नेपाल सरकार

ऊर्जा, जलस्रोत तथा सिंचाइ मन्त्रालय

वैकल्पिक ऊर्जा प्रवर्द्धन केन्द्र

ताहाचल, काठमाडौं

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सूचना: दररेट पेश गर्ने सम्बन्धमा।

(प्रकाशित मिति : २०८३ भाद्र १० गते समय: राति १०:०० बजे)

उपरोक्त बिषयमा भोटेकोशी तथा त्रिशूली नदीमा आएको बाढी तथा पहिरोबाट प्रभावित परिवारहरूलाई तत्काल राहत तथा आधारभूत ऊर्जा सेवामा पहुँच सुनिश्चित गर्न आवश्यक सौर्य तथा ऊर्जा सम्बन्धी सामग्रीहरू सार्वजनिक खरिद ऐन, २०६३ को दफा ६६ बमोजिम विशेष परिस्थितिमा खरिद गर्ने सम्बन्धी व्यवस्था तथा प्रचलित सार्वजनिक खरिद नियमावली बमोजिम यस केन्द्रबाट तपसिलमा उल्लेखित नवीकरणीय ऊर्जा प्रविधिहरु खरिद गरी स्थानीयलाई वितरण गर्ने प्रयोजनको लागि योग्य तथा इच्छुक उत्पादक/आपूर्तिकर्ता/फर्महरूबाट मू.अ. कर बाहेकको प्रति एकाई दर केन्द्रको कार्यालय, ताहाचल, काठमाडौँमा उपलब्ध गराउने गरि मिति २०८३ भदौ ११ गते अपरान्ह १:०० भित्र इमेल (info@aepc.gov.np) वा पत्र मार्फत केन्द्रमा उपलब्ध गराईदिनु हुन यो सूचना प्रकाशित गरिएको छ।

तपसील

क्र.स.	नवीकरणीय ऊर्जा प्रविधिको संक्षिप्त विवरण	आवश्यक अनुमानित परिमाण	उपलब्ध गराउन सक्ने परिमाण	दर रेट (रु.)	कैफियत
१	**20 Wp Solar Home System (SHS) Plug and Play type**	500 pcs			
२	**2kWp -Institutional Solar Photovoltaic System**	50 Set			
३	**Natural draft portable metallic improved cooking stove**	2000 Pcs			

आफुले उपलबध गराउन सक्ने परिमाण समेत उल्लेख गरि दरभाउ उपलब्ध गराउनुपर्नेछ। समानहरु यथासिघ्र उपलब्ध गराउन पर्नेछ। आवश्यकता तथा मागको मात्र आधारमा सामग्री खरिद गरिनेछ। सामग्री उपलब्ध गराउने स्थान यस केन्द्रको कार्यालय, ताहाचल, काठमाडौँ हुनेछ। सामग्री उपलब्धताको आधारमा एक वा एक भन्दा बढी व्यवसायी छनौट हुन सक्नेछन। सामग्री खरिद भए पश्चात रकम भुक्तानी हुनेछ।

TECHNICAL SPECIFICATIONS

1. 20 Wp Solar Home System (SHS) Plug and Play type

Technical Parameters:

S.N.	Specification	Bidder Specifications
1	Ready and easy to install without technician support	
2	20 Wp solar PV module	
3	≥ 5.2 Ah lithium-ion battery	
4	Three number of LED Lamp 3 watt	
5	Port for charging mobile	
6	Inbuilt charge controller	
7	Complete connection acccessories	
8	RETS Certified	
9	Operation time at full charge: Lights 10 hours per day, mobile: 5 hours per day	

