This document provides the technical grid connection requirements for Renewable Energy Systems (RES). The stated technical requirements are universally needed for grid connection requirements for RES and also applicable to both stationary and mobile Battery Energy Storage Systems (BESS). For application in BESS, the wordings “RES” or “Generator” in the document have the same meaning of “BESS”. For system larger than 1MW, additional requirements might be necessary subject to case-by-case study at the point of connection.

You can contact us by email (CSD@clp.com.hk) or on telephone no. (2678-0322) and we are happy to arrange our Engineers to discuss the technical details of your proposed system.

Grid Connection Requirements for Renewable Energy Systems (RES)

1. Introduction

1.1. This document sets out the general technical requirements for the parallel connection of the Customer (Operator)'s RES connecting to the CLPP (Company)'s 11kV or 380V system.

1.2. The connection of generator of larger capacity, at other voltage level, or at specific interconnection locations or conditions may have additional requirements which will be determined by the Company on an individual basis.

1.3. The term of "Generator" in the document refers the Operator's RES and associated equipment.

1.4. References to "point of common coupling" in this document refer to the point in the Company's system, electrically nearest to the Operator for whom the new connection is proposed, at which other customers are, or may be, connected.

1.5. In addition to this document, the Operator shall design, install, maintain and operate his equipment and facilities in accordance with applicable laws, international standards, good utility practice, applicable ordinances, regulations and guidelines, including the Electricity Ordinance and the Technical Guidelines on Grid Connection of Renewable Energy Power Systems issued by the Electrical and Mechanical Services Department (EMSD).

1.6. The Company may by giving written notice to the Operator to amend, modify, or include additional conditions in this document for safety, system security and power quality reasons. The Operator shall accept and abide by such amendment, modification or additional conditions specified in the Company's notice, which shall become effective on the date specified in the notice.

1.7. The Company reserves the right to waive the application of part of this document.

1.8. In this document, unless inconsistent with the context, words denoting the masculine gender include the feminine gender and the neuter gender, and words denoting the singular number include the plural number and vice versa.

2. Design

2.1. The design of the Generator must be compatible with the Company's system to which it is to be connected. The specific connection pattern for each Generator shall be determined by the capacity, the fault current contribution, the location and the type of the Generator and will be considered by the Company on an individual basis.

2.2. The Operator shall comply with all requirements imposed by the Company in respect of the design of the equipment including without limitation ensuring the compatibility of the Generator with the Company's system.

2.3. The Company may with prior notice to the Operator modify its distribution system and the Operator shall modify the Generator at its own cost within the time specified by the Company in the notice to ensure compatibility of the Generator with the modified Company's system.

2.4. The Operator shall protect his Generator such that the Company's system outages, faults, switching operation or other disturbances do not damage the Operator's equipment.

2.5. The Operator shall submit the design of the Generator to the Company and obtain its approval prior to the installation of the Generator. Documents to be submitted to the Company may include (without limitation):

- Technical drawings illustrating the installation of the Generator
- Single-line electrical diagrams of the Generator showing details of the proposed grid connection
- Electrical schematic diagrams with proposed setting calculations for the electrical protective, control, synchronising, alarm/monitoring, data acquisition and metering system/equipment
- Arrangement (including sealing facilities), ratio, rating accuracy class and markings of metering VTs and CTs
- Drawing showing Operator's earthing system connection and bounding arrangement
- Operator's present and projected load and generation
- Details of the Generator including description of functions, parameters, testing reports
- Study reports on load flow, fault currents, voltage/current distortion and interference
- The voltage control characteristics of the regulating facility
- The design of protection systems of the Generator
- Any other documents as reasonably requested by the Company

2.6. The Operator shall provide the Company with all details of any proposed modification to the Generator and shall obtain written approval from the Company prior to making any changes to the Generator including its capacity.

3. Testing and Inspection

3.1. The Operator shall be required to conduct the tests in accordance with the test requirements as required by the Company from time to time.

3.2. The Company shall have the right to witness any tests the Operator is required to conduct.

3.3. The Operator shall provide a copy of the test results to the Company for assessment.

Verification tests performed on the protection, communication, control, metering VTs and CTs, Supervisory Control and Data Acquisition (SCADA), telemetry system, synchronising system, and others such as harmonic voltage and current distortion, unbalance voltage and voltage fluctuation as a result of the connection and tripping of all and parts of the Generator must be carried out on site. Tests performed before the installation of the Generator are not acceptable.

3.4. The Operator must keep a written record of all protection settings, test results, inspection results and maintenance works carried out on the Generator. Notwithstanding anything to the contrary contained in the Technical Guidelines on Grid Connection of Renewable Energy Power Systems issued by the EMSD, the Operator shall make available such records for inspection as required by the Company or representatives of regulatory authorities. Further, an as-built single-line electrical diagram of the Generator and its connection to the Company's system shall be displayed at the metering position at all times.

