form including Laplace transfer functions
c. A detailed list of gains, constants and parameters, with explanations of the derivations for each of the modelled functions of the governor system model
d. Plant test data from which the **Model** was derived

GC 16.8 Synchronous Generating Unit Parameters

Parameter	Symbol	Unit	Value
Direct axis synchronous reactance	*Xd*	% on rating	
Direct axis transient reactance saturated	*Xd sat*	% on rating	
Direct axis transient reactance unsaturated	*Xd unsat*	% on rating	
Sub-transient reactance unsaturated	*X"d=X"q*	% on rating	
Quad axis synchronous reactance	*Xq*	% on rating	
Quad axis transient reactance unsaturated	*Xq unsat*	% on rating	
Negative phase sequence synchronous reactance	*X2*	% on rating	
Zero phase sequence reactance	*X0*	% on rating	
Turbine generator inertia constant for entire rotating mass	H	MW s/MVA	
Stator resistance	Ra	% on rating	
Stator leakage reactance	*XL*	% on rating	
Poiter reactance	*Xp*	% on rating	
Generator time constants:			
Direct axis open-circuit transient	Tdo'	sec	
Direct axis open-circuit sub-transient	Tdo''	sec	
Quad axis open-circuit transient	Tqo'	sec	
Quad axis open-circuit sub-transient	Tqo''	sec	
Direct axis short-circuits transient	Td'	sec	
Direct axis short-circuits sub-transient	Td''	sec	
Quad axis short-circuits transient	Tq'	sec	
Quad axis short-circuits sub-transient	Tq''	sec	
Speed damping	D		
Saturation ratio at 1 PU terminal voltage	S (1.0)		
Saturation ratio at 1.2 PU terminal voltage	S (1.2)		

The **Generator** shall attach a plot of generator terminal voltage versus field current that shows the air gap line, the open-circuit saturation curve, and the saturation curve at full load and rated power factor.

GC 16.9 Unit step-up transformer

Parameter	Units
Number of windings	
Vector group	
Rated current of each winding	Amps
Transformer rating	MVA
Transformer nominal LV voltage	kV
Transformer nominal HV voltage	kV
Tapped winding	
Transformer ratio at all transformer taps	
Transformer impedance at all taps (for three winding transformers the HV/LV1, HV/LV2 and LV1/LV2 impedances together with associated bases shall be provided)	% on transformer rating
Transformer zero sequence impedance at nominal tap	Ohm
Earthing arrangement, including neutral earthing resistance and reactance	
Core construction (number of limbs, shell or core type)	
Open-circuit characteristic	Graph
Saturation characteristic	Graph
Validated **Model** in the format required by the power system simulation software used by the **System Operator**	Electronic file

GC 16.10 Current and Voltage Transformers

Data	Unit	Value
Current Transformer: (a) Number of CT provided (b) Type (c) Model/Make (d) Burden for protection (e) Burden for metering (f) Accuracy class for protection (g) Accuracy class for metering (h) Rated primary current (i) Rated secondary current (j) Number of primaries (k) Saturation curve		
Voltage Transformer: (a) Number of units installed (b) Type (c) Model/Make (d) Burden (e) Rated primary voltage (f) Rated secondary voltage (g) Accuracy class (h) Transformation ratio (i) Rated thermal output		
Model of the **CTs** and **VTs** in the electronic format required by the power system simulation tools used by **System Operator**.		

GC 16.11 Decommissioning of generating plant

Decommissioning of plant is the permanent withdrawal from service of generating plant. The **Generator** shall submit the following information to the **System Operator** with a one-year notice period:

i. Generator name
ii. Power station name
iii. Unit number
iv. Date to be removed from commercial service
v. Auxiliary supplies required for dismantling and demolition