2. 2kWp -Institutional Solar Photovoltaic System

2 kWp system			
Item	**Component**	**Minimum Key Requirements**	
1	Solar PV Array	Total Peak Power: 2,000 Wp PV module ≥ 100 Wp Crystalline Silicon (c-Si) technology See section 2.1	
2	Solar Charge Controller (SCC)	DC Input: 2,800 Wp MPPT or PWM Type. See section 2.3	
3	Battery Bank	Capacity: 14,400 Wh (C10) Tubular Lead Acid Flooded or sealed (VRLA) Parallel string connection ≤ 4 See section 2.2	
4	Inverter	Nominal Power: 3,000 VA See section 2.4	
5	Mounting structure	Orientation: South Inclination: 30° Structure Material: Aluminium or Hot Dip Galvanized Steel (with a minimum coating thickness of 70 µm) Accessories: Aluminium/Stainless steel (SAE 304) Design lifetime: 20 years Withstand 180 km/hr maximum wind speed	
6	Installation	As per requirements in section 2.6	
7	Lightning Protection System and Earthing	As per requirements in section 2.5	
8	Cables and conduits	As per requirements in section 2.6.4 Maximum cabling losses as per Table 2-3	
9	System Voltage	24/48V to be selected by the Installation Company as per proposed components and design Compatibility with all system components shall be ensured	

Detailed technical specifications attached separately

3. Natural draft portable metallic improved cooking stove:

Stove Type : Natural draft, Portable, Chimneyless stove
Pot hole : One
Material : Metallic Body
Fuel : Fuel wood

Technical Parameters:

SN	Description	Technical Specifications	Bidders proposed Specification
Mandatory Performance Parameters			
1	High Power Thermal Efficiency (Cooking only)	$\geq$ 25% (NIBC, 2016 requirement)	
2	Total Emission (Indoor) : High Power PM 2.5	$\leq$ 513 mg/MJ_d (NIBC, 2016 requirement)	
3	Total Emission (Indoor) : High Power CO	$\leq$ 10 g/MJ_d (NIBC, 2016 requirement)	
Others			
4	Stove outer diameter	Minimum 10 inch	
5	Safety Performance	As per NIBC, 2016 requirement	
6	Durability Conformity	• Fulfill material durability conformity requirements (As per NIBC, 2016 requirement) • Extended run test for heat resistant paint on stove body (exclusive for SS and non corrosive metal parts).	
7	Warranty	1 Year replacement warranty	
8	Stove operation leaflet	Brief information in Devanagari script (preferred) or English or self-explanatory pictorial messages	
9	Product Introductory Test Certification	The bidder shall submit the Product Introductory Test (PIT) certificate	
10	Product finishing	The product should have unique serial number in permanent tag and the whole stove body including top plate & grate should be duly heat resistant painted (exception for SS parts) and packaged with at least cartoon box and proper labeling of information. **Note: Heat resistant paint should sustain while performing extended run test.**	

1 SCOPE OF WORK

The scope of work of the Supplier (also called Installation Company “IC”) shall include all necessary components for the turn-key installation of an Institutional Solar Photovoltaic System (ISPS), including supply of equipment, delivery on site, installation of the PV system and electrical circuits, testing and commissioning, training to the Institution representatives and after sale service for a period of two years.

Annex A includes the form to be completed at the bidding stage, as well as the documentation to be provided with the quotation.

Table 1-1: Summary of the minimum capacity for the key components

2 kWp system		
Item	**Component**	**Minimum Capacity**
1	Solar PV Array	Total Peak Power: 2,000 Wp
2	Solar Charge Controller (SCC)	DC Input: 2,800 Wp
3	Battery Bank	Capacity: 14,400 Wh (C10)
4	Inverter	Nominal Power: 3,000 VA