4. Operation and Maintenance

4.1. The Operator must operate and maintain the Generator in good order and repair at all times in conformity with good electrical practice and shall keep complete records in relation to the same. The Company may review all such records at all reasonable times.

4.2. The Generator must be operated and maintained only by persons who are authorised and competent to carry out his or her job.

4.3. The Operator's representative(s) shall be available at all times to receive communications from the Company's representative(s) so that emergencies requiring urgent action by the Operator can be dealt with adequately.

4.4. The Operator shall, when requested by the Company, inform the Company's representative(s) of any abnormalities that occur on the Generator (e.g. the generator oscillates against the system) which have caused, or might cause, disturbance to the Company's system.

4.5. The Operator shall ensure that active and reactive power will only be supplied to the Company's system on terms agreed between the Company and the Operator.

4.6. The Operator shall not energize any section of the Company's system. Where the Operator requires its Generator to supply a temporarily disconnected section of the Company's system, this may only occur in accordance with arrangements agreed between the Company and the Operator.

4.7. The Company has automatic switching and automatic re-closing schemes adopted in its system. During the switching operations, the Company's system could be subjected to interruption of 0.2 second to more than 10 seconds without prior notification. The Generator shall be designed and operated so that it shall decouple with the Company's system by opening the incoming circuit breaker at Operator side such that out-of-phase re-closing does not occur. After the disconnection of the Generator to the Company's system, it could be reconnected to the Company's system when the system voltage and frequency return to a normal and stable condition (refer to Clause 11 below).

4.8. If improvement on the Company's re-closing and automatic switching scheme or additional equipment is required, the Operator shall accept and comply with such requirements. The Company shall not be liable for damage caused to the Operator's equipment as a result of such re-closing and switching operation as stated in Clause 4.7 above.

4.9. The Operator shall notify the Company in advance of any operation and maintenance or repair work on the metering VTs and CTs systems or the telecommunication facility and promptly confirm to the Company upon completion of work.

4.10. The Operator shall not at any time take power from or export power to the Company's system at the point of coupling exceeding the mutually agreed limits.

4.11. Notwithstanding anything to the contrary contained in the Technical Guidelines on Grid Connection of Renewable Energy Power Systems issued by the EMSD, the Operator shall ensure that periodic inspection of the Generator is carried out by an appropriate registered electrical worker. The Operator shall follow the frequency of inspection required under the Wiring Regulations of the Electricity Ordinance. The Operator shall keep a record of all inspection results and make available such records when requested by the Company.

5. Voltage and Power Factor Control

5.1. The Generator shall be equipped with a continuously acting automatic voltage regulator. This facility must be co-ordinated with the Company's automatic voltage regulator of the supply transformers.

5.2. The Generator shall provide over-voltage and under-voltage protection with the following suggested settings:

Voltage at connection point (% of nominal voltage)	Maximum Trip Time (second)
$120 < V$	0.16
$110 < V \leq 120$	1
$70 \leq V \leq 110$	Continuous operation
$45 \leq V < 70$	2
$V < 45$	0.16

(Reference to IEEE1547)

5.3. The generator which operates in parallel with the Company's system shall be capable of delivering its rated power output for a power factor range of 0.9 lagging to 0.9 leading at the generator terminals.

5.4. The Generator shall be provided with a power factor controller acting through the automatic voltage regulator. The power factor controller shall be capable of maintaining a power factor within +/- 0.01 between 0.9 lagging and leading. The effective response time of the power factor controller shall be adjustable.

5.5. Where power factor correction equipment is used to improve the power factor, the Operator shall ensure that the correction equipment will not cause excessive voltage disturbance, inrush current, over-voltage, or resonance with the Generator or the Company's system components.

5.6. The power factor of the Operator's imported power as recorded at the point of common coupling must meet the requirements stipulated in the Supply Rules.

5.7. The Generator shall be capable of disconnecting from the Company's system if under or over voltage is detected at the Company's supply point. The range of abnormal operating voltages and the corresponding minimum holding time before disconnection and maximum trip time (voltage ride through capability) shall be as follows:

Abnormal Voltage Range (% of nominal voltage)	Minimum Holding Time (second)	Maximum Trip Time (second)
$V > 120$	--	0.16
$117.5 < V \leq 120$	0.2	--
$115 < V \leq 117.5$	0.5	--
$110 < V \leq 115$	1.0	--
$88 \leq V \leq 110$	Infinite	--
$65 \leq V < 88$	2.0	--
$45 \leq V < 65$	0.32	--
$30 \leq V < 45$	0.16	--
$V < 30$	--	0.16

(Reference to IEEE1547)

6. Fault Current

6.1. After the connection of the Generator to the Company's system, the overall fault current must not exceed the fault current withstand or breaking capability of any equipment connected to the Company's system under all possible operating conditions.

