Technical Guideline for Connection of Indirect Solar PV Power Generation to Distribution System for Solar Accelerated Transition Action Programme (Solar ATAP)

May 2026

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1.0 Overview

1.1 Introduction : Solar PV generation by the Consumer in aggregate would impact the Distribution system behaviour, especially when there is excess of generation from the Consumer. Due consideration of the impacts must be taken to mitigate the problem caused by the generation for example voltage rise, safety, power quality etc

RE developers, service providers, operators and parties otherwise involved in the installation and commissioning of solar PV generation to the grid can utilise these guidelines for:

a) Understanding the interconnecting requirements whether for small, intermediate or large solar PV systems of indirect solar PV power generation.
b) Finding out the methods available for interfacing of the solar PV generator to the grid system (connection schemes), including the compliance requirements for SCADA as per Distribution Code.
c) Finding out the power quality requirements for solar PV interconnection with medium and low voltage distribution networks.
d) Understanding the practices to ensure the safety of the personnel and equipment involved in utility-connected solar PV operations.
e) Reference to issues related to grid connection of solar PV.

1.2 Regulations : Paralleling indirect solar PV power generation system to the grid shall be subjected to compliance to the prevailing electricity supply rules & regulations to ensure adherence to the standard practices, quality of supply and personal & public safety.

Regulating authority is Suruhanjaya Tenaga Malaysia.

The following document shall be referred in determining the compliance to operational conditions terms:

a) Electricity Supply Act & Regulations
b) The Malaysian Distribution Code
c) Guidelines for Solar Accelerated Transition Action Programme in Peninsular Malaysia

For Consumer connected to EUC system, connecting indirect solar PV power generation system internally requires compliance to requirements stated in this document. Power generated from indirect solar PV power generation system is potentially able to disrupt the existing network quality, security and safety.

Without proper consideration, connecting indirect Solar PV power generation system could result in:

a) Voltage fluctuation
b) Voltage rise
c) Voltage unbalance
d) Overloading of existing grid connecting feeder/cable. i.e. reverse power flow
e) Power Quality issues
f) Safey concerns
g) Coordination with other on-site generations such as backup generator, co-gen and energy storage system

In addition, the applicants shall comply with relevant Acts and Regulations.

1.3 Boundary of ownership and responsibilities : Boundary and responsibility limits of EUC & Solar ATAP Consumer must be clearly demarcated, agreed and documented.

EUC responsibility is up to the metering point which is as the normal distributor Consumer boundary

1.4 Approvals & license to build & operate : The Consumer shall acquire the appropriate approval from relevant authorities and employ competent personnel to design the installation which include:

- Permit by local authority
- Permit by respective regulatory bodies
- Competent installer under regulation
- Competent operator
- Repair & maintenance

2.0 Scope

2.1 Scope : The main objective of this guideline is to provide guidance on the technical requirements for Consumer connected to the distribution system who plan to install indirect solar PV generation.

This guideline outlines technical requirements to ensure that connection of the indirect solar PV power generation system would be standardised in terms of scheme, devices, operation and limits. The ultimate objective is to harmonise indirect solar PV power generation system with the existing supply network, neighbouring Consumer and other Distributed Generators (DG) within the same distribution network. Connection of indirect solar PV power generation system should not cause breach of power quality, reliability and security of the network and safety of the operators and public.

This guide covers requirements for connection of indirect Solar PV power generation system to the Consumer internal system. Power generation include:

a) Indirect connection solar photovoltaic
b) Battery Energy Storage System (BESS)

Refer to Section 6.5 for installed capacity limit.

2.2 Commercial matters : Commercial matters are not part of this guideline.

2.3 Application process : Consumers that intend to install indirect solar PV power generation system are required to register with the EUC. Registration to EUC is a statutory requirement as the Consumer has altered the system registered during initial application.

The application process and procedures are described in the “Guidelines for Solar Accelerated Transition Action Programme in Peninsular Malaysia”.

3.0 Glossary

Battery Energy Storage System (BESS)	:	means battery energy storage system coupled with solar PV system;
Connection point	:	The point where indirect Solar PV power generation system is connected to the consumer distribution board.
Consumer	:	means an owner or occupier of a premise who is supplied with electricity by the EUC;
Demand	:	The demand of MW or MVAr of electricity (i.e. both Active Power and Reactive Power respectively) unless otherwise stated.
Distribution Code	:	Distribution Code for Peninsular Malaysia, Sabah & F.T. Labuan"
Distribution System	:	means an electricity system of electric lines, cables, switchgear and associated equipment at nominal voltage of less than 132kV used, worked or operated by the EUC for distribution of electricity in the areas of supply set out in the licence granted by the Commission under section 9 of the Act;
EUC	:	means the Electricity Utility Company which is Tenaga Nasional Berhad (TNB) that holds the licence under section 9 of the Act to distribute and supply electricity;
Grid-following inverters	:	A grid-following inverter is an inverter-based resource that synchronizes with the grid's voltage and frequency (often using a phase-locked loop), controlling and injecting current (active & reactive) to meet prescribed setpoints. It relies on the presence of a stable grid voltage/frequency reference and does not itself generate the voltage waveform.
Power System Harmonic	:	A harmonic of a voltage or current waveform is a sinusoidal wave whose frequency is an integer multiple of the fundamental frequency.
Indirect Solar PV Power Generation (ISPPG)	:	A configuration in which solar photovoltaic (PV) systems are installed at the load side of the consumer after EUC meter. The generated electricity is injected directly into the consumer's internal distribution system to supply on-site loads as priority. Any surplus generation that exceeds internal demand may be exported to the distribution system through the point of common coupling (PCC).
Inverter	:	A machine, device, or system that changes dc power to ac power.

Islanding (customers' installations)	:	Island mode for a customer premise/ installation is when the premise's energy system, such as a solar and battery setup, or cogeneration facilities disconnects from the main utility grid and operates autonomously. This mode ensures power continues to flow during a power outage, drawing from batteries and solar panels (if available) or others to power critical loads, and can be enabled automatically or manually;
Load profile	:	24-hour, 4-day profile (consisting of Friday to Monday) of Consumer electricity demand profile which include voltage, kW, kVAr for a minimum 60-minutes sampling.
Low Voltage	:	means a voltage normally not exceeding 1,000 volts alternating current or 1,500 volts direct current between conductors, or 600 volts alternating current or 900 volts direct current between conductor and earth;
Medium Voltage	:	means a voltage normally exceeding low voltage but equal to or not exceeding 50,000 volts;
Non-Domestic Consumer	:	means any consumer of the EUC from category other than domestic;
Peak load	:	Highest demand recorded in the load profile.
Point of common coupling (PCC)	:	The point of connection between utility system and Consumer.
Power Factor	:	Power factor (PF) is calculated by dividing the Real Power, P, in the W unit by the Apparent Power, S, in the VA unit.
Solar ATAP Consumer	:	means a consumer with solar PV Installation registered under the Solar ATAP Programme.
TNB	:	means Tenaga Nasional Berhad as the holder of a license granted by the Commission under section 9 of the Act to distribute and supply electricity in the Peninsular Malaysia with the electricity supplied from the Single Buyer Market;
Total Harmonic Distortion (THD)	:	Total harmonic distortion (THD) is a measurement of the unwanted voltage harmonic that are added to an original sinusoidal voltage waveform, which causes it to deviate from its ideal voltage waveform. It is calculated as the ratio of the sum of the powers of all voltage harmonic to the power of the fundamental voltage and is typically expressed as a percentage.
Trough load	:	Lowest demand recorded in the load profile.
Type Test	:	Test of one or more devices made to a certain design to demonstrate that the design meets certain specifications.

