

## List of Abbreviation

AEPC	:	Alternative Energy Promotion Centre
AGM	:	Absorbed Glass Mat
CRI	:	Color Rendering Index
DOD	:	Depth of Discharge
ESAP	:	Energy Sector Assistance Programme
HVD	:	High Voltage Disconnect
IEC	:	International Electro technical Commission
IECEE	:	IEC System for Conformity testing and Certification of Electro technical Equipment and Components
Imp	:	Current at Maximum Power
LVD	:	Low Voltage Disconnect
LVR	:	Low Voltage Reconnect
MPPT	:	Maximum Power Point Tracker
NRREP	:	National Rural and Renewable Energy Programme
NS	:	Nepal Standard
PQ	:	Pre-Qualified
PV	:	Photovoltaic
RETS	:	Renewable Energy Test Station
RST	:	Random Sampling Test
PIT	:	Product Introduction Test
SHS	:	Solar Home System
SSHS	:	Small Solar Home System
STC	:	Standard Test Condition
TL	:	Tubular Lamp
Vmp	:	Voltage at Maximum Power
WLED	:	White Light Emitting Diode

# NEPAL PHOTOVOLTAIC QUALITY ASSURANCE (NEPQA)

## PREAMBLE

This technical standard for components of Solar Photovoltaic (PV) System, called Nepal Photovoltaic Quality Assurance (NEPQA) was first developed and adopted by Alternative Energy Promotion Centre/Energy Sector Assistance Programme (AEPC/ESAP) in December 2000 for dissemination of SHS under ESAP. The interim standard was needed due to absence of Nepal Standard (NS) for the components used in PV systems. It was revised for the first time in Nov 2002, second time in September 2005, third time in July 2009 and this is the fourth revision. Innovative technologies will be adopted accordingly.

NEPQA specifies the documents and technical requirements of the components used in PV application i.e Solar Home System (SHS), Small Solar Home System (SSHS) and Institutional PV applications, Institutional pumping PV system etc. Based on this document, Renewable Energy Test Station (RETS) will test and certify the quality of the PV systems and components used in PV application. This document is fully owned by AEPC , RETS and the entire PV sector.

RETS shall conduct two type of tests: Product Introduction Test (PIT) and Random Sampling Test (RST). Product Introduction Test is carried out to introduce Solar PV System and its components for the first time in the market. It is done before importing or locally manufacturing in bulk quantity. Importer / Manufacturer shall provide three samples of components for PIT testing. AEPC shall allow the importer / Manufacturer to import the goods only for the items that successfully pass Product Introduction Test.

Random Sampling Test is carried out by collecting random samples from the warehouse of the importer / manufacturer. On the importer's / manufacturer's request and based on the approved sampling plan RETS' technician will collect random samples from the available lot and conduct testing as per approved testing procedures. Before components are used ,they must pass Product Introduction test and Random sampling test.

## 1 VALITDITY OF DOCUMENT

This document replaces the existing NEPQA 2009 and will be effective from its approval date and shall remain valid until a new version formally replaces it.

This standard has been divided into two categories.

### **CATEGORY A: Subsidy Scheme:**

The components and systems to be installed under government subsidy scheme through AEPC as per the guidelines of subsidy delivery mechanism shall be tested and certified under this category.

## **CATEGORY B: Non- Subsidy Scheme:**

In this category, the components and systems for non-subsidy scheme shall be tested and certified. Any importer or manufacturer willing to test and certify the products from RETS falls in this category.

### **2. STANDARD FOR SUBSIDY PROGRAM**

#### **2.1 Minimum Required Standard of Solar PV System Components (Above 10 W<sub>p</sub>)**

##### **2.1.1 PV Module**

The PV module must be of a Crystalline Silicon (Mono Crystalline or Poly Crystalline) or a Thin film Type.

##### **2.1.1.1 Documents**

1. IEC certificate of PV module. Model/type of PV module must be mentioned in certificate.

- Mono Crystalline Silicon PV module and Poly Crystalline Silicon PV module must be tested and certified according to the standard-"IEC 61215 Edition 2 2005-04 (or EN 61215 Edition 2) - Crystalline Silicon Terrestrial Photovoltaic (PV)- Design Qualification and Type Approval".
- Thin-film PV modules must be tested and certified according to the standard - "IEC 61646 - Thin-film Terrestrial Photovoltaic (PV) Modules- Design Qualification and Type Approval".

The PV Module must be certified by a Certifying Body Testing Laboratory (CBTL) or National Certifying Body (NCB) enlisted in the IECCE website. The enlisted CBTL or NCB must have scope of PV Testing.

- 2 A letter provided by principal PV module Manufacturer in their letter head stating the warranty period for their PV module. The warranty period for PV Module must be at least 10 years against a maximum 10% reduction and 20 years against a maximum 20% reduction of output power at STC.
3. Local importer must provide Minutes of understanding (MoU) document between local importer and principle PV manufacturer, signed and stamped by authorized persons stating warranty period and after sales services for their PV Module. In case of local PV manufacturer, it has to provide document stating warranty period stated in clause 2 and after sales services for their module in their letter head signed and stamped by authorized person.
- 4 Catalogue and technical specification of PV module

### **2.1.1.2 Technical Requirements**

1. Indelible labels must be firmly fixed on the PV module, containing the following details:

- Name of the manufacturer
- Model/Type
- Manufacturer's serial number
- Maximum power in Watt Peak
- Open circuit voltage in Volt
- Short circuit current in Ampere
- Maximum rated voltage in Volt
- Maximum rated current in Ampere
- Brand (if applicable)

2. Electrical parameters of PV Module

- Deviation of maximum power from nominal values stated by the manufacturer must be within – 5% and +20% (minus five and plus twenty) at STC. In case of Thin-film type modules, deviation of maximum power will be measured after exposing the PV modules in ambient conditions for 380 KWh/m<sup>2</sup> (Equivalent to 80 days to attain stable state). However, if original PV manufacturer provides test certificate of stabilized power output of thin film module from accredited laboratory, the deviation of power will be measured without exposing in ambient condition.
  - The maximum rated Voltage (V<sub>mp</sub>) of the 36 cell Crystalline PV module must be at least 17V at STC . The maximum rated Voltage (V<sub>mp</sub>) of 72 cell PV module must be at least 34 V at STC.
  - The maximum rated Voltage (V<sub>mp</sub>) of the thin film PV module to be used for 12V system must be at least 17V at STC. And for 12X system voltage V<sub>mp</sub> must be at least 17X at STC, where X is a natural number.
3. The PV modules of size 40Wp or above must have inbuilt bypass diodes. Junction box need not be opened, if the principal PV manufacturer provides assurance in their letter head about the existence of bypass diode in the junction box.
4. The module efficiency for crystalline module must be at least 11% for above 10Wp to 50 Wp, 12% for above 50Wp to 100 Wp, and 14% for above 100Wp.
5. The module efficiency for thin film module must be at least 8% up to 100 Wp and 10% above 100Wp.

6. The Model , Serial Number and Brand Name must be laminated inside the Glass of PV Module up to 100Wp.For the PV Module greater than 100Wp must have Serial Number inside the glass of PV Module.