6.2. The fault current contribution from the Generator to a fault in the Company's system shall not affect the normal operation of the protective relays in the Company's system.

6.3. Both three-phase fault current and single-phase-to-ground fault current shall be considered in fault current studies.

6.4. The fault current study parameters and procedures shall comply with the IEC Standard 909 - Short Circuit Calculation on Three-phase A.C. Systems.

7. Metering and Telemetry

7.1. The Company shall design, supply, own and maintain all necessary meters and associated equipment to record power (including kVA demand) and energy import to and export from the Company's system and the Generator.

7.2. The Operator shall supply and install, at no cost to the Company, the metering VTs and CTs for the Generator as required by the Company and provide suitable accommodation on his premises as agreed by the Company for the installation of all Company's meters and other associated equipment.

7.3. Metering equipment shall be installed at the point of supply and the generator terminals to record measurements to the requirements of the Company. These may include both the export and import of active and reactive electrical power and energy to and from the Operator and the Generator.

7.4. If the rated current of the Generator is greater than 100 Ampere (Three-Phase), a current transformer operated meter will be adopted and the Operator shall provide at no cost to the Company a dedicated Public Switched Telephone Network (PSTN) line adjacent to the location of the metering equipment or subscribe 3G/4G network service for remote meter data collection, unless the design of the Generator allows connection of multiple Whole Current Meters.

7.5. Whenever the generation capacity of the Generator is greater than 200kW, telemetry system should be installed at the terminals of the Generator to record measurements (including active power, reactive power, voltage, current, circuit breakers' status, etc.)

7.6. If the Generator with generation capacity greater than 200kW is planned for exporting power to the Network, additional telemetry should be installed at the supply points for monitoring of the active power and reactive power flow.

8. Point of Interconnection and Disconnecting Switch

8.1. The Operator shall furnish and install a manual disconnect device that has a visual break capable of disconnecting the Generator from the Company's system.

8.2. The disconnect device must be accessible to Company personnel, and capable of being locked by a separate padlock in the open position. Access to the points of isolation should be kept clear and unobstructed. The Operator shall follow the Company's switching, isolation and earthing procedure.

8.3. The means of isolation should normally be installed close to the metering point but may be positioned elsewhere with the Company's prior agreement.

8.4. The Operator must grant the Company rights of access to the means of isolation without undue delay and the Company must have the right to isolate the Operator's infeed at any time should such disconnection become necessary for safety reasons and in order to comply with statutory obligations.

8.5. At the point of interconnection, or as near as practicable to it, a diagram shall be displayed showing all electrical infeeds. This diagram should indicate the limits of responsibility of the Company and the Operator.

9. Communication Channels

9.1. Communication channel(s) may be installed as part of the protection, remote control and monitoring, remote metering and/or direct voice contact between the Company and the Operator. These channel(s) may be telephone circuit, power pilot wire, microwave, or optical fibre etc. Details of the communication channel requirement will be determined by the Company taking into account the Generator size and its location.

10. Frequency Variation

10.1. When connecting to the Company's system, the Generator shall maintain continuous and normal operation for frequency excursion between 48.5Hz and 51.0Hz.

11. Synchronising

11.1. The Operator shall be responsible for synchronization to the Company's system and shall always acquire authorization from the Company prior to synchronization to the system. In case the Generator is disconnected to the system due to an out-of-bounds event in the Company's system, the Generator should remain disconnected until the voltage and frequency of the Company's system have been maintained at the normal values continuously for a minimum period of 5 minutes.

11.2. Prior to paralleling the Generator with the Company's system, it is necessary to minimise the difference of voltage, phase angle, and frequency between the Generator and the Company's system. Automatic synchronising equipment shall be installed for the circuit breakers to parallel the Generator and the Company's system. For circuit breakers not equipped with synchronising equipment and that could become a possible parallel point with the Company's system, mechanical key interlocking must be applied to prevent unsynchronised closure.

11.3. Closing of the coupling circuit breaker for paralleling the Generator with the Company's system shall normally be triggered by automatic synchronising equipment. Where manual synchronising is provided the acceptability of switching procedures and operational staff is subject to agreement with the Company.

11.4. Telemetry of status of the synchronous point, active and reactive outputs and other operational information of the Generator shall be provided to the Company's system control centre.

11.5. Operation procedures of synchronising and de-coupling the Generator shall be submitted to the Company for review and approval before the commissioning of the Generator.

11.6. The voltage fluctuation on the Company's system during synchronisation should at most times not exceed 3% at the point of common coupling.

12. Distortion and Interference

12.1. The Generator must be designed and operated to comply with the harmonic distortion and other power quality interference criteria specified in IEEE Std 519.