4.0 Description of Indirect Solar PV Power Generation

4.1 Description : A configuration in which solar PV systems are installed on the consumer side after the EUC meter.

The generated electricity is injected directly into the Consumer's internal distribution system to supply on-site loads as priority. Any surplus generation that exceeds internal demand may be exported to the distribution system through the point of common coupling (PCC).

Consumers may decide to install indirect solar PV power generation system to reduce their import from the EUC. The connection scheme is described in Chapter 5 of this guideline.

4.2 Inverter requirements : The grid-connected inverter for solar PV power generation shall comply to the following standards and references, in term of design, operation and maintenance:

a)	MS 1837	Connection scheme of grid connected inverter.
b)	IEC 61727	Photovoltaic systems – characteristics of utility interface.
c)	IEEE 1547	• Standard for Interconnecting Distributed Resources with Electric Power Systems. • This standard describes the connection requirements of various Distributed Resources to the utility network.
d)	IEC TS 62786-3	Distributed energy resources connection with the grid – Part 3: Additional requirements for stationary battery energy storage system.
e)	Suruhanjaya Tenaga	*"Distribution Code For Peninsular Malaysia, Sabah & F.T. Labuan"*
f)	TNB	*"Tenaga Nasional Berhad – Technical Guidelines for Interconnection of Distributed Generator to Distribution System, 2018"*
g)	TNB	*"Tenaga Nasional Berhad – Technical Guideline for Application of Inverters to Mitigate the Fault Current Contribution of Inverter-Based Distributed Generation in Distribution Systems"*

Only inverters that comply with the above standards are allowed to be operated in distribution system. Type test certifications could be used as proof of compliance.

4.3 Power limiting capability : Inverter shall have power limiting capability to ensure voltage compliance in accordance to Distribution Code.

5.0 Connection Scheme

5.1 Introduction : The connection scheme clauses take into the following considerations:

a) Safety
b) Compliance to regulatory requirements
c) Connection with least alteration to existing network
d) Cost

5.2 Indirect connection method : The indirect connection method of Solar PV power generation system is as below:

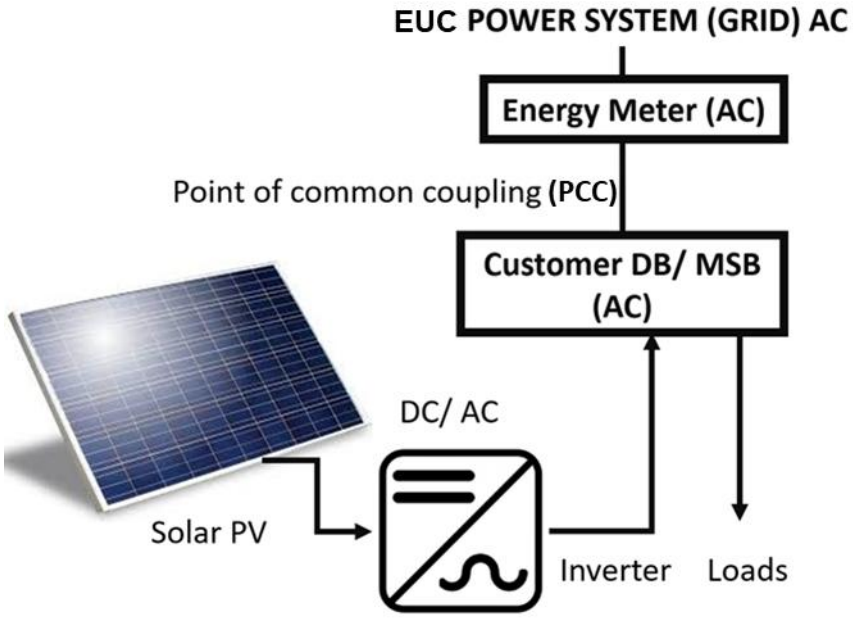


Figure 5.1: Connection to EUC Grid

Connection point is within the Consumer's internal supply network without direct connection to the EUC system. Power consumption and export are measured by EUC meter at PCC. The meter shall have bi-directional capability to register the import and export units.

5.3 Earthing requirement : Solar consumer shall use T-T system in compliance with IEC 60364 where the solar consumer's earthing (grounding) has its own independent earth connection, often a ground rod, which is separate from the utility's earth connection.

6.0 General Requirements

6.1 Introduction : The connection of indirect solar PV power generation systems shall be implemented within the Consumer internal electrical system. Such connections shall not require any upgrading of existing utility supply infrastructure — including cables, fuses, switchgear, transformers, and protection schemes — unless otherwise specified by the outcome of a feasibility study.

6.2 Connection requirement : As a result of installation of indirect solar PV power generation system, the quality of power at the PCC shall not be made worse than the existing quality of supply. Quality of supply is measured as compliance to the standards on voltage, flicker, frequency, harmonics and power factor. To ensure that the addition of indirect solar PV power generation system does not adversely impact the quality of supply, the following requirements shall be imposed and adhered by the Consumer.

Deviation from these standards represents out-of-bounds condition and may require the PV system to sense the deviation and properly disconnect from EUC system.

Power quality parameters (harmonics and voltage) must be measured at the utility interface/point of common coupling unless stated otherwise. At PCC, the power quality requirements must comply with Malaysian Distribution Code and this Technical Guidebook.

6.3 Connection point design consideration : Although the connection of indirect solar PV power generation system is within the Consumer's premise, the following requirement shall be fulfilled to ensure that the connection does not interfere with the existing power supplied by the EUC. The following items are to be considered during design.

a) Consumer load during peak and trough
b) Anti-islanding
c) Protection system
d) Step-up transformer (if applicable)
e) Interlocking
f) Back-up power supply (if applicable)
g) Energy storage system (if applicable)
h) Sensitive load
i) Harmonic limits for inverter
j) Reactive power management

During periods of low consumption (trough) and high generation from indirect solar PV power generation system, Consumer is to ascertain that the internal network is capable of utilising all the generated energy and its protection system to use of external device or energy storage to mitigate the export of excess energy from Consumer's solar PV system to the distribution system.

6.4 Connected Voltage : The connected voltage level for connections carried out within the Consumer's installation shall be determined based on the configuration of the Consumer's internal electrical power system.

The consumer shall appoint a qualified consultant to design the interconnection between the internal indirect Solar PV power generation system and his existing plant/premise.

The interconnection shall comply with the standards as described in this guideline and other regulations issued by the Suruhanjaya Tenaga.