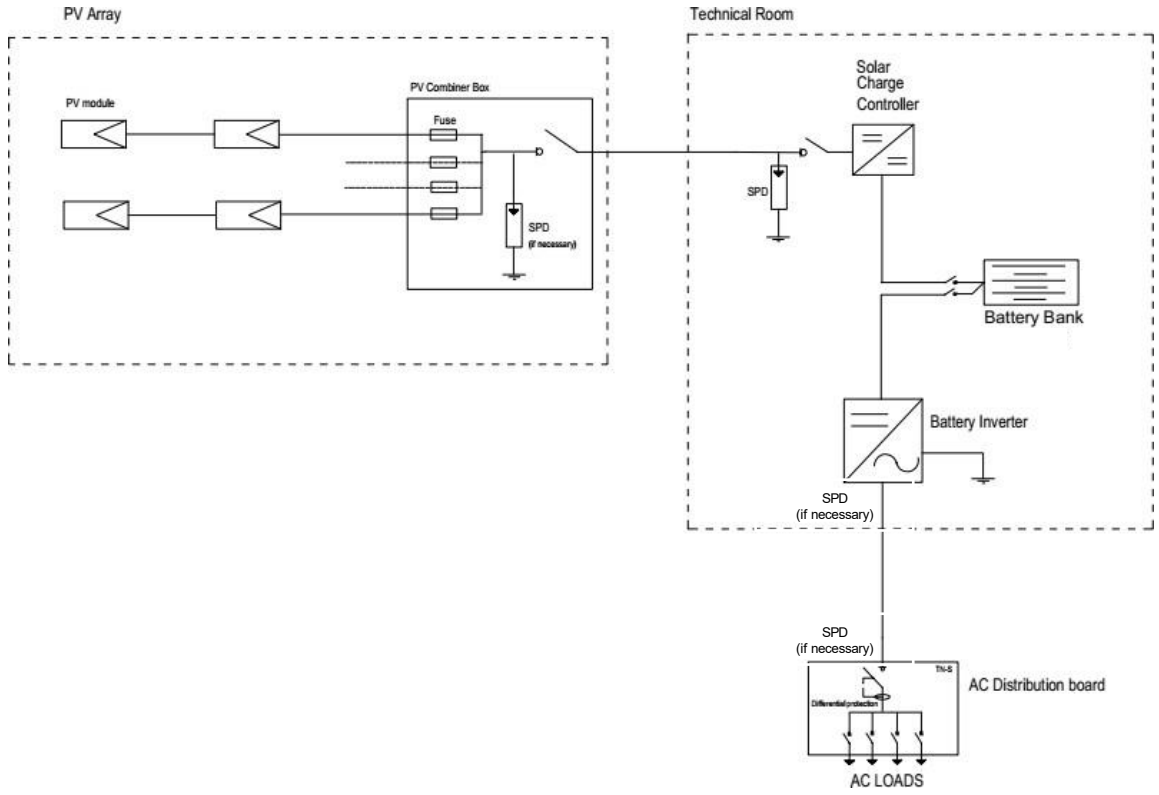


Figure 1-1: ISPS typical Single Line Diagram (indicative only)

1.1 Design Requirements

Table 1-2: Summary of the minimum key requirements

2 kWp system		
Item	**Component**	**Minimum Key Requirements**
1	Solar PV Array	Total Peak Power: 2,000 Wp PV module ≥ 100 Wp Crystalline Silicon (c-Si) technology See section 2.1
2	Solar Charge Controller (SCC)	DC Input: 2,800 Wp MPPT or PWM Type. See section 2.3
3	Battery Bank	Capacity: 14,400 Wh (C10) Tubular Lead Acid Flooded or sealed (VRLA) Parallel string connection ≤ 4 See section 2.2
4	Inverter	Nominal Power: 3,000 VA See section 2.4
5	Mounting structure	Orientation: South Inclination: 30° Structure Material: Aluminium or Hot Dip Galvanized Steel (with a minimum coating thickness of 70 µm) Accessories: Aluminium/Stainless steel (SAE 304) Design lifetime: 20 years Withstand 180 km/hr maximum wind speed
6	Installation	As per requirements in section 2.6
7	Lightning Protection System and Earthing	As per requirements in section 2.5
8	Cables and conduits	As per requirements in section 2.6.4 Maximum cabling losses as per Table 2-3
9	System Voltage	24/48V to be selected by the Installation Company as per proposed components and design Compatibility with all system components shall be ensured

1.2 PIT and RST Certificates

PIT (Product Introduction Test) and RST (Random Sampling Test) certificates are applicable for PV Modules, Solar Charge Controller, Battery and Inverter. PIT Certificates must be submitted with the quotation at the bidding stage.