### **2.1.2 Battery**

The battery must be a deep cycle type and one of following category.

- I. Flooded lead acid battery :  
Vented; Tubular Plate
- II. Valve Regulated Lead acid battery: Tubular plate
  - a. AGM (Absorbed Glass Mat); Tubular Plate
  - b. GEL; Tubular Plate
  - c. Sealed Maintenance free; Tubular Plate
  - d. Maintenance free; Tubular Plate
- III. Lithium Ion(Li-Ion)
- IV. Nickel Hydride(Ni-MH)

#### **2.1.2.1 Documents**

1. Battery test certificate issued by third party

OR

A statement provided by principal battery manufacturer in their letter head describing the quality assurance and testing method used by them to assure that the battery meets the technical requirements stated in chapter 2.2.2.2 of this document.

2. Catalogue and technical specification of battery.
3. Local importer must provide Minutes of Understanding (MoU) document between local importer and principle battery manufacturer, signed and stamped by authorized persons stating warranty period of at least 3 years and after sales services for their battery. In case of local battery manufacture, it has to provide document stating warranty period of at least 3 years and after sales services for their battery in their letter head signed and stamped by authorized person.

#### **2.2.2.2 Technical Requirements**

1. The operational life cycle of 12 V tubular lead acid battery must be at least 3,000 cycles at 20% DoD and 1,000 cycles at 80% DoD.
2. The operation life cycle of Lithium Ion/Ni-MH battery must be at least 4,000 cycles at 20% DoD and 2,000 cycles at 80% DoD.
3. The operational life cycle of 2 V tubular plate lead acid battery must be at least 4,000 cycles at 20% DoD and 1,500 cycles at 80% DoD.
4. Deviation of battery capacity from its rated capacity must not exceed + 10% (plus ten) and -5 % ( minus five) within 10 cycles of the test. This clause is applicable to all the above mentioned battery.
5. The charge/discharge efficiency of the battery must not be less than 80%.
6. The manufacturer's serial number must be engraved on the outer surface of the battery
7. Flooded type battery, must have proper indicator for electrolyte level.
8. The following minimum information must be included on the label of the battery and the label must be screen printed on the battery casing:
  - Battery Manufacturer
  - Model/Brand and type
  - Rated capacity in Ampere-hours at the discharge rate C10.
  - Nominal voltage

### **2.1.3 Lamp**

The Lamp must be WLED Lamp

#### **2.1.3.1 White Light Emitting Diode (WLED)**

#### **2.3.3.2 Documents**

Lamp test certificate issued by third party

OR

A statement provided by principal lamp manufacturer in their letter head describing the quality assurance and testing method used by them to assure that the lamps meets the technical requirements stated in chapter 2.3.3.3 of this document.

1. Catalogue /Technical specification of the lamp and single WLED used in the Lamp.

2. A letter provided by principal WLED lamp manufacturer in their letter head mentioning the operational life of the WLED lamp to be at least 30,000 hours.
3. Local importer must provide Minutes of Understanding (MoU) document between local importer and principle WLED Lamp, signed and stamped by authorized persons stating warranty period of at least 3 years and after sales services for their lamp. In case of local lamp manufacturer, it has to provide document stating warranty period of at least 3 years and after sales services for their lamp in their letter head signed and stamped by authorized person.

### **2.3.3.3 Technical Requirement**

1. The viewing angle of individual WLED should not be less then 2x50° degree
2. The Luminous Efficacy of individual WLED must not be less than 100 lm/Watt.
3. The Color Rendering Index (CRI) of the WLED must not be less than 60 and the color temperature must be in the range of 5000°K to 6000°K.
4. In the lamp with multiple WLEDs, the WLEDs used must not differ by more than 10% in WLED parameters (forward voltage and color temperature) at specified current
5. Luminous efficacy or Luminous yield of WLED lamp must not differ by more than 5% from the initial value after burning for 200 continuous hours under constant current source.
6. WLED driver circuit efficiency must be at least 80%.
7. The Luminous Yield of WLED Lamp must be at least 85 Lumen/watt
8. The rated power of WLED Lamp must be at least 2 (Two) Watt.
9. The lamp must be protected against reverse polarity.
10. The following minimum information must be included in the firmly fixed or screen printed label of the WLED lamp:
  - Brand/Model and Serial Number
  - Nominal power in Watt
  - Nominal voltage

### **2.1.4 Charge Controller**

#### **2.4.4. 1 Documents**

1. Charge Controller test certificate issued by third party

OR

A statement provided by principal charge controller manufacturer in their letter head describing the quality assurance and testing method used by them to assure that the charge controller meets the technical requirements stated in chapter 2.4.4.2 of this document.

2. Catalogue and technical specification of charge controller
3. Local importer must provide Minutes of Understanding (MoU) document between local importer and principle Charge Controller manufacturer, signed and stamped by authorized persons stating warranty period of at least 3 years and after sales services for their Charge Controller. In case of local charge controller manufacturer, it has to provide document stating warranty period of at least 3 years and after sales services for their charge controller in their letter head signed and stamped by authorized person.

#### **2.4.4.2 Technical Requirement**

1. The charge controller must function in accordance with Pulse Width Modulation (PWM) principles or in MPPT principle.
2. a) For charge controller up to 12V/10Amp

Must have Deep discharge protection, without any option for manual de-activation.

Low Voltage Disconnection (LVD) must not be less than 11.4 V for 12V system. And for 12X system voltage, Low Voltage Disconnect (LVD) must be at least 11.4X. Where X is a natural number and setting point must be within +/- 2% at 25°C.

b) Charge controller higher than 12V/10Amp

Must have Deep discharge protection, with or without option for manual de-activation.

Low Voltage Disconnection (LVD) must not be less than 11.4 V for 12V system. And for 12X system voltage, Low Voltage Disconnect (LVD) must be at least 11.4X. Where X is a natural number and setting point must be within +/- 2% at 25°C.

3. Low Voltage Reconnection (LVR) must not be less than 12.5 V for 12V system. And for 12X system voltage, Low Voltage Reconnection (LVR) must be at least 12.5X. Where X is a natural number and setting point must be within +/- 2% at 25°C.
4. Over charge protection must be included. High Voltage Disconnection (HVD) must be within the range of (14 -15) V for 12V. And for 12X system voltage, High Voltage Disconnection (HVD) must be at least within the range of (14-15) X. Where X is natural number and setting point must be within +/- (plus and minus) 2% at 25°C. Manufacturer's claim at 25°C.



5. Usage of electro-mechanical relays is not permitted.
6. The quiescent current consumption (for PWM based controllers) must not exceed
  - a. 10 milli-amperes at nominal system voltage (the non-critical indicators are turned off) for charge controller sized up to 20 ampere.
  - b. 50 milli-amperes at nominal system voltage for charge controller sized above 20 ampere.
7. The quiescent current consumption (for MPPT based controllers) must not exceed
  - a. 50 milli-amperes at nominal system voltage (the non-critical indicators are turned off) for charge controller sized up to 20 ampere.
  - b. 150 milli-amperes at nominal system voltage for charge controller sized above 20 ampere.
8. The reverse leakage current must not exceed :
  - a. For PWM type charge controller 500 micro-ampere.
  - b. For MPPT type charge controller 2500 micro-ampere.