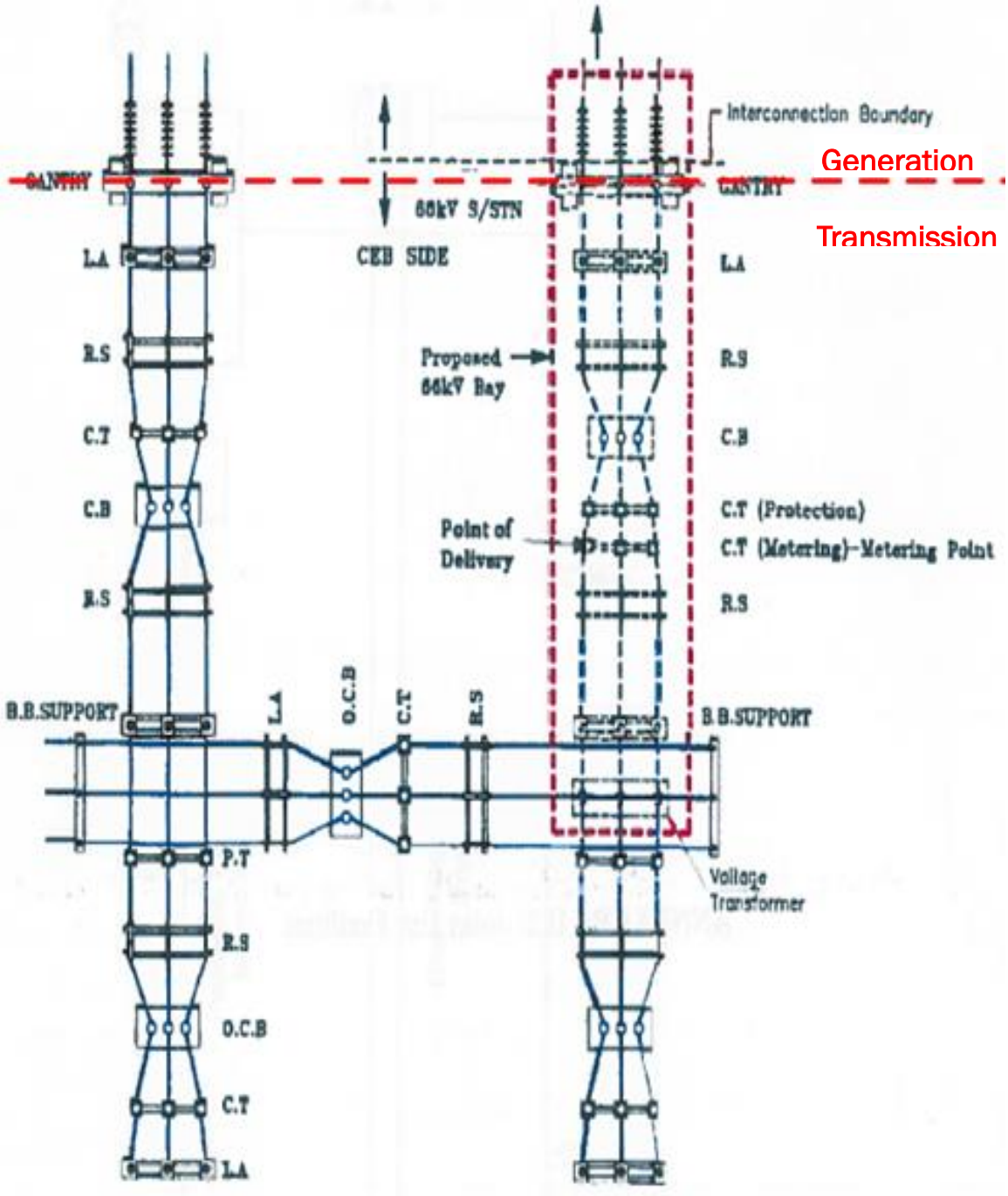

Figure 11: Interconnection Boundary in an AIS Substation.

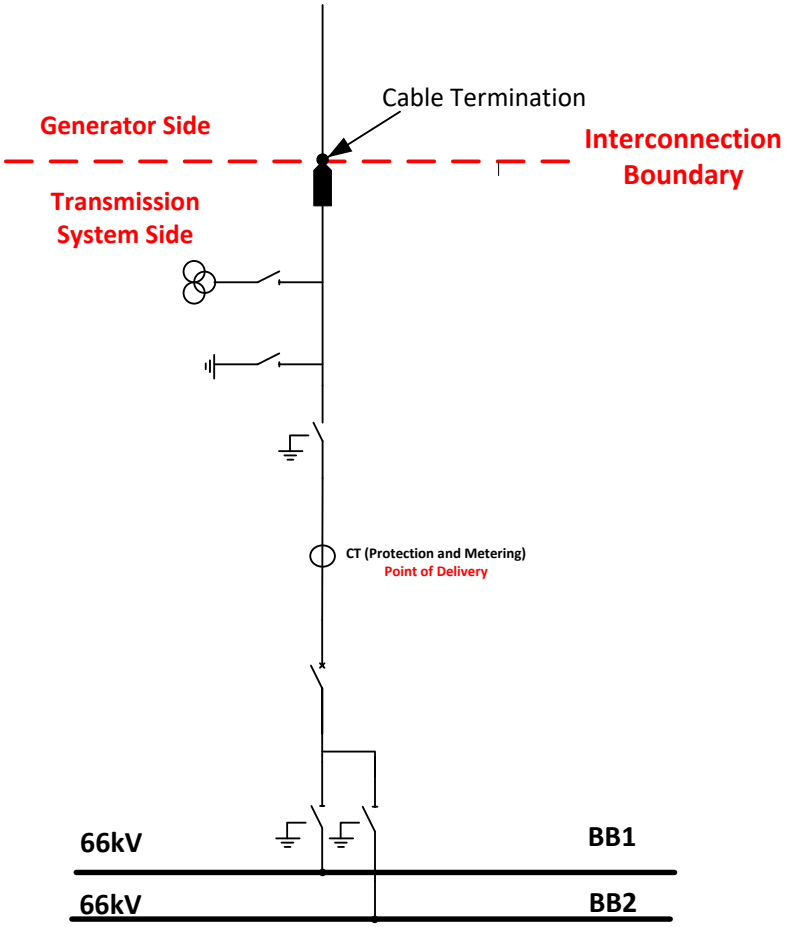

Figure 12: Interconnection Boundary in a GIS Substation.