RST Certificates can be provided at the bidding stage if available but must be submitted at the latest within the deadline of completion of project (before the testing and commissioning takes place). If a product fails to comply with the NEPQA (Nepal Photovoltaic Quality Assurance) requirements, AEPC will not provide subsidy for such system.

2 SPECIFIC TECHNICAL SPECIFICATIONS

Compliance with the requirements of the latest edition of NEPQA is verified by PIT and RST certificates. This section details additional specific requirements to NEPQA which shall be considered by the Installation Company for the component selection, design and installation of the system.

2.1 PV Modules

Additionally to the latest NEPQA requirements, the following specific requirements are applicable:

- PV module technology shall be crystalline silicon (c-Si - mono or poly);
- PV modules shall be certified (by an independent accredited laboratory) compliant with:
    - IEC 61215 (Terrestrial photovoltaic PV modules - Design qualification and type approval)
    - IEC 61730 (PV module safety qualification)
    - For both international standards above, test reports and certificates issued by an independent accredited laboratory shall be provided with the quotation (validity date of the certificate shall be at least 6 months after the date of the quotation)
- PV module warranty against design and manufacturing defects shall be minimum 5 years for modules up to 150 Wp and 10 years for modules greater than 150 Wp;
- The PV module original manufacturer shall have:
    - Minimum 5 years of PV Module manufacturing experience. Evidence of manufacturing experience shall be provided with the quotation
    - ISO 9001 and ISO 14001 certification. Evidences shall be provided with the quotation
- For PV modules above 250 Wp, the minimum efficiency shall be 15%;
- PV module tolerance on the nominal peak power (nameplate at STC) shall be positive and no more than 5%;
- Junction box (located on the back side of the module) shall be rated at least IP65 according to IEC 60529;
- All PV modules to be installed shall be of same type, same model and same power rating (from same manufacturer) for each individual site;
- PV module capacity shall be more than 100 Wp;
- PV modules must be warranted for their rated output, with a minimum of 90% at year 10 and a minimum of 80% at year 25.

2.2 Battery

Additionally to the latest NEPQA requirements, the following specific requirements are applicable:

- The battery original manufacturer shall have:
    - Minimum 3 years of battery manufacturing experience. Evidence of manufacturing experience shall be provided with the quotation
    - ISO 9001 and ISO 14001 certification. Evidences shall be provided with the quotation
- Original battery documentation shall clearly indicate:
    - the recommended voltage values for battery protection (Low Voltage, Reconnection Voltage, and High Voltage) and normal charging to facilitate the solar charge controller programming
    - the curve showing the quantity of cycles versus the depth of discharge (confirming at least 1,500 cycles at 70% depth of discharge as per NEPQA requirement)
- All batteries to be installed shall be of same type, same model and same capacity rating (from same manufacturer) for each individual site;
- Self discharge shall be ≤3% per month at 25°C.

2.3 Solar Charge Controller (SCC)

Additionally to the latest NEPQA requirements, the following specific requirements are applicable:

- SCC shall be compliant with applicable requirements stated in:
    - IEC 62109 (Safety of power converters for use in photovoltaic power systems)
    - IEC 62509 (Battery charge controllers for photovoltaic systems - Performance and functioning)
    - A certificate issued by a third-party accredited laboratory or a statement provided by the principal SCC manufacturer (signed document with letter head) shall be provided with the quotation
- The SCC manufacturer shall have:
    - Minimum 3 years of SCC manufacturing experience. Evidence of manufacturing experience shall be provided with the quotation
    - ISO 9001 and ISO 14001 certification. Evidences shall be provided with the quotation
- SCC shall be installed indoor and shall be rated at least IP21 according to IEC 60529;
- SCC shall have a display indicating the battery voltage/the state of charge, charging and discharging currents, current functioning status, and alarms;

- SCC shall include reverse polarity protection (on PV module and battery sides), overtemperature protection and reverse current protection at night;

- The voltage range for Low Voltage Disconnection (LVD), Low Voltage Reconnection (LVR) and High Voltage Disconnection (HVD) functions within the SCC shall be compatible with the recommendations of the battery manufacturer. The confirmation of these values shall be provided by both manufacturers and compatibility will be verified during testing and commissioning.