6.5 Installed capacity for solar PV installation : Proper system design is critical to ensure safe and stable integration of solar PV installation into the distribution network.

As part of the design process, the installed capacity must be accurately declared during the application stage, measured as the total peak capacity (kWp or MWp).

Accurate capacity declaration allows for effective planning and management of system performance, ensuring that voltage levels remain within acceptable limits during varying load and generation conditions.

Consumer	Category	Solar A.T.A.P Capacity Limit
Domestic	1ph	5kW ac For > 5kW, CCC is required before approval granted.
	3ph	15kW ac For > 15kW, CCC is required before approval granted.
Non-Domestic	LV	100% of MD (not exceed 1 MW)
	MV	100% of MD (not exceed 1 MW)

The Consumer shall ensure that the exported power from the solar PV installation to the EUC's grid, does not exceed the installed capacity of the solar PV installation and remains within the existing capacity of both the EUC and the Consumer's equipment. Appropriate inverter functionality or external devices shall be provided to limit export in accordance with this requirement.

The peak or maximum demand is to be supported by actual 24-hour, 4-day load profile consisting of Friday to Monday. The load profile with minimum 60-minutes reading interval. The capacity described above is total capacity for each site.

6.6 Battery Energy Storage System (BESS) : BESS is charged directly by the solar PV system and the charging arrangement shall be designed to comply with this requirement.

6.7 Land requirement for CESS : For brownfield area, the distance between the allocated land and the existing PE shall not exceed a 70m radius.

The figure below shows the minimum land size required for CESS. If developer cannot provide land area as specified, developer should submit a proposal to EUC with a suggested alternative land size. EUC will review the proposal and may give approval subject to certain conditions that must be fulfilled by LEGA.

Fig 1.1 – Land Requirement for Brownfield Area

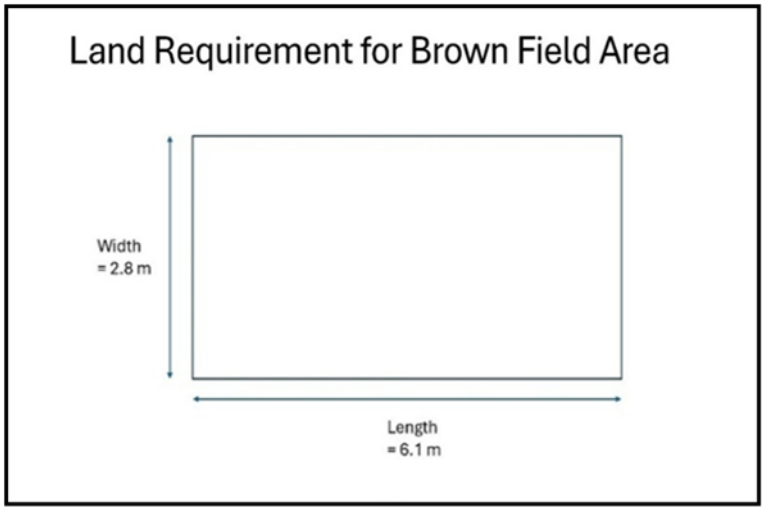


Fig 1.2 – Land Requirement for Greenfield Area (Double Chamber)

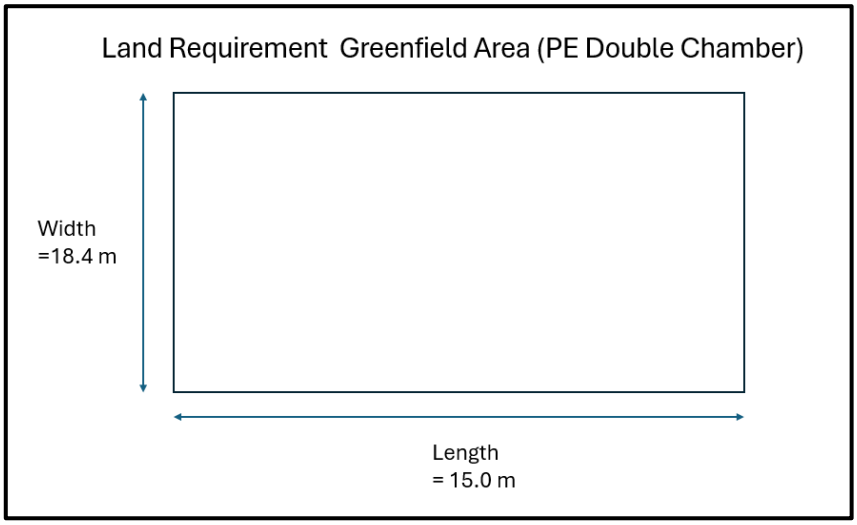
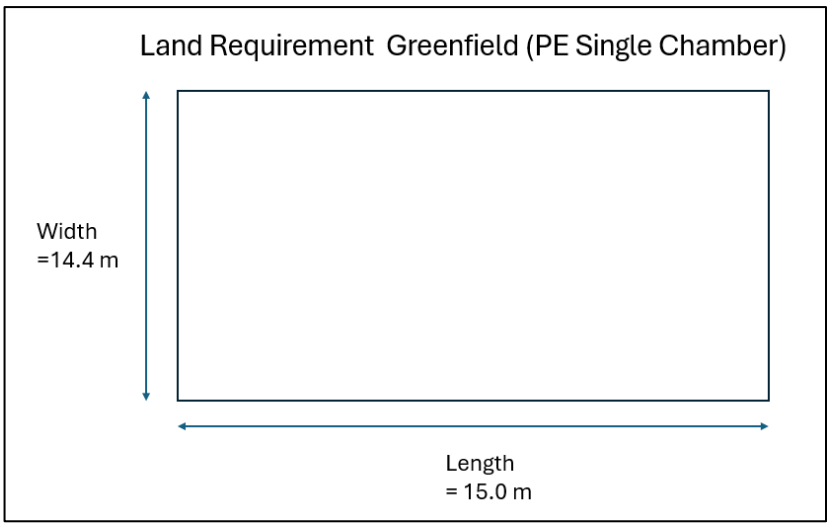


Fig 1.3 – Land Requirement for Greenfield Area (Single Chamber)



6.8 Boundary of ownership & operation : Boundary and operational limits of EUC & Solar ATAP Consumer must be clearly demarcated, agreed and documented. The Interconnection Operation Manual (IOM) shall be prepared and endorsed by both parties prior to the operation of the indirect solar PV power generation system. EUC's responsibility is up to the metering point which is as the ordinary EUC's consumer boundary.

6.9 Equipment Performance and Grid Compliance : Major components of the indirect solar PV power generation system that interface with the grid shall comply with applicable grid interconnection, protection, and performance standards:

a. MS 1837
b. IEC 61727
c. IEEE 1547 or EN50549

The design of the BESS shall comply to the following IEC TS 62786-3 standard.

6.10 Normal voltage operation range : The indirect LV Photovoltaic (PV) system shall operate within the voltage tolerance defined in Table 6.1.

Table 6.1: Normal operating condition at PCC (LV)

Nominal Voltage (V)	Steady state voltage limits
400	+10% and -6%
230	+10% and -6%

MV indirect solar PV power generation system shall operate within the tolerance defined in Table 6.2.