Note: Excluding quotient current consumption and reverse leakage current of MPPT type charge controller will be tested with the same procedure with that of PWM type.

9. For 12 volt systems, voltage drop across the charge controller when charging (PV panel to battery terminals) must not exceed 1 volt and when discharging (battery to load terminals) must not exceed 0.5 volt. And for 12X volt system, the voltage drop during the charging must not exceed X volt and when discharging it must not exceed 0.5X volt, where X is a natural number.
10. The charge controller must withstand rated current from the PV module to battery and from battery to load at an ambient temperature range of  $-5^{\circ}\text{C}$  to  $40^{\circ}\text{C}$ .
11. Protection against reverse polarity must be provided in both the PV module and battery sides.
12. Short circuit protection must be included on load side.
13. Reverse leakage current must be less than 500 micro-ampere (current from battery to module, when module is exposed to sun)
14. The allowable Printed Circuit Board (PCB) for solar charge controller is
  - Glass epoxy

- Metal core printed circuit board(MCPCB)
15. Charge controller boxes should display good workmanship and should have protection against direct entry of dust, moisture, oil, and smoke etc.
16. Charge controller inbuilt with mobile charger must have SMPS function.
17. The following minimum information must be included at the label of the charge controller and the label must be firmly fixed or screen printed on the charge controller:
- Manufacturers name
  - Brand/Model
  - Serial Number
  - Maximum input current
  - Maximum load current

**Note:** If mobile charger(SMPS) not integrated in the charge controller, company /importer must provide charge controller along with SMPS based mobile charger to the RETS.

## **2.2 MINIMUM REQUIRED STANDARDS OF SMALL SOLAR HOME SYSTEM (SSHS)**

### **2.2.1 PV Module**

#### **2.2.1.1 Required Documents**

1. Mono Crystalline Silicon PV module and Poly Crystalline Silicon PV module must be tested and certified according to the standard-"IEC 61215 Edition 2 2005-04 (or EN 61215 Edition 2) - Crystalline Silicon Terrestrial Photovoltaic (PV)- Design Qualification and Type Approval".

- The PV Module must be certified by a Certifying Body Testing Laboratory (CBTL) or National Certifying Body (NCB) enlisted in the IECEE website. The enlisted CBTL or NCB must have scope of PV Testing.
2. A letter provided by principal PV module Manufacturer in their letter head stating the warranty period for their PV module. The warranty period for PV Module must be at least 10 years against a maximum 10% reduction and 20 years against a maximum 20% reduction of output power at STC.
3. Local importer must provide Minutes of Understanding (MoU) document between local importer and principle PV manufacturer, signed and stamped by authorized persons stating warranty period and after sales services for their PV Module. In case of local manufacturer, it has to provide document stating warranty period stated in clause 2 and after sales services for their module in their letter head signed and stamped by authorized person.
4. Catalogue and technical specification of the PV modules

#### **2.2.1.1 Technical Requirement**

1. The PV module must be of Crystalline Silicon type (Mono/Poly). The electrical parameter of the module needs to be tested and certified by Renewable Energy Test Station (RETS).
- The deviation of maximum power from its nominal values stated by the manufacturer must be within -5% to +20% (minus five to plus twenty) at STC.
  - The maximum rated Voltage ( $V_{mp}$ ) to be used for 12V must be at least 17V at STC.
2. Indelible labels must be firmly fixed on the PV module, containing the following details:
- Name of the manufacturer
  - Brand/Model
  - Maximum power in Watt Peak
  - Maximum rated voltage in Volt

- Maximum rated current in Ampere
  - Serial Number of PV Module
3. The Brand, Model and Serial Number of the modules must be inside the glass of the PV Module.
  4. The module efficiency must not be less than 10%.

### **2.2.2 Battery**

A: The battery must be rechargeable maintenance free deep cycle type with one of following category.

- I. Valve Regulated Lead Acid ( VRLA) battery ; Tubular
  - a. AGM (Absorbed Glass Mat); Tubular
  - b. GEL: Tubular
- II. Lithium Ion Battery
- III. Nickel Metal Hydride Battery

B: Flooded tubular or GEL Flat plate till the end of December 2013

#### **2.2.2.1 Documents**

1. Battery test certificate issued by third party

OR

A statement provided by principal battery manufacturer in their letter head describing the quality assurance and testing method used by them to assure that the battery meets the technical requirements stated in chapter 2.2.2.2 of this document.

2. Catalogue and technical specification of battery.
3. Local importer must provide Minutes of Understanding (MoU) document between local importer and principle battery manufacturer, signed and stamped by authorized persons stating warranty period of at least 3 years and after sales services for their battery. In case of local battery manufacture, it has to provide document stating warranty period of at least 3 years and after sales services for their battery in their letter head signed and stamped by authorized person.

#### **2.2.2.2 Technical Requirements**

1. The operational life cycle of 12 V lead acid batteries must be at least 3,000 cycles at 20% DoD.

2. The operational life cycle Li-Ion and Ni-MH batteries must be at least 4,000 cycles at 20% DoD.
3. Deviation of battery capacity from its rated capacity must not exceed + 10% (plus ten) and -5 % (minus five) within 10 cycles of the test. This clause is also applicable to Li-Ion and Ni-MH battery.
4. The charge/discharge efficiency of the battery must not be less than 80%.
5. The manufacturer's serial number must be engraved on the outer surface of the battery
6. The following minimum information must be included on the label of the battery and the label must be screen printed on the battery casing.
  - Battery Manufacturer
  - Model/Brand and type
  - Rated capacity in Ampere-hours at the discharge rate C10
  - Nominal voltage

### **2.2.3 Charge Controller**

#### **2.2.3.1 Documents**

1. Charge Controller test certificate issued by third party

OR

A statement provided by principal charge controller manufacturer in their letter head describing the quality assurance and testing method used by them to assure that the charge controller meets the technical requirements stated in chapter 2.2.3.2 of this document.

2. Catalogue and technical specification of charge controller
3. Local importer must provide Minutes of Understanding (MoU) document between local importer and principle charge controller, signed and stamped by authorized persons stating warranty period of at least 3 years and after sales services for their charge controller. In case of local manufacturer, it has to provide document stating warranty period of at least 3 years and after sales services for their charge controller in their letter head signed and stamped by authorized person.