In-built solar charge controllers in the inverter are accepted as long as they meet the technical requirements as mentioned above. In case of in-built SCC within the inverter, only the PIT and RST certificate of the inverter is required.

2.4 Inverter

Additionally to the latest NEPQA requirements, the following specific requirements are applicable:

- The inverter shall deliver a pure sine wave voltage (AC output voltage of 230 V, 50 Hz);

- The inverter shall be compliant with applicable requirements stated in:

    - IEC 61000-6-1 (Electromagnetic compatibility - Immunity standard) and IEC 61000-6-3 (Electromagnetic compatibility - Emission standard)

    - IEC 62109 (Safety of power converters for use in photovoltaic power systems)

    - For both international standards above, a certificate issued by a third-party accredited laboratory or a statement provided by the principal inverter manufacturer (signed document with letter head) shall be provided with the quotation

- Product warranty from the manufacturer shall be 3 years;

- The inverter shall indicate its functioning status (output power, battery state and alarm), at least with LED signals;

- The inverter shall include:

    - A stand-by function for which self-consumption during stand-by (i.e. no load but in load detection mode) shall not be more than 1% of the rated power

    - An automatic load detection function which allows the inverter to be in a stand-by mode when there is no electrical demand. This option enables to limit the battery discharge due to self-consumption of the inverter (especially at night)

- The inverter manufacturer shall have:

    - Minimum 3 years of inverter manufacturing experience. Evidence of manufacturing experience shall be provided with the quotation

    - ISO 9001 and ISO 14001 certification. Evidences shall be provided with the quotation

- The inverter shall be installed indoor and shall be rated at least IP21 according to IEC 60529;

- The inverter shall be able to operate with a power factor range from 0.5 to 1;
- Compatibility between inverter LVD, LVR and HVR range/values and battery manufacturer recommendations and solar charge controller disconnection voltage shall be verified according to the design (direct connection of the inverter to the battery or not).

2.5 Lightning Protection System and Earthing

The Lightning Protection System (LPS) shall be of the enhanced type which is designed to attract lightning to a preferred point and safely convey the lightning energy to ground with minimal risk of side flashing via a pre-determined route. The complete LPS will comprise the following key components:

a) Air-termination system: composed of the air-terminal rod intended to intercept lightning flashes
b) Down conductor system: intended to conduct lightning current from the air-termination system to the earth-termination system
c) Earth-termination system: intended to conduct and disperse lightning current into the earth with the use of earthing electrodes
d) Surge Protection Devices (SPD): intended to limit transient overvoltage and divert surge current

a), b) and c) together are also referred as the external LPS.

2.5.1 Practical Technical Note on Lightning Protection Installation

In the present section, some practical design parameters and requirements are presented to support the correct design and installation of the LPS in the specific environment of ISPS.

2.5.1.1 Design parameters

The proposed LPS design is valid under the following assumptions:

- For PV ground-mounted installation, the external LPS (especially the air-terminal rod) **is always isolated** from any metallic parts of the PV array (minimum separation distance shall be maintained). The Minimum Separation Distance is defined in section 2.5.1.2.
- For PV roof-mounted installation, the external LPS (especially the air-terminal rod) can **be isolated** (minimum separation distance maintained) **or not isolated** (minimum separation distance not maintained) from any metallic parts of the PV array, depending on the available space on the roof.
- It is expected that the PV array (roof-mounted or ground-mounted) will be composed of one or several adjacent rows depending on the PV array size and site constraints, as shown on the following picture. Each row can be divided into several separate sub-arrays.