Table 6.2: Normal operating condition at PCC (MV)

Nominal Voltage (V)	Steady state voltage limits
6.6	±5%
11	±5%
22	±5%
33	±5%

Table 6.1 and Table 6.2 are adopted from the “Malaysian Distribution Code”

6.11 Voltage fluctuation and flickers : Solar PV systems cause voltage fluctuations primarily due to the intermittency of solar energy, which is affected by factors like passing clouds, shadows, and temperature. This can lead to rapid, unpredictable changes in power output, causing voltage dips or spikes in the grid.

The limits for voltage fluctuation and flickers for solar PV installations are defined in Table 6.3.

Table 6.3: Limits for voltage fluctuation and flickers

Distribution system voltage level which the fluctuating load is connected	Absolute short term flicker severity (P_{st})	Absolute long term flicker severity (P_{lt})
LV Systems	1.0	0.8
11kV – 33kV	0.9	0.7
Above 33kV	0.8	0.6

Voltage fluctuations and flicker negatively impact both utilities and consumers by degrading equipment performance, shortening lifespans, causing operational disruptions, and introducing safety risks.

An appropriate voltage control is to be undertaken to mitigate the voltage fluctuation and flickers.

6.12 Harmonics : Power system harmonics are unwanted voltage and current waveforms at frequencies that are integer multiples of the fundamental power frequency (50 or 60 Hz). They are caused by non-linear loads, such as modern electronics, variable speed drives, and computers, which draw current in non-sinusoidal pulses.

Solar PV systems are a source of harmonics primarily due to their inverters, which convert DC power to AC power using high frequency switching methods like Pulse Width Modulation (PWM).

Harmonics lead to increased heating, equipment malfunction, and reduced efficiency in the power system, which can be mitigated with devices like harmonic filters.

Total harmonic distortion (THD) is a measure of how much a power supply's voltage or current waveform deviates from a perfect sine wave, calculated by dividing the root mean square (RMS) of all harmonic voltages or currents by the RMS of the fundamental frequency voltage or current. This is expressed as a percentage and quantifies unwanted frequencies that are integer multiples of the main power frequency. A pure sine wave has zero THD.

The PV system output should have low current-distortion levels to ensure that no adverse effects are caused to other equipment connected to the utility system.

Total harmonic current distortion shall be less than 5 % at rated inverter output. Each individual harmonic shall be limited to the percentages listed in Table 6.4.

Even harmonics in these ranges shall be less than 25 % of the lower odd harmonic limits listed.

Table 6.4: Current distortion limit (IEC 61727-2003 Table 1)

Odd harmonics	Distortion limit (%)
3-9	< 4.0
11-15	< 2.0
17-21	< 1.5
23-33	< 0.6

Even harmonics	Distortion limit (%)
2-8	< 1.0
10-32	< 0.5

Note:

- *The harmonic current injection should be exclusive of any harmonic currents due to harmonic voltage distortion present in the utility grid without the PV system connected.*
- *Type tested inverters meeting the above requirements should be deemed to comply without further testing.*

6.13 Inverter Power Factor : Inverter power factor is the ratio of real power to apparent power in an AC circuit, indicating how efficiently the inverter converts DC power to AC power.

PV systems shall have a leading or lagging power factor greater than 0.9 and 0.85 respectively when the output is greater than 20 % of the rated inverter output power.

The smart inverters used shall automatically make necessary adjustments to ensure that the power factor does not cause voltage rise beyond the permissible limit.

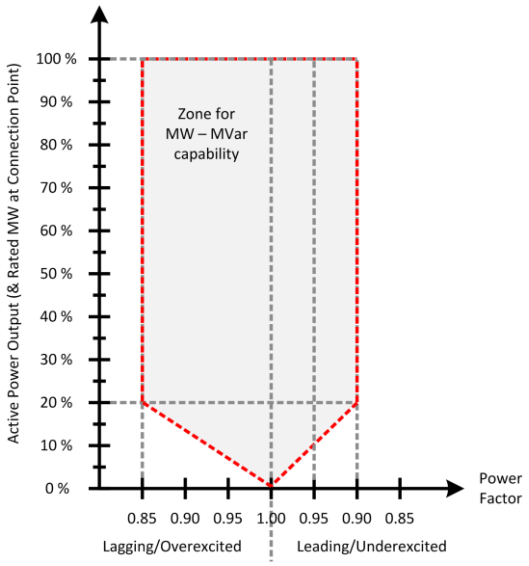


Fig. 6.1: Reactive power requirement at connection point

6.14 Reactive Power Compensation : Consumer should be aware that if the installed indirect solar PV power generation system is set to operate at unity power factor, reactive power for their load will be totally imported from EUC and real power will be mixed of own generation and import from EUC.

This will result in low power factor reading at EUC tariff meter as the ratio of imported reactive power to imported active power is higher.

The solar PV systems primarily reduce the amount of active power drawn from the grid, while the demand for reactive power from on-site inductive loads (like motors and AC units) remains largely unchanged.

Therefore, Consumer is advised to consult their service provider to provide internal reactive power compensation to avoid from being penalised.

6.15 DC Injection : The solar PV system shall not inject DC current greater than 1 % of the rated inverter output current into the utility interface under any operating condition.

The requirement is defined in IEC 61727.

The limitation on DC current injection is a critical power quality requirement designed to prevent several issues within the utility grid infrastructure.

6.16 Voltage unbalance : Voltage unbalance is defined as the ratio of the negative sequence voltage component to the positive sequence voltage component.

Negative Phase Sequence Voltage (%): 2% for 1-minute duration when multiple single-phase PV units are installed, and it should be distributed evenly among the three phases of the power system.

Infrequent short duration peaks with a maximum value of 2% are permitted for Voltage Unbalance.

The unbalance voltage shall not exceed 1% for 5 occasions within any 30-minute time period at the terminals of a user's installation.

6.17 Short circuit level : By regulation, EUC is required to ensure that short circuit level of the network is within the equipment ratings. The regulation specifies that network maximum sub-transient 3-phase symmetrical short circuit shall be within 90% of the equipment designed short-time make & break capacity. Table 6.5 highlights the typical equipment ratings in EUC.

Table 6.5: Typical Equipment ratings in EUC

Nominal Voltage [kV]	Rated Voltage [kV]	Fault Current [kA]
33	36	25
22	24	20
11	12	20
0.4	1.0	31.5

7.0 Penetration Limit

7.1 Introduction : An indirect solar Photovoltaic (PV) system will inject power into the utility grid when it produces more electricity than is being consumed by the local loads (e.g., in a home or business) at that moment, resulting in excess power being exported to the grid.

This is an operational characteristic of grid-tied solar systems and is often referred to as "export power" or "back feed".

The Consumer shall ensure that the exported power does not exceed the installed capacity and remains within the existing capacity of both the EUC and the Consumer's equipment. Appropriate inverter functionality or external devices shall be provided to limit export in accordance with this requirement.

The amount of penetration limit is to be determined by the EUC during the application process.