#### **2.2.3.2 Technical Requirement**

##### **A. Compulsory:**

1. The charge controller must function in accordance with Pulse Width Modulation (PWM) principles or in MPPT principle.
2. Deep discharge protection, without any option for manual de-activation, must be included. Low Voltage Disconnection (LVD) must not be less than 11.4 V for 12V system and setting point must be within +/- 2% at 25°C.
3. Low Voltage Reconnection (LVR) must not be less than 12.5 V for 12V system and setting point must be within +/- 2% at 25°C.
4. Over charge protection must be included. High Voltage Disconnection (HVD) must be within the range of (14 -15)V for 12V and setting point must be within +/- (plus and minus) 2% at 25°C.
5. Usage of electro-mechanical relays is not permitted.
6. The quiescent current consumption (for PWM based controllers) must not exceed 10 milli-amperes at nominal system voltage (the non-critical indicators are turned off) for charge controller sized up to 20 ampere.
7. For 12 volt systems, voltage drop across the charge controller when charging (PV panel to battery terminals) must not exceed 1 volt and when discharging (battery to load terminals) must not exceed 0.5 volt.
8. The charge controller must withstand rated current from the PV module to battery and from battery to load at an ambient temperature range of -5° C to 40° C.
9. Protection against reverse polarity must be provided in both the PV module and battery sides.
10. Short circuit protection must be included on load side.
11. Reverse leakage current must be less than 500 micro-ampere (current from battery to module, when module is exposed to sun)
13. The allowable Printed Circuit Board (PCB) for solar charge controller is
  - Glass epoxy
  - Metal core printed circuit board(MCPCB)
- 14 Charge controller boxes should display good workmanship and should have protection against direct entry of dust, moisture, oil, and smoke etc.
15. Charge controller inbuilt with mobile charger must have SMPS function.
16. The following minimum information must be included at the label of the charge controller and the label must be firmly fixed on the charge controller:

- Manufacturers name
- Brand/Model
- Serial Number
- Maximum input current
- Maximum load current

**Note:** If mobile charger(SMPS) not integrated in the charge controller, company /importer must provide charge controller along with SMPS based mobile charger to the RETS.

## **2.2.4 Lamp**

### **2.2.4.1 Required Documents**

The Lamp must be of White LED(s).

1 Lamp test certificate issued by third party.

OR

A statement provided by WLED lamp manufacturer in their letter head describing the quality assurance that the lamps meet the technical requirements as defined in the 2.2.4.2.

2. Catalogue / Technical specification of the lamp and individual WLED used in the lamp

3. A letter provided by the principal manufacturer in their letter head mentioning the operation life of the WLED lamp to be at least 30,000 hours.

4. Local importer must provide Minutes of Understanding (MoU) document between local importer and principle WLED lamp manufacturer, signed and stamped by authorized persons stating warranty period of at least 3 years and after sales services for their lamp. In case of local manufacturer, it has to provide document stating warranty period of at least 3 years and after sales services for their WLED lamp in their letter head signed and stamped by authorized person.

### **2.2.4.2 Technical Requirement**

1. The viewing angle of individual WLED should not be less than 2x50° degree

2. The Luminous Efficacy of individual WLED, the Luminous Efficacy must not be less than 100 lm/Watt.

3. The Color Rendering Index (CRI) of the WLED must not be less than 60 and the color temperature must be in the range of 5000°K to 6000°K.

4. In the lamp with multiple WLEDs, the WLEDs used must not differ by more than 10% in WLED parameters (forward voltage and color temperature) at specified current
5. Luminous efficacy or Luminous yield of WLED lamp must not differ by more than 5% from the initial value after burning for 200 continuous hours under constant current source.
6. WLED driver circuit efficiency must be at least 80%.
7. The Luminous Yield of the WLED Lamp must be at least 85 Lumen/watt.
8. The rated power of WLED Lamp must be at least 2(two) Watt.
9. The lamp must be protected against reverse polarity.
10. The following minimum information must be included in the firmly fixed or screen printed label of the WLED lamp:
  - Brand/Model and Serial Number
  - Nominal power in Watt
  - Nominal voltage

## **2.2.5. Mounting Structure for PV Modules**

### **2.2.5.1 Documents:** None

### **2.2.5.2 Technical Requirement**

1. Support frame structures must be made of corrosion resistant metallic frame; i.e. aluminum with minimum thickness of 3mm.
2. Height of the mounting pole must be at least 30 cm from the holding surface.

## **2.2.6 Cables**

**2.2.6.1 Document:** Cable used should meet Nepal Standard or International quality standard Certified

### **2.2.6.2 Technical Requirement**

1. The size of the cable used for 10Wp to less than 20Wp PV system must be multi-strand DC cable having at least 10 strands for 1.0 mm<sup>2</sup> cables (Charge controller to Battery section) and at least 5 strands for 1.0 mm<sup>2</sup> cables (Junction box to load section).
2. The reference size of the cable used for Solar Home system as per annex 1.



3. The Cable sections, which are used out door, especially between the PV module and charge controller must be UV resistant. The size of two cores multi-strand UV cable for 10Wp System must be at least  $1.0 \text{ mm}^2$  (for individual cable)
4. U clips and cable shoes must be used to firmly connect the cables at the terminal of battery and charge controller.
5. Cables must be color coded or with proper polarity identification code in accordance with the existing electric coding norms.

**Note:** Size of cable used for SPV system is indicative. Therefore, company/importer can provide the appropriate or larger size of the cables using following formula for the system above 55Wp

PV System. 
$$S = \frac{0.3LI_m}{\Delta V}$$

Where, S - Required wire size (cross-sectional area of the copper wire in sq.mm),

L - Length of the wire in meters,

$I_m$  – The maximum current in Ampere, and

$\Delta V$  – Maximum allowable voltage drop in percent. (i.e. 3%)

## **2.2.7. Switches, Sockets, Junction Box and Protections**

### **2.2.7.1 Documents: None**

### **2.2.7.2 Technical Requirement**

**2.2.7.3** DC sockets must be used with a reverse polarity protection or three pin DC sockets must be used.

## **2.2.8 Solar Inverter**

### **2.2.8.1 Required parameters:**

The minimum information must be included in the label of the inverter:

- i. Manufacturers' name and model
- ii. Rated power in Watt or VA
- iii. Input and output voltage in Volt
- iv. Charging current, load current, power factor, efficiency
- v. Inverter Type

### **2.2.8.2 Technical Requirement**

1. The Inverter must have a rated AC output voltage of  $220V \pm 5\%$  at battery operating voltage from DC 90% to 120% and maximum load current from 10% to 110% of the rated value.
2. Inverter efficiency when operating with resistive loads at full load must be at least 90%.
3. The quiescent current drawn by the inverter must not exceed 1% of the rated current of the inverter.
4. Inverter or Inverter circuits must include:
  - 4.1 Low battery shut down must be at battery voltage not less than 10.5 V for tubular plate battery in case of 12 V systems. For 24 V or 48V systems, low battery shut down voltage must be multiplied by factor  $10.5 \times N$ . Here N stands for the number of 12 V batteries in a series connection.
  - 4.2 Short-circuit protection of input and output terminals
  - 4.3 Reverse polarity protection on DC input terminals
  - 4.4 Appropriate indicators: main, charging, inverter ON, short circuit and overload
    - a. The inverter must have either cooling system with fan or appropriate heat sink to avoid excessive heating.
    - b. The inverter input and output terminals must have protection measures from external contacts
    - c. The inverter must have a power saving/Sleep mode.
    - d. The inverter must not produce noise more than 60db at 2m.
- 5 Output frequency of the inverter must be  $50\text{Hz} \pm 2\%$ .
6. The output waveform's Total Harmonic Distortion (THD) must be less than 5% at full load.
7. Inverter must be capable of :
  - i. Operating safely for at least one minute at 125% of rated power.
  - ii. Operating safely for at least ten seconds at 150 % of rated power.
  - iii. Operating safely for at least five second at 200% of rated power.
- 8.Complete documentation for the inverter including the following must be provided:
  - i. Installation instructions
  - ii. Operating instructions
  - iii. Technical specification and ratings
  - iv. Safety warnings
  - v. Warranty for 2 years