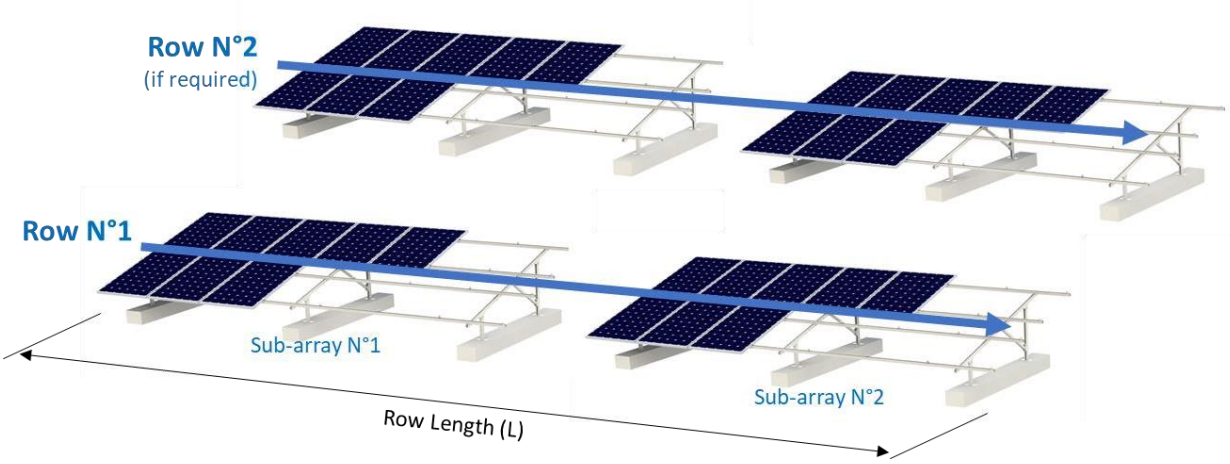


Figure 2-1: PV array layout and definition (valid for ground-mounted or rooftop installations)

The width of the PV array is assumed to be maximum 5 meters. The lower front part of the PV array is assumed to be not higher than 2 meters from ground level (for ground-mounted installations) and not higher than 0.5 meters from roof level for roof-top installations. The inclination of the PV array is assumed to be maximum 35°, as illustrated on the following figure:

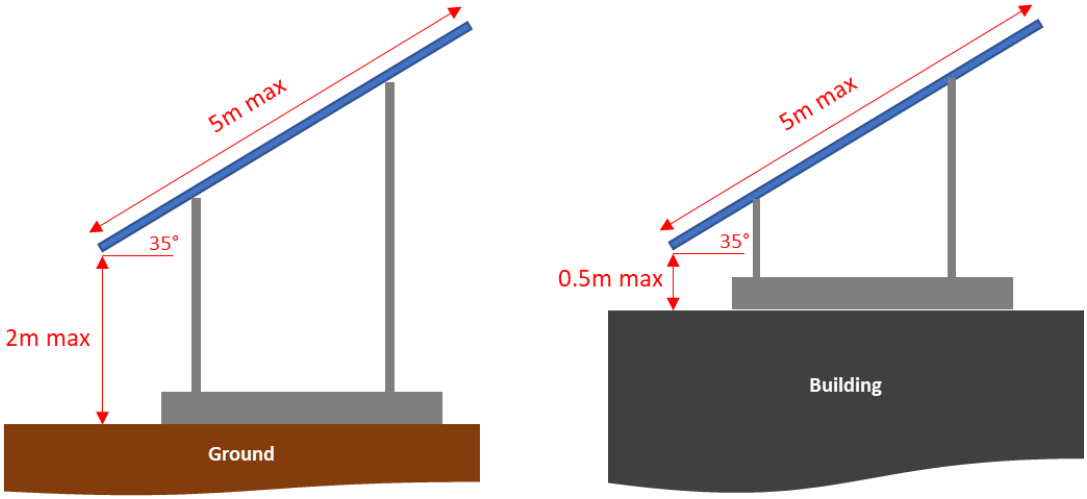


Figure 2-2: Maximum size of the PV array (profile view) for the proposed LPS design

The lightning protection area is determined by the rolling sphere method.