7.2 Individual penetration : a) Solar ATAP

Applicable for EUC registered Consumer only. Consumer should decide on the installed capacity with consideration of their own daytime peak demand. Maximum installed capacity as shown in Table 7.1

Table 7.1: Maximum installed capacity allowed for Solar A.T.A.P

Consumer	Category	Solar A.T.A.P Capacity Limit
Domestic	1ph	5kW ac For > 5kW, CCC is required before approval granted.
	3ph	15kW ac For > 15kW, CCC is required before approval granted.
Non-Domestic	LV	100% of MD (not exceed 1MW)
	MV	100% of MD (not exceed 1MW)

However, where the installed capacity exceeds as in Table 7.1 for Confirmation Connection Check (CCC) or above 72 kW for Connection Assessment Study (CAS), a technical assessment study shall be undertaken, and the allowable penetration limit shall be determined based on the outcome of that study as in Table 11.1.

8.0 Protection Guidelines

8.1 Introduction : Protection system for indirect solar PV power generation system is to be designed to isolate the fault from the healthy sections of the system.

Unlike operation with normal load connection, the solar inverter requires appropriate synchronizing scheme at the interconnection feeder to avoid unsynchronized switching of the plant to the system. For Solar ATAP Consumer interconnection feeder protection scheme shall inhibit unsafe synchronization.

DG protection scheme is under Solar ATAP Consumer responsibility and Solar ATAP Consumer is to declare the protection scheme and settings to EUC. Solar ATAP Consumer shall design a protection system that fits his target degree of system security. Nonetheless, Solar ATAP Consumer shall comply to EUC's protection requirements to ensure that the fault would not spread beyond the plant.

8.2 Smart inverter : Connection of power generation to distribution network could cause voltage rise during low load, high generation condition.

Also, sudden loss of generation from DG could cause instability of the network, especially for system with high DG penetration.

Advanced inverters or known as smart inverters are capable of providing additional features in addition to the power conversion. Smart inverters are PV inverters that stay connected and provide additional functions to help actively support the grid - mainly voltage and frequency. Traditional inverters simply disconnected when the grid voltage or frequency went out of range.

Broadly, smart inverters provide some additional benefit to the grid beyond simply converting direct-current (DC) electricity to alternating current (AC) from PV systems. The smart inverter functions are outlined in the Attachment A.

8.3 Hybrid inverter : A hybrid inverter is a type of inverter used in solar PV systems that can manage power from both solar panels and batteries — and often also from the grid. It combines the functions of a grid-tied inverter and an off-grid (BESS) inverter into a single device.

Below are the examples of PV installation design with BESS for reference but not limited to design in Figure A and Figure B.

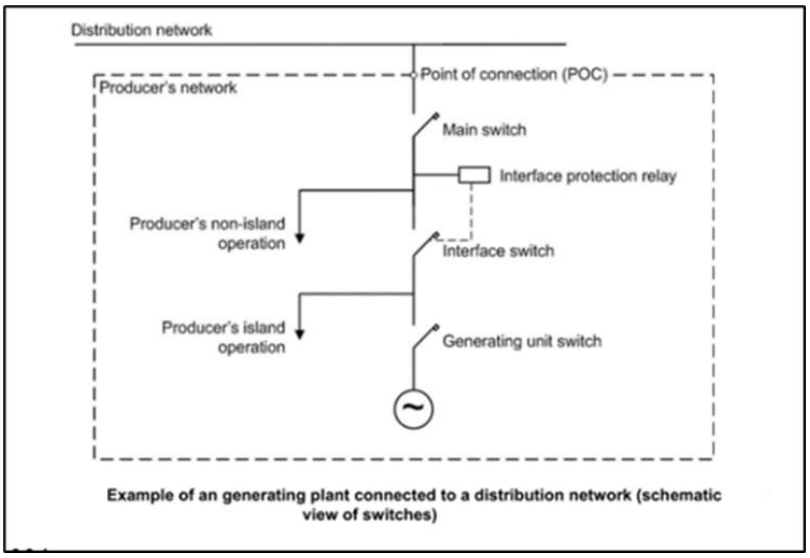


Figure A

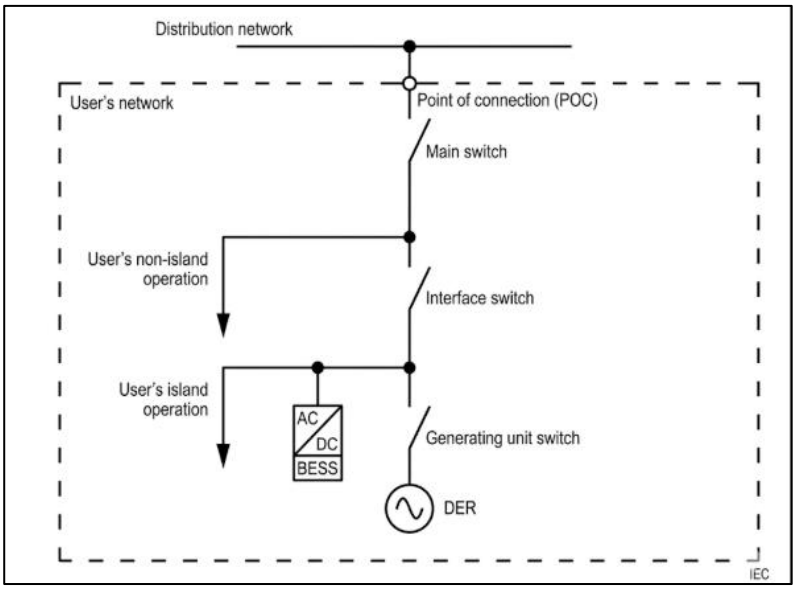


Figure B

The hybrid inverter technical requirement is as below:

A. Grid Interface & Compliance Standards

The hybrid inverter and its sensing hardware must be certified and type-tested to meet:

- **MS IEC 61727**: Photovoltaic (PV) systems – Characteristics of the utility interface.
- **MS IEC 62116**: Test procedure of islanding prevention measures for utility-interconnected photovoltaic inverters.
- **MS 1837**: Installation of Grid-Connected PV Systems (Latest Revision).
- **IEEE 1547**: Standard for Interconnection and Interoperability of Distributed Energy Resources.

B. Operational Sensing Thresholds

The inverter firmware shall be locked to the Malaysia / EUC Grid Profile and shall incorporate hard-coded sensing thresholds as applicable to the PCC. The operational sensing thresholds shall be as specified in Table 8.3.

C. Reconnection & Synchronization Logic

The "Smart Sensing" device shall manage the grid re-entry process using the following logic:

- **Stability Observation:** Upon grid restoration, the sensing device must verify grid stability for a continuous as per Table 8.2 before attempting synchronization.
- **Automatic Reset:** If any sensing parameter (V or f) falls out of range during the 300s window, the timer must reset to zero.
- **Phase Synchronization:** The inverter shall ensure the phase angle difference $\Delta\phi$ between the inverter output and the EUC grid is $<10^{o}$ before relay closure.
- **The "Smart Sensing" device**: The device shall enforce synchronization control such that reconnection to the grid is enabled only when all synchronization parameters specified in Table 8.1 are met.