12.2. The level of negative phase sequence voltage at the point of common coupling on a three-phase system shall not exceed 1.3% of the positive phase sequence

voltage, assuming an initially symmetrical of the Company's system at this point.

12.3. After the connection of the Generator to the Company's system, the voltage fluctuation at the point of common coupling due to the variation of Generator input motive power shall not exceed 1%.

12.4. Where the Generator is run-up to speed as a motor connected to the Company's system, any associated disturbance must be within the limits stipulated in the Supply Rules.

12.5. The Generator shall be designed and operated to protect against direct current flowing into the Company's system. Devices such as an isolation transformer, a direct current sensor with a high speed disconnect switch, etc. may be used. The DC current into the AC interface shall not exceed 0.5% of rated inverter output under either normal or abnormal operating conditions.

13. Earthing System

13.1. The Operator must provide an adequate earthing system to ensure the safety of personnel and equipment, and the reliable operation of the protection equipment. The Operator shall ensure his system be properly earthed even when operating in isolation from the Company's system.

13.2. The earthing system shall meet the requirements stipulated in the IEEE Guide for Safety in AC Substation Grounding.

13.3. The Operator must ensure the continuance of safe conditions if any neutral point connected with earth in any apparatus operated at high voltage becomes disconnected from earth.

13.4. If the Generator is connected to Company's 11kV system via a transformer (e.g. generator transformer), the primary side (e.g. operator side) of the transformer shall be in "star" connection with neutral earth while the secondary side (e.g. Company's 11kV side) should be in "delta" connection. Connection of the generator transformer with different winding arrangement shall be agreed with the Company in advance.

13.5. The Operator shall provide an earthing transformer (e.g. Zigzag transformer with Neutral Earthing Resistor) connected at Operator's 11kV side with back-up protection (e.g. Neutral Voltage Displacement protection) whenever any generator is connected directly to Company's 11kV system. The total zero-sequence impedance of the earthing transformer shall be agreed with the Company to avoid affecting protective fault-clearing relays in the Company's system. Different arrangement shall be agreed with the Company in advance.

14. Insulation Co-ordination

14.1. The insulation level of the Operator's equipment shall be compatible to that of the Company's in accordance with IEC Standards 60071 on Insulation Co-ordination.

14.2. Proper lightning protection systems shall be installed for the outdoor generator and equipment to protect personnel and equipment from lightning stroke and transient over-voltages.

15. Stability

15.1. The Operator shall ensure the stable operation of the Generator under normal and contingency conditions.

15.2. The Operator shall conduct a study on the stability of the Generator connecting to the Company's system. The study report and details of the stabilizing devices (e.g. Power System Stabilizer, inter-tripping system and pole-slip relay etc.) and the stability limits of the Generator must be submitted to the Company for approval and record.

16. Protection

16.1. The Operator shall install protective device of standards acceptable to the Company to prevent damage to the Company's system.

16.2. The electrical protective devices that are required to protect each generator will depend on its design and capacity of each generator. In general, the protective devices shall consider:

- Generator differential for protection of phase-to-phase or three-phase stator windings faults
- Stator earth fault protection for detection of stator winding earth faults if the stator winding is earthed via an earthing resistor
- Neutral voltage displacement for detection of stator winding earth faults if the stator winding is earthed via a distribution transformer
- Reverse power to detect the loss of prime mover
- Voltage dependent overcurrent for system back-up protection if a fault in the system is not cleared by other protection
- Under-voltage and over-voltage used to back-up the speed control governor and automatic voltage regulator
- Under-frequency to detect overloading of generator caused by various system disturbances or operating conditions
- Over-frequency used to back-up the speed control governor if over-speeding occurs
- Sensitive directional earth fault to detect generator internal earth faults
- Field failure to protect generator against high value of reactive current drawn from power system should there is loss of excitation.
- Voltage fuse detection to block protection devices that are affected by the loss of voltage

- Loss of mains to detect a failure of the mains, an auto-reclosing or auto-switching of the Company's system and disconnect the Generator immediately
- Reversed power alarm to detect possible loss of mains and to monitor the power flow direction

16.3. Operator shall submit the setting calculations of each electrical protective device to the Company for review and approval before testing and commissioning of any part of the Generator.

16.4. The protective devices for the Generator must be housed in protective cabinets located a place that allows immediate visual inspection of the protective devices but is secure from interference by unauthorised personnel.

16.5. The Company may require direct transfer trip channels to trip Operator's main switches to disconnect all or parts of the Generator when:

1) the Company's automatic re-closing and automatic switching is activated;
2) the Operator's protective devices fail to clear primary system faults occur on the Generator; or
3) operation of the Generator shall jeopardize the security, reliability or supply quality of the Company's system.

Remarks:
Starting from 1st March 2021, all RES/FiT applications must incorporate over-voltage protection, under-voltage protection and voltage ride through capability.