## **2.2.9 Solar Pump:**

### **2.2.9.1 Required Documents**

The manufacturers or installing companies has to provide test certificates of Solar Pump from reputed the third party agencies according to the national or international standard. The accepted quality certification systems are:

- IEC Certificate or Certificate according to the ISO 9000 series or Quality assurance certificate issued by international reputed agencies like DNV, TUV, Loyds Register, Germanischer, Bureau of Veritas, UL or quality assurance certification from national or international laboratory /institutions.

### **2.2.9.2 Technical Requirement:**

The pump can be centrifugal, positive displacement, progressive cavity, submersible or surface type with the following parameters:

1. Pump motor efficiency must be at least 55%.
2. The pump must have thermal protection against overload, reverse polarity and temperature
3. The pump or pump set must have control circuit with MPPT facility.
4. The pump must use standard submersible cable for submersible pump.
5. The pump or pump set must have provision of stopping operation under dry running or insufficient energy supply.
6. The pump must have protection against sand, and silt.
7. Indelible label must be fixed on the pump, containing the following details:
  - Name of the manufacturers or distinctive logo
  - Model and serial number

**Note:** At present, the testing facility of pump is not available, Therefore, RETS will verify the pumps parameters from the submitted documents.

### **3. STANDARD FOR NON SUBSIDY SCHEME**

#### **3.1 Minimum Required Standard for PV System (10 W<sub>p</sub> and above )**

##### **3.1.1 PV Module**

The PV module must be of a Crystalline Silicon (Mono Crystalline or Poly Crystalline) or a Thin film Type.

##### **3.1.1.1 Documents**

1. IEC certificate of PV module. Model/type of PV module must be mentioned in certificate.

- Mono Crystalline Silicon PV module and Poly Crystalline Silicon PV module must be tested and certified according to the standard-"IEC 61215 Edition 2 2005-04 (or EN 61215 Edition 2) - Crystalline Silicon Terrestrial Photovoltaic (PV)- Design Qualification and Type Approval".

- Thin-film PV modules must be tested and certified according to the standard - "IEC 61646 - Thin-film Terrestrial Photovoltaic (PV) Modules- Design Qualification and Type Approval".

The PV Module must be certified by a Certifying Body Testing Laboratory (CBTL) or National Certifying Body (NCB) enlisted in the IECCE website. The enlisted CBTL or NCB must have scope of PV Testing.

2 A letter provided by principal PV module Manufacturer in their letter head stating the warranty period for their PV module. The warranty period for PV Module must be at least 10 years against a maximum 10% reduction and 20 years against a maximum 20% reduction of output power at STC.

3. Catalogue and technical specification of PV module

##### **3.1.1.2 Technical Requirements**

1. Indelible labels must be firmly fixed on the PV module, containing the following details:

- Name of the manufacturer
- Model/Type
- Manufacturer's serial number
- Maximum power in Watt Peak
- Open circuit voltage in Volt

- Short circuit current in Ampere
- Maximum rated voltage in Volt
- Maximum rated current in Ampere
- Brand (if applicable)

## 2. Electrical parameters of PV Module

- Deviation of maximum power from nominal values stated by the manufacturer must be within – 5% and +20% (minus five and plus twenty) at STC. In case of Thin-film type modules, deviation of maximum power will be measured after exposing the PV modules in ambient conditions for 380 KWh/m<sup>2</sup> (Equivalent to 80 days to attain stable state). However, if original PV manufacturer provides test certificate of stabilized power output of thin film module from accredited laboratory, the deviation of power will be measured without exposing in ambient condition.
  - The maximum rated Voltage (Vmp) of the 36 Cells PV modules must be at least 17V at STC. The Vmp of the module increases with the same ratio of increase in number of cells in a module. i.e (  $V_{mp} = K * \text{Number of Cells}$ ) where K is proportional constant for 36 cells module.
3. The PV modules of size 40Wp or above must have inbuilt bypass diodes. Junction box need not be opened, if the principal PV manufacturer provides assurance in their letter head about the existence of bypass diode in the junction box.
  4. The module efficiency for crystalline module must be at least 10% for 10Wp, 11% for above 10Wp to 50 Wp, 12% for above 50Wp to 100 Wp, and 14% for above 100Wp.
  5. The module efficiency for thin film module must be at least 8% for up to 100 Wp and 10% for above 100Wp.
  6. For Pv Module Up to 100 Wp,the Brand Name, Model and Serial Number of the module must be inside the glass of the PV Module.
  - 7 For Pv Module Greater then 100 Wp,The Serial Number of the module must be inside the glass of the PV Module

### 3. 1. 2 Battery

The battery must be a deep cycle type and one of following category.

- I. Flooded lead acid battery :
  - a. Vented: Tubular / Flat Plate
  - b. Sealed (valve regulated) : Tubular Plate/Flat

## II. Valve Regulated Lead Acid battery; Tubular/Flat

- a. Absorbed Glass Mat(AGM)
- b. Gel
- c. Maintenance free ; Tubular/Flat

## III. Li-Ion

## IV. Ni-MH

### **3.1.2.1 Documents**

1. Battery test certificate issued by third party

OR

A statement provided by principal battery manufacturer in their letter head describing the quality assurance and testing method used by them to assure that the battery meets the technical requirements stated in chapter 3.1.2.2 of this document.

2. Catalogue and technical specification of battery.

### **3. 1.2.2 Technical Requirements**

1. The operational life cycle of 12 V battery must be at least 3,000 cycles at 20% DoD and 1,000 cycles at 80% DoD for tubular plate type.
2. The operational life cycle of 12 V lead acid battery must be at least 1,800 cycles at 20% DoD and 250 cycles at 80% DoD for flat plate type.
3. The operational life cycle of 2 V lead acid battery must be at least 4,000 cycles at 20% DoD and 1,500 cycles at 80% DoD for tubular plate type.
4. The operational life cycle of Lithium Ion and Nickel Metal Hydride battery must be at least 3,000 cycles at 20% DoD.
5. Deviation of battery capacity from its rated capacity must not exceed + 10% (plus ten) and -5 % ( minus five) within 10 cycles of the test. This clause is available for all above mentioned batteries.
6. The charge/discharge efficiency of the battery must not be less than 80%.
7. The manufacturer's serial number must be engraved on the outer surface of the battery
8. Flooded type battery, must have electrolyte level indicator.
9. The following minimum information must be included on the label of the battery and the label must be screen printed on the battery casing:

- Battery Manufacturer
- Model/Brand and type
- Rated capacity in Ampere-hours at the discharge rate C20 or C10 or C5
- Nominal voltage

### **3.1.3 Lamp**

The Lamp must be one of following type;

#### **I. Fluorescent Lamp**

a. Compact Fluorescent Lamp (CFL)

b. Tubular Lamp (TL)

#### **II. White Light Emitting Diode (WLED) Lamp**

### **3.1.3.1 Fluorescent Lamp (CFL or TL)**

#### **3.1.3.1.1 Documents**

1. Lamp test certificate issued by third party

OR

A statement provided by principal lamp manufacturer in their letter head describing the quality assurance and testing method used by them to assure that the lamps meets the technical requirements stated in chapter 3.1.3.1.2 of this document.