8.4 Frequency : EUC shall maintain the system frequency and the PV system shall operate in synchronism with EUC's frequency. EUC shall operate with nominal 50 Hz system with ±1% range band.

8.5 Synchronization : Synchronisation is an act of matching, within allowable limits, the required DG parameters with the EUC's utility supply parameters as in Table 8.1.

Table 8.1: Parameters required for synchronization

Parameters	Required range
Frequency difference	<0.2 Hz
Voltage magnitude difference	< 10%
Voltage angle difference	< 10 deg
Interlocking logic are satisfied	-
Phase sequence	The order of phases (in three-phase systems) must match the grid's sequence, which is a fixed physical installation check.

The synchronisation is to be done at the inverter. Re-synchronising is only to proceed once EUC's system is normalized and stabilized as in Table 8.2.

Table 8.2: Parameters required for synchronization

Voltage	Time
LV	2 minutes
MV	5 minutes

8.6 Anti-islanding requirement : All Grid-following inverters installed for indirect solar PV connections, where generation is first consumed within the Consumer's internal distribution system before any potential export to the grid, shall be equipped with certified anti-islanding protection in compliance with international standards, Section 4.3, and the Distribution Code. Where a BESS is installed, excess solar PV generation may be stored and later used within the Consumer's installation in accordance with applicable regulations.

This requirement ensures that, in the event of a grid outage, the inverter (solar and/or BESS) will immediately and automatically disconnect from the utility supply to prevent unintentional islanding, safeguard utility personnel, and maintain EUC's power system stability. Solar ATAP Consumer shall disconnect from the EUC's system for loss of main within 2 seconds.

Inverters used by Solar ATAP Consumer shall provide all anti-islanding detection techniques as below:

a) Under Voltage
b) Over Voltage
c) Under Frequency
d) Over Frequency
e) 1 additional anti-islanding technique

Solar ATAP Consumer is to prove the anti-islanding capability of the plant during commissioning tests.

8.7 Islanding mode operation : Islanded operation requirement:

a. The hybrid system comprising the BESS and solar PV shall be physically isolated from the EUC grid through a mechanical switch prior to entering islanded mode.
b. During the absence of grid supply, the solar PV system shall be isolated from the grid, and the BESS & solar PV system may only be connected sequentially one after another, after completing and verified isolation from the grid.
c. The islanding mode operation mechanism shall ensure that anti-islanding protection, together with mechanical isolation at the PCC, prevents any unintended energization of the EUC network during islanded operation.

Restoration of connectivity to EUC Network:

a. Upon detection of voltage from EUC network, the BESS shall be immediately disconnected and isolated.
b. Reconnection to the EUC network shall only be allowed upon confirmation that all requirements under Clause 8.3(c) have been fully complied with.

8.8 Inverter Fault Detection : PV system with inverter shall use abnormal voltage or frequency sensing for fault detection.

8.9 Inverter fault current contribution : Based on IEEE 1547, the fault current to be controlled and limited. The typical range of short circuit current is between 100% and 200% of the rated inverter current. Solar ATAP Consumer shall ensure that inverters used comply to the IEEE1547 requirement.

In areas where the network's Short Circuit Level has reached its threshold, as specified in Section 6.17, the inverter used must comply with Short Circuit Testing Certification (SCTC) requirements. Applicants are advised to contact the EUC for further clarification on the SCTC process.

8.10 Internal protection schemes : The basic requirements for the design of the internal protection schemes shall be as follows:

a) For any internal fault in the indirect Solar PV power generation system, the indirect solar PV power generation system must not cause problems to the EUC system and its Consumers.
b) For any distribution network fault outside the indirect solar PV power generation system plant, the PV system must be protected from any damaging effect and be able to ride through network faults.

Solar ATAP Consumer shall be required to provide other protection devices to complement existing special features.

8.11 Failure of indirect Solar PV power generation system protection or control equipment : Indirect solar PV power generation plant must be disconnected from the distribution system during any of the system failure. Failure condition of indirect solar PV power generation system equipment shall include:

a) Failure of protection equipment
b) Failure of control equipment
c) Loss of control power

8.12 Voltage disturbance : The inverter should sense abnormal voltage and respond according to the conditions in Table 8.3. Consideration shall be given to monitoring voltage in this clause in order to avoid problems due to voltage drop in various transformer, wiring or feeder circuit. When the inverter senses the voltage lies outside its operating limits, the recommended action shall be as in Table below.

Table 8.3: Voltage disturbance

Voltage (at PCC)	Maximum trip time (s)
V<50%	0.10
50%≤V<90%	2.00
90%≤V≤110%	Continuous operation
110%<V<135%	2.00

Inverters are expected to continuously operate during distribution network voltage fluctuation ±10% of its nominal.

Loss-of-mains is indicated by voltage drop less than 50%.

Over voltage and under voltage detection scheme shall be provided for all 3 phases.

8.13 Frequency disturbance : The under frequency and over frequency levels and the corresponding inverter trip time shall be as follows:

a) When the utility frequency is outside the nominal 50 Hz value by ±1 %.
b) Trip time shall be within 0.20 s.
c) Applicable for both LV and MV interconnection.

8.14 Utility interface disconnect switch

Indirect solar PV power generation system interconnection must incorporate utility interface disconnect switch to allow disconnection of indirect solar PV power generation system output from the interconnecting with EUC for safe utility line works. The requirement of such switch could be referred to MS 1837. The switch shall be manual, lockable, load break disconnect switch that:

a) Provide clear indication of switch position.
b) Visible and accessible to maintenance and operational personnel.
c) Provide visual verification of the switch contact position when the switch is in open position

8.15 SCADA

The provision of SCADA together with RTU cubicle, associated cards and SCADA ready switchgear is mandatory for all DG plant interconnection of 1MW and above. SCADA equipment to be used is subject to the approval by EUC.

The following parameters are to be made available for monitoring by the EUC Control Centre:

a) Voltage (V)
b) Current (A)
c) Real Power Energy Flow (kW or MW)
d) Reactive Power Energy Flow (kVAr or MVar)

All interfacing wiring to be prepared by DG developer with EUC supervision.

9.0 Metering Requirement

9.1 Introduction : The import or export of electricity shall be metered, and the metering equipment shall be provided and maintained by EUC. The meter installation point shall be terminated at a location that is readily accessible to EUC personnel. “Accessible to EUC personnel” shall mean that the meter is located as close as reasonably practicable to the service line termination point, positioned facing the main entrance of the premises, and designed to allow ease of access for EUC personnel. Meters and their associated accessories shall be installed only in clean and dry locations that are protected from direct weather exposure, mechanical damage, vibration, direct sunlight, and rain.

1. For Ordinary Power Consumer (OPC):
   a) New connection - developer / consumer shall provide the meter board or metering panel according to latest TNB Electricity Supply Application Handbook
   b) Relocation of existing connection:
      i. For individual metering - the meter board, meter and associated accessories will be relocated by EUC. Consumer / registered wireman appointed by the consumer shall consult EUC for this purpose
      ii. For grouping metering – if consumer request to relocate the meter, consumer is responsible to relocate the metering room / steel netting meter cage and metering panel and EUC will re-locate the meter and its accessories

If existing single-phase and three-phase is installed with conventional whole current meter, the meter will need to be replaced to a bi-directional meter (smart meter).

2. For Large Power Consumer (LPC):
   a) New connection of LV supply – EUC shall provide LV CTs for the meter installation and ground metering kiosk (GMMK). If consumer opts to supply their own GMMK, consumer shall provide and installed the GMMK. In both scenarios, the cost shall be borne by customers and shall follows latest Electricity Supply Application Handbook

   b) New connection of MV supply – CTs and VTs will be provided by EUC at EUC’s outgoing switchgear. However, for a situation whereby CTs and VTs could not be provided by EUC, CTs and VTs shall be provided and installed by consumer which should follows the following requirements as per Electricity Supply Application Handbook:
      i. The metering CTs shall be subjected to testing by EUC
      ii. Test certificates for the metering VTs, issued by an accredited laboratory, shall be submitted.

iii. A pre-commissioning test shall be conducted on the VTs and CTs by the consumer and witnessed by a EUC representative.

c) Relocation of existing connection:

i. For both LV and MV supply, customer shall relocate the metering room, metering panel, CTs and VTs and termination of both primary and multicore cables for metering purposes. The new relocated installation will follow the same requirement as per Electricity Supply Application Handbook and clause 2b (iii) above.

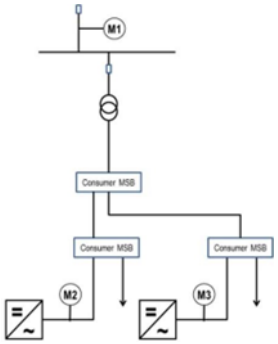
Where relocation of the meter is required, the associated cost shall be borne by EUC.

9.2 Energy Meter : Energy meters are required to measure:

a) The monthly Solar ATAP Consumer import & export (M1) for the purpose of net energy calculation. The M1 meter will be installed by EUC for billing EUC.

b) The generation output energy from the indirect Solar PV power generation system (M2, M3). The M2/M3 meters will be installed by the Consumer for purposes of checking meter.

Figure 9.1: Location of Energy Meters



9.3 Communication Signal : The Consumer shall ensure that the cellular network or any other EUC-approved communication medium at the metering room or meter location is sufficient to enable reliable remote meter reading. The Consumer shall also consult EUC to verify the minimum signal strength requirements and any additional facilities needed to support effective communication.

10.0 Safety Requirement

10.1 Introduction : The installation of grid-connected indirect Solar PV power generation systems shall comply with the requirements of MS IEC 60364 or MS IEC 60364-7-712. The provisions of this section are aimed at ensuring that these requirements are met, taking into account a range of system topologies and earthing arrangements. The Solar ATAP Consumer and installer shall comply with the DOSH Guidelines for the Prevention of Falls at Workplaces during installation and maintenance activities.

10.2 Operation : It is important that for the safety of operating staff and public, both the EUC and the consumer operator must coordinate, establish and maintain the necessary isolation and earthing when work and/or tests are to be carried out at the interface/connection point.

The safety coordination applies to when work and/or tests that are to be carried out involving the interface between the distribution network and the indirect solar PV power generation system plant and it is the responsibility of the EUC and Solar ATAP Consumer operator to comply with the requirements of statutory acts, regulations, sub – regulations, individual license conditions, Standardized Distributor licensee's Safety Rules and the Malaysian Distribution Code.

All solar PV installations shall comply with fire safety requirements set by the Fire and Rescue Department of Malaysia (Bomba), including providing clear rooftop access, installing proper isolation points and signage, and ensuring that the system design and components do not compromise firefighting operations or building fire integrity.

For safety purposes, the BESS and solar PV system must be completely disconnected from the EUC grid using a physical switch before operating in island mode. During a grid outage, the solar PV system must remain isolated from the grid, and the BESS and solar PV system can only be connected one after another after confirming that the grid connection has been fully disconnected. The system must also have protection to ensure that electricity from the BESS or solar PV does not flow back into the EUC network during island operation. When the grid supply returns, the BESS must be immediately disconnected, and reconnection to the EUC network is only allowed after confirming that all safety and isolation requirements have been met.

10.3 Interconnection Operation Manual : Interconnection Operation Manual (IOM) is to be prepared by the Solar ATAP Consumer for indirect Solar PV power generation system >425kW.

10.4 Labelling : Labels shall be clearly placed to remind the operator that the device should be access cautiously as there could be an energised part that comes from the indirect solar PV power generation system.

Test before touch must be practiced.

11.0 Technical Information Required for Application

11.1 Introduction : The application workflows shall follow Schedule 2 of the main Guidelines for Solar Photovoltaic Installation Under the Programme of Solar ATAP in Peninsular Malaysia.

Technical assessment study for Solar ATAP programme is described in table below:

Table 11.1: Technical Assessment Study

Voltage Level	LV (1ph)	LV (3ph)	LV (1ph)	LV (3ph)	LV (3ph)	MV	MV
Capacity per account	≤5kW	≤15kW	>5kW	>15kW	>72kW	<425kW	>425kW
Domestic below 72kW	No Study		Require Connection Confirmation Check (CCC)				
Domestic-Group (New development with solar rooftop)	Require Connection Assessment Study (CAS)						
Domestic & Non-domestic					Require Connection Assessment Study (CAS)	Require Connection Assessment Study (CAS)	Require Connection Assessment Study (CAS) including Fault Current Analysis

*Notes: For developer driven solar installation, the MD will be based on total aggregated MD.

A technical assessment study is required to ensure the distribution network remains safe, reliable, and efficient, which includes:

a. Connection Confirmation Check (CCC)

A CCC for residential solar PV shall be carried out to verify the declared installed capacity (kW), current rating (A), voltage level (V), and the capability of the distribution network to safely accommodate the additional generation without compromising system reliability or network safety. CCC will be conducted by EUC.

b. Connection Assessment Study (CAS)

A CAS is required for all applications with solar PV installation with capacity exceeding 72kW for Non-Domestic Consumer and Domestic-Group in order to check the acceptability of the installation to be connected to the Supply System, and the cost to conduct the CAS shall be the responsibility of the Applicant.