2. Catalogue and technical specification of fluorescent lamp.

#### **3.1.3.1.2 Technical Requirement**

1. Luminous yield of the total ballast and lamp system must be at least 45 lumens/Watt within 15 minutes after switching on.
2. Reduction in the output (reference lumen) must not exceed 10% following 1,000 on/off cycles and must not exceed 30% following 5,000 on/off cycles.
3. Ballast must ensure safe and regulated ignition within 10 seconds in the voltage range from 10.3 to 15V over temperature range of  $-5^{\circ}$  C to  $+40^{\circ}$  C.
4. The electrical efficiency of the lamp (ballast and tube combined) must be at least 70% at 12 Volt.

5. The lamp must be protected against reverse polarity.
6. Standby consumption (in no-tube condition) of ballast must be less than 20% of rated or nominal capacity.
7. The following minimum information must be included in the label of the lamp and the label must be firmly fixed on front side of lamp.
  - Name of the Manufacturer/Company
  - Brand/Model and Serial Number
  - Nominal power in Watt
  - Permitted tube size(s) in Watt
  - Nominal voltage in Volt

### **3.1.3.1.2 Fluorescent Lamp Tube**

#### **3.1.3.1.2.1 Documents None**

#### **3.1.3.1.2.2 Technical Requirement**

1. Tube for compact fluorescent lamp (CFL) or Tubular Lamp (TL) when tested with the ballast used must fulfill criteria 1- 4 mentioned in clause 3.1.3.1.2.

### **3.1.3.1.3 WLED Lamp**

#### **3.1.3.1.3.1 Documents**

Lamp test certificate issued by third party

OR

A statement provided by principal lamp manufacturer in their letter head describing the quality assurance and testing method used by them to assure that the lamps meets the technical requirements stated in chapter 3.1.1.3.2 of this document.

1. Catalogue /Technical specification of the lamp and single WLED used in the Lamp.
2. A letter provided by principal WLED lamp manufacturer in their letter head mentioning the operational life of the WLED lamp to be at least 30,000 hours.

#### **3.1.1.3.2 Technical Requirement**

1. The viewing angle of individual WLED should not be less than 2x50° degree



2. The Luminous Efficacy of individual WLED must not be less than 100 lm/Watt.
3. The Color Rendering Index (CRI) of the WLED must not be less than 60 and the color temperature must be in the range of 5000°K to 6000°K.
4. In the lamp with multiple WLEDs, the WLEDs used must not differ by more than 10% in WLED parameters (forward voltage and color temperature) at specified current
5. Luminous efficacy or Luminous yield of WLED lamp must not differ by more than 5% from the initial value after burning for 200 continuous hours under constant current source.
6. WLED driver circuit efficiency must be at least 80%.
7. The Luminous Yield of WLED Lamp must be at least 85 Lumen/watt
8. The rated power of WLED Lamp must be at least 1(one) Watt.
9. The lamp must be protected against reverse polarity.
10. The following minimum information must be included in the label of the WLED lamp:
  - Brand/Model and Serial Number
  - Nominal power in Watt
  - Nominal voltage

### **3.1.4 Charge Controller**

#### **3.1.4.1 Documents**

1. Charge Controller test certificate issued by third party

OR

A statement provided by principal charge controller manufacturer in their letter head describing the quality assurance and testing method used by them to assure that the charge controller meets the technical requirements stated in chapter 3.1.4.2 of this document.

2. Catalogue and technical specification of charge controller

#### **3.1.4.2 Technical Requirement**

1. . The charge controller must function in accordance with Pulse Width Modulation (PWM) principles or in MPPT principle.
2. a) For charge controller up to 12V/10Amp

Must have Deep discharge protection, without any option for manual de-activation.

Low Voltage Disconnection (LVD) must not be less than 11.4 V for 12V system. And for 12X system voltage, Low Voltage Disconnect (LVD) must be at least 11.4X. Where X is a natural number and setting point must be within +/- 2% at 25°C.

b) Charge controller higher than 12V/10Amp

Must have Deep discharge protection, with or without option for manual de-activation.

Low Voltage Disconnection (LVD) must not be less than 11.4 V for 12V system. And for 12X system voltage, Low Voltage Disconnect (LVD) must be at least 11.4X. Where X is a natural number and setting point must be within +/- 2% at 25°C.

3. Low Voltage Reconnection (LVR) must not be less than 12.5 V for 12V system. And for 12X system voltage, Low Voltage Reconnection (LVR) must be at least 12.5X. Where X is a natural number and setting point must be within +/- 2% at 25°C.
4. Over charge protection must be included. High Voltage Disconnection (HVD) must be within the range of (14 -15) V for 12V. And for 12X system voltage, High Voltage Disconnection (HVD) must be at least within the range of (14-15) X. Where X is natural number and setting point must be within +/- (plus and minus) 2% at 25°C. Manufacturer's claim at 25°C.
5. Usage of electro-mechanical relays is not permitted.
6. The quiescent current consumption (for PWM based controllers) must not exceed
  - a. 10 milli-amperes at nominal system voltage (the non-critical indicators are turned off) for charge controller sized up to 20 ampere.
  - b. 50 milli-amperes at nominal system voltage for charge controller sized above 20 ampere.
7. The quiescent current consumption (for MPPT based controllers) must not exceed
  - a. 50 milli-amperes at nominal system voltage (the non-critical indicators are turned off) for charge controller sized up to 20 ampere.
  - b. 150 milli-amperes at nominal system voltage for charge controller sized above 20 ampere.
8. The reverse leakage current must not exceed :
  - a. For PWM type charge controller 500 micro-ampere.
  - b. For MPPT type charge controller 2500 micro-ampere.

Note: Excluding quotient current consumption and reverse leakage current of MPPT type charge controller will be tested with the same procedure with that of PWM type.