11.2 Technical information : The following technical information is required to make assessment of the proposal.

Table 11.2: Technical information

	CAS and CCC
Project information	
Applicant identity	✓
Information of project	✓
Design	
SLD[1]	✓
Installed capacity	✓
Declared Annual Availability	✓
Expected commissioning	✓
Equipment datasheet	
Inverter/converter datasheet	✓
BESS datasheet	✓[2]
Prove of anti-islanding compliance	✓
Power limiting device datasheet	✓[3]
Penetration assessment	
Consumer 4-day load profile consisting of Friday to Monday	✓
Profile of Distributor licensee import-indirect Solar PV power generation system demand mix	✓
Confirmation of zero export / limit (if required)	✓

[1] SLD shall be endorsed by the Professional Engineer with Practicing Certificate. (PEPC)
[2] Required if BESS is made part of the system
[3]Exception could be considered if this feature is incorporated within BESS management system

12.0 Testing & Commissioning

12.1 Introduction : Solar ATAP Consumer is responsible to comply with the requirements stated in this chapter.

There are 3 types of testing required:

i. Inverter compliance tests
ii. Interconnection compliance tests
iii. Functionality of the island mode scheme (if applicable)

i) Inverter compliance test

Certified results of tests must be submitted for verification.

ii) Interconnection compliance tests

Prior to commissioning, the interconnection must be tested to ensure that the performance is up to the required standard, installations are according to the approved scheme, settings are done as approved, etc.

Connection of indirect Solar PV power generation system plant should not have detrimental impact to the operation of EUC's grid.

Tests to prove the following items shall be carried out in the commissioning process:

a) Anti-islanding on loss of mains,
b) Interlocking scheme (if any)
c) Equipment functional tests

iii) Functionality of the island mode scheme (if applicable)

Tests to prove the following items, shall be carried out in the commissioning process:

a) Functionality of the transfer switch together with BESS and solar PV during power outage
b) Functionality of the transfer switch together with BESS and solar PV during power restoration

12.2 Commissioning tests : Commissioning tests of the installation shall be carried out by the competent person appointed by Solar ATAP consumer.

All tests must be carried out by qualified testers in compliance with safety regulations. Test equipment must have valid calibration certificate.

12.3 Consumer Smart Inverter setting : All inverters installed for Solar ATAP shall comply with the setting stated in the Smart Inverter Functions and Setting attachment.

13.0 Operation and Maintenance

13.1 Introduction : Solar PV installation is owned and maintained by the Consumer

13.2 Boundary : Any failure of supply from EUC network including the bidirectional meter shall be rectified and normalized by EUC.

Any failure of the Consumer's electrical installation (after EUC meter) and solar PV system shall be rectified and normalized by the Consumer.

In the event of EUC supply failure, the Consumer has to ensure that there shall not be any reverse power/back feed from any internal source of generation (example solar PV, BESS, generator) to EUC network.

The Consumer is solely responsible for any accident/incident to human beings and equipment that may occur due to reverse power/back feed from any internal source of generation when the EUC network supply is off.

EUC reserves the right to disconnect EUC supply to Consumer at any time in the event of default as specified in the contract, damage to its network, meter, etc, or to prevent accident or damage.

ATTACHMENT A: Example on functionalities for Smart Inverter

Below are examples for the functionalities of smart inverters to be referred by Consumers.

- Continued growth of PV generation puts more challenges on grid network infrastructure designed for distribution from centralized energy sources. Advanced or smart inverter functions can help address the grid network stability problems posed by high levels of variable distributed generation

- Smart inverters are PV inverters that stay connected and provide additional functions to help actively support the grid network - mainly voltage and frequency. Smart Inverters able to receive commands from grid network operators and report information. Traditional inverters simply disconnected when the grid network voltage or frequency went out of range.

- Broadly, smart inverters provide some additional benefit to the grid network beyond simply converting direct-current (DC) electricity to alternating current (AC) from PV systems. They typically support overall grid network reliability by offering the following functions:

No.	Functions	Description	Setting	Reference
1	Anti-islanding Protection	Automatically disconnect during grid failure within certain duration. The duration is adjustable. Anti-islanding protection is to ensure inverter doesn't back-feed a disabled grid	LV : • Disconnect 2sec • Reconnect 2min MV: • Disconnect 2sec • Reconnect 5min	• Distribution Code: 7.8.3.5 - Protection and Control Requirements
2	Voltage and Frequency Ride-through Capability	Inverter must meet the mandatory and permissive operation requirements as well as the must trip limits when the AC grid voltage and frequency high or low limits are exceeded. Inverters support the grid during short duration voltage disturbances or frequency excursions. This function will help the grid to self-heal from a disturbance. During periods of (sometimes extreme) deviations in grid voltage and/or frequency, smart inverters are designed to remain connected to the grid and adjust their output to act as a counterbalance to frequency or voltage changes	LVRT/HVRT: Refer graph (Distribution Code) LFRT/HFRT: uninterrupted range 47Hz to 50.5Hz	• Distribution Code: 6.5.5.1 - Low Voltage Ride Through & 6.5.5.2 - Frequency disturbance

No.	Functions	Description	Setting	Reference
3	Ramp Rate Control	Ramp rate control for solar inverters manages the speed of solar power output fluctuations to ensure grid stability by limiting the rate of change in power, typically expressed as a percentage of the inverter's nominal power per minute. To help smooth transitions from one output level to the next. Supports grid by ramping up slowly giving the grid time to adjust to the PV energy coming back online.	Does not exceed 15% of rated capacity per minute. Applicable for capacity of 5MW and above	• Grid Code: CC6.4.12
4.	Reactive Power Control Functions	These functions allow the inverter to inject or absorb reactive power as needed to maintain a set power factor, regulate grid voltage within a specific range, or supply a constant amount of reactive power, often dynamically adjusting based on grid condition. • Variable Power Factor provides active voltage stabilization: • Grid voltage nominal, purely active power • Grid voltage high, add 'inductive' reactive power • Grid voltage low, add 'capacitive' reactive power • Adjusting VARs keeps grid voltage from oscillating; acts like a shock absorber The reactive power control can be achieved using 3 main controls: (a) Dynamic Volt/VAr Mode (voltage control) (b) Fixed power factor (pf control) (c) Fixed reactive power (eg: using switched reactor or capacitor)	Voltage range: (MV-11kV&33kV) ± 5% (LV- 230V & 400V) -6% +10% Power Factor range: 0.85 lagging to 0.9 leading	• Distribution Code: 5.4.4.1 - Voltage range, 6.5.5.5 - Reactive power, 7.8.3.8 - Power factor
5.	Active Power Control Functions Frequency-Watt (Droop Curve) and Volt-Watt	Support grid frequency and voltage by changing inverter wattage output: Help to stable the grid during an under/over frequency and voltage event by controlling the real output of the solar system. • Grid frequency/voltage nominal, inverter at max output • Grid frequency/voltage high, inverter curtails power • Grid frequency/voltage low, inverter increases power	Frequency range: 47Hz to 50.5Hz Voltage range: (MV-11kV&33kV) ± 5% (LV- 230V & 400V) -6% +10%	• Distribution Code: 6.5.5.4 - Droop curve, 5.4.41 - Voltage range & 6.5.5.3 - Power output management

No.	Functions	Description	Setting	Reference
6.	Data log/Memory card for event logs	Capture profile of networks parameters – Voltage, Current, Frequency, Power (active & reactive), power factors and events log. The data log can be used for troubleshooting and monitoring purposes.	N/A	Distribution Code: 6.8.1.3 - Distribution System Control Structure
7.	Remote monitoring and configurability	Able to control remotely using SCADA system (for capacity 1MW and above)	N/A	Distribution Code: 6.8.1.3 - Distribution System Control Structure