9. For 12 volt systems, voltage drop across the charge controller when charging (PV panel to battery terminals) must not exceed 1 volt and when discharging (battery to load terminals) must not exceed 0.5 volt. And for 12X volt system, the voltage drop during the charging must not exceed X volt and when discharging it must not exceed 0.5X volt, where X is a natural number.
10. The charge controller must withstand rated current from the PV module to battery and from battery to load at an ambient temperature range of  $-5^{\circ}\text{C}$  to  $40^{\circ}\text{C}$ .
11. Protection against reverse polarity must be provided in both the PV module and battery sides.
12. Short circuit protection must be included on load side.
13. Reverse leakage current must be less than 500 micro-ampere (current from battery to module, when module is exposed to sun)
14. The allowable Printed Circuit Board (PCB) for solar charge controller is
  - Glass epoxy
  - Metal core printed circuit board(MCPCB)
15. Charge controller boxes should display good workmanship and should have protection against direct entry of dust, moisture, oil, and smoke etc.
16. Charge controller inbuilt with mobile charger must have SMPS function.
17. The following minimum information must be included at the label of the charge controller and the label must be firmly fixed or screen printed on the charge controller:
  - Manufacturers name
  - Brand/Model
  - Serial Number
  - Maximum input current
  - Maximum load current

**Note:** If mobile charger(SMPS) not integrated in the charge controller, company /importer must provide charge controller along with SMPS based mobile charger to the RETS.

## **3.2 Minimum Required Standard of PV System Components (Less than 10Wp to 5Wp)**

### **3.2.1 PV Module**

#### **3.2.1.1 Required Documents**

1. A letter provided by PV manufacturer in their letter head stating the warranty period of the PV Module. The warranty period of Solar PV Module must be at least 10 years against maximum 10% reduction in output power at STC.
2. The PV module must have IEC certification in its larger sized module.
3. Catalogue and technical specification of the PV modules

#### **3.2.1.2 Technical Requirement**

1. The PV module must be of Crystalline Silicon. The electrical parameter of the module needs to be tested and certified by Renewable Energy Test Station (RETS).
  - The maximum rated voltage ( $V_{mp}$ ) of the PV modules to be used for 12V systems must be at least 17 V at STC. For system less than 12V, the  $V_{mp}$  of the module must be 33% higher than the system voltage at STC.
2. A nameplate must be mounted on the PV module frame with the following details:
  - Name of the manufacturer
  - Model or Type No.
  - Maximum power in Watt Peak
  - Maximum rated voltage in Volt
  - Maximum rated current in Ampere
  - Serial Number of PV Module

### **3.1. 2 Battery**

#### **3.2.2.1 Required Documents**

1. A letter provided by principle battery manufacturers in their letter head mentioning the warranty for at least 2 years
2. The operational life cycle of the VRLA battery must be at least 1000 cycles at 30 % DoD and at least 1000 cycle at 50 % DoD for NiMH/Li-Ion batteries.
3. Catalogue and technical specification of the battery.

#### **3.2.2.2 Technical Requirement**

1. The battery can be rechargeable Nickel Metal Hydride (Ni-MH) or Lithium Ion (Li-Ion) or Valve Regulated Lead Acid (VRLA).
2. The capacity of battery can be up to 10Ah.
3. The deviation of battery capacity from its rated capacity stated by the manufacturer must not exceed the limit of -10% to +20% (minus 10% to plus 20%) within 5 cycles of test.
4. The following minimum information must be included in the label of the battery:
  - Brand and name of the manufacturer
  - Model/Type
  - Rated capacity in Ampere-hours
  - Nominal voltage in Volt

### **3.2.3 Charge Controller**

#### **3.2.3.1 Technical Requirement**

1. Charge controller must be of Pulse Width Modulation (PWM) type and should have the following settings:

##### **For 12V VRLA,**

- Low voltage disconnect: not less than 11.4 Volt and setting point must be within +/- 2% at 25°C
- High voltage disconnect: 14 Volt – 14.5 Volt and setting point must be within +/- 2% at 25°C
- Low voltage reconnection: not less than 12.5V and setting point must be within +/- 2% at 25°C

##### **For 6 V VRLA,**

- Low voltage disconnect: not less than 5.7 and setting point must be within +/- 2% at 25°C

- High voltage disconnect: 7 Volt – 7.25 Volt and setting point must be within +/- 2% at 25°C
- Low voltage reconnection: not less than 6.25 Volt and setting point must be within +/- 2% at 25°C

**For 3.6 V Ni-MH or Lithium ion,**

- High voltage disconnect: 4.2 – 4.5 Volt and setting point must be within +/- 2% at 25°C

**For 1.8 V Ni-MH or Lithium ion,**

High voltage disconnect: 2.1 – 2.25 Volt and setting point must be within +/- 2% at 25°C

**For 1.2 V Ni-MH or Lithium ion,**

High voltage disconnect: 1.4 – 1.5 Volt and setting point must be within +/- 2% at 25°C.

### **3.2.4 Lamp**

#### **3.2.4.1 Required Documents**

The Lamp must be of White LED(s).

1. Lamp test certificate issued by third party.

OR

A statement provided by WLED lamp manufacturer in their letter head describing the quality assurance that the lamps meet the technical requirements as defined in the **3.2.5**

#### **3.2.5 Technical Requirement**

1. A viewing angle of individual WLED must be equal to or greater than 2\*50 degree.
2. The luminous Efficacy(lm/w) of individual WLED must be at least 100 Lumen/Watt
3. WLED driver circuit efficiency must be at least 80%.
4. Luminous Efficacy (lm/w) of WLED lamp must not differ by more than 5 % after 200 hours of continuous burning from its original value.
5. The Color Rendering Index (CRI) of the WLED must not be less than 60 and the color temperature must be in the range of 5000°K to 6000°K.
6. The lamp and its enclosure should display good workmanship and should provide protection against dust, oil, and smoke.

##### **3.2.5.1 The Solar PV system should have following features.**

- At least two units of WLED based lights

- Must support for everyday use at least 4 hours lighting of both the lights and 2 hours of radio use

### **3.2.5.2 Design Consideration:**

1. Battery DOD (VRLA): 35%
2. Battery DOD (Ni-MH/Li-Ion): 60%
3. Battery Efficiency: 80%
4. Array to load Ratio: 1:1
5. Peak Sun (Hour): 4.5
6. Insolation: 4500Wh/sqm/day
7. De-rating factor: 0.9
8. Columbic Efficiency: 0.95
9. Vmp of module: Must be 33% higher than the system voltage

For this capacity of solar system, RETS will test with the following procedures:

- Design Verification
- Quality testing of complete solar package and individual PV components

### **3.3 Minimum Standard for less than 5 WP PV Systems**

For the system of capacity less than 5Wp, manufacturer or importer must provide third party certificate of the solar package or its components issued from the accredited national or international laboratory and the RETS will perform verification of the submitted documents and issues the certificate.

In case of the PV products not having third party certificate, RETS conduct the performance test that includes:

1. Preliminary test:
  - It includes visual screening to access the workman-ship of cables, mounting , fixtures ,PCB Soldier joints in electronic circuit, switches and housing of the components
  - Visual screening of mechanical and electronics layout of solar PV components and overall system design

- Documentation of delivered information( manual, troubleshooting guides , repair instruction )
2. Test and measurement : it includes detailed assessment of PV components
- PV Module; Deviation from nominal rating
  - Battery; Deviation from nominal rating
  - Charge controller; Setting points and self- consumption
  - Lamp; Lux measurement and its degradation

Only the RETS certified SPV system and its components are eligible for getting the government subsidy.

### **3.4 Quality Testing**

The Renewable Energy Test Station (RETS) is authorized to carry out the quality test of the Solar Photovoltaic system and its components and issue the certificate.



## DEFINITIONS

1. A "Solar Home System" (hereinafter called SHS) is a photovoltaic system of more than 10Wp used for domestic and commercial purposes for providing primarily lighting services. Additional services such as information and entertainment through television sets or radios as well as fans may also be provided in addition to lighting.
2. A "Small Solar Home System" (hereinafter called SSS) is a 10Wp photovoltaic system used for domestic purposes for providing basic lighting services and access to information through a small radio. It consists of WLED DC lamps, radios as well as outlet for mobile charging. The system can have separate charge controller and battery or can have an integrated charge controller and battery.
3. An "Institutional Solar PV System" (hereafter called ISPS) is a DC or AC photovoltaic system used for lighting and power supply to appliances like computer, telephone, refrigerator, etc., in public institutions like VDC buildings, schools, health posts, religious buildings, clubs, etc.
4. A "Photovoltaic Pumping System" (hereafter called PVPS) is a DC or AC photovoltaic water pumping system operated by photovoltaic electricity to lift water for drinking and drip irrigation purposes.
5. Absorbed Glass Mat (AGM) battery: A technique for sealed lead-acid batteries. The electrolyte is absorbed in a matrix of glass fibers, which holds the electrolyte next to the plate, and immobilizes it preventing spills. AGM batteries tend to have good power characteristics, low internal resistance, and good behavior during charging.
6. Ambient Temperature: The temperature of the surrounding area.
7. Ampere-Hour (Ah): A measure of the flow of current (in amperes) over one hour; used to measure battery capacity.
8. Autonomy Days (N): Maximum number of consecutive days where the daily load can be fulfilled without charging the battery, starting the first day with a fully charged battery.
9. Battery: Two or more electrochemical cells enclosed in a container and electrically interconnected in an appropriate series/parallel arrangement to provide the required operating voltage and current levels.
10. Battery Capacity: The maximum total electrical charge, expressed in ampere-hours, which a battery can deliver a load under a specific set of conditions.
11. Battery Cycle Life: The number of cycles, to a specified depth of discharge, that a battery can undergo before failing to meet its specified capacity or efficiency performance criteria.
12. Battery Cycle: The discharge and subsequent charge of a battery.

13. Ballast: An electronic device that converts DC to AC and regulates and controls the current through a fluorescent tubular lamp.
14. Bypass Diode: A diode connected across one or more solar cells in a photovoltaic module such that the diode will conduct if the cell(s) become reverse biased. It protects these solar cells from thermal destruction in case of total or partial shading of individual solar cells while other cells are exposed to full light.
15. C20, C10, C5: An expression describing rate of discharge. The number indicates the number of hours to completely discharge the battery at a constant current. C20 is the current draw at which the battery will last for 20 hours, C10 is the current at which the battery will last for 10 hour. The useful capacity of a battery changes depending on the discharge rate, so battery capacities are stated with respect to a particular rate.
16. Charge Controller: A component of a photovoltaic system that controls the flow of current to and from the battery to protect it from over-charge and over-discharge.
17. Color Rendering Index (CRI): The calculated rendered color of an object. The higher the CRI (based upon a 0-100 scale), the more natural the colors appear. Natural outdoor light has a CRI of 100.
18. Current at Maximum Power ( $I_{mp}$ ): The current at which maximum power is available from a PV module.
19. Deep-Cycle Battery: A battery that can withstand many discharges to a low state-of-charge.
20. Depth of Discharge (DOD): The ampere-hours delivered from a fully charged battery, expressed as a percentage of rated capacity. For example, the delivered of 25 ampere-hours from a fully charged 100 ampere-hours rated cell results in a 25% depth of discharge.
21. Flood Lead-Acid Battery: A battery containing a liquid solution of acid and distilled water.
22. Gel-Type Battery: Lead-acid battery in which the electrolyte is composed of a silica gel matrix.
23. High Voltage Disconnect: The voltage at which a charge controller will disconnect the photovoltaic module from the batteries to prevent overcharging.
24. Lead-Acid Battery: A general category that includes batteries with plates made of pure lead, lead-antimony, or lead-calcium immersed in an acid electrolyte.

25. Low Voltage Disconnect (LVD): The voltage level at which a charge controller will disconnect the load from the battery.
26. Lumen (lm): The SI unit of luminous flux or quantity of light and equals the amount of light that is spread over a square foot of surface by one candle power when all parts of the surface are exactly one foot from the light source.
27. 23. Lumens per watt (lm/W): The amount of light a light source produces for each watt of electricity consumed.
28. Lux (lx): The SI unit of illuminance, or luminous flux incident on a unit area, frequently defined as one lumen per square meter (lm/m).
29. Open-Circuit Voltage (Voc): The maximum possible voltage across a photovoltaic Module at no load condition.
30. Overcharge: Forcing current into a fully charged battery.
31. Maximum rated current (Imp): Amperes produced by a photovoltaic module operating at the voltage of the I-V curve that will produce maximum power from the module.
32. Peak Watt: A unit used to rate the performance of solar module. Maximum nominal output of a photovoltaic device, in watts (Wp) under STC.
33. Photovoltaic (PV) System: A complete set of components for converting sunlight into electricity by the photovoltaic process, including the array and balance of system
34. Polycrystalline Silicon: A material used to make photovoltaic cells, which consist of many crystals unlike single-crystal silicon.
35. Pulse Width Modulation (PWM): It is the most effective means to achieve constant voltage battery charging by switching the controller's power device. In PMW regulation, the current from the solar array tapers according to the battery's condition and recharging need.
36. Rated Battery Capacity: The term used by battery manufacturers to indicate the maximum amount of energy that can be withdrawn from a battery under specified discharge rate and temperature.
37. Reverse Leakage Current Protection: Protection in charge controller for preventing unwanted current flow from the battery to the PV module (usually at night).
38. Sealed Battery: A battery with a captive electrolyte and a resealing vent cap, also called a valve-regulated battery. Electrolyte cannot be added.
39. Self-Discharge: The rate at which a battery, without load, will discharge.

40. Short-Circuit Current ( $I_{sc}$ ): The current flowing freely through an external circuit that has no load or resistance; the maximum current possible.
41. Solar Home System: A "Solar Home System" (hereinafter called SHS) is a photovoltaic system used for providing primarily lighting services.
42. Specific Gravity: The ratio of the weight of the solution to the weight of an equal volume of water at a specified temperature.
43. Standard Test Conditions (STC): Standard Test Condition is defined as  $1,000 \text{ W/m}^2$  solar radiations in the plane of the array, 1.5 air-mass ratios and  $25^{\circ}\text{C}$  cell temperature.
44. State-of-Charge (SOC): The available capacity remaining in the battery, expressed as a percentage of the rated capacity.
45. Third party: Testing and Certification Institution duly accredited by the authorized entity of the government.
46. Voltage at Maximum Power ( $V_{mp}$ ): The voltage at which maximum power is available from a photovoltaic module.