The diameter of the rolling sphere is depending on the class of LPS. Due to the absence of reliable data regarding keraunic level in the different regions of Nepal, it is recommended to consider a Class I for the LPS of ISPS. This represents the maximum protection level (conservative approach) which is justified by the medium to high density of lightning expected in the project area (especially in regions of altitude), the remoteness of the site and the corresponding difficulty to replace equipment in case of damage. For LPS Class I, a radius of rolling sphere of 20 m is considered, as per IEC 62305-3.

2.5.1.2 Minimum separation distance (S_{min})

The separation distance (S) is the distance between the air-terminal rod (and the external LPS in general) and the closest metallic part of the PV array, as illustrated on the graphs below. Based on

the design parameters presented above, the following installation requirements and LPS design shall be followed:

- For PV ground-mounted installations, the separation distance (S) shall be more than **0.40 meter (S_{min})** when the air-terminal rod is installed on its own concrete base (or foundation) with support accessories or more than **0.60 meter (S_{min})** when the air-terminal rod is fixed on the PV mounting structure with glass-fibre reinforced UV resistant plastic holders (material factor km > 0.7);

  Metallic fences shall be preferably placed at a distance from the air-termination system of at least 1 meter, but in all cases not less than 0.6 meter.

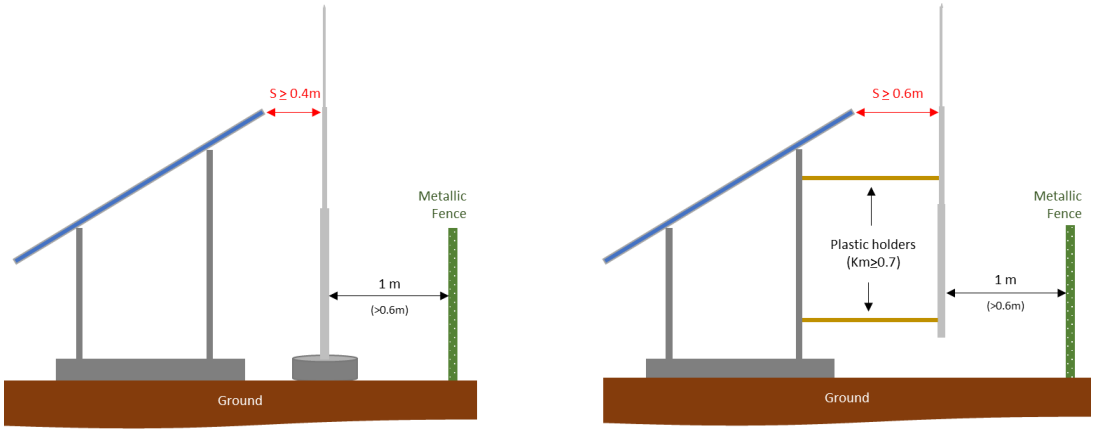


Figure 2-3: Separation distances (S) for ground-mounted installations

- For roof-mounted installations, the minimum separation distance shall be according to the below table:

Table 2-1: Minimum separation distance (S_{min}) for roof-mounted installations

Length of the down conductor [m]	Minimum separation distance (S_{min}) [m]	
Distance from the base of air-terminal rod on the roof to the earthing electrode at the base of the building	Air-terminal rods installed on its own concrete base	Air-terminal rods fixed on PV mounting structure with glass-fibre holders (km>0.7)
3	0.64	0.92
5	0.80	1.15
7	0.96	1.38
9	1.12	1.60
11	1.28	1.83
12	1.36	1.95
15	1.60	N/A*
17	1.76	N/A*
20	N/A*	N/A*
25	N/A*	N/A*
30	N/A*	N/A*

N/A: in this case, the mounting structure must be connected to the air-terminal system (external LPS) with copper conductor having a cross-section of at least 16 mm² AND with an actual separation distance inferior to 1 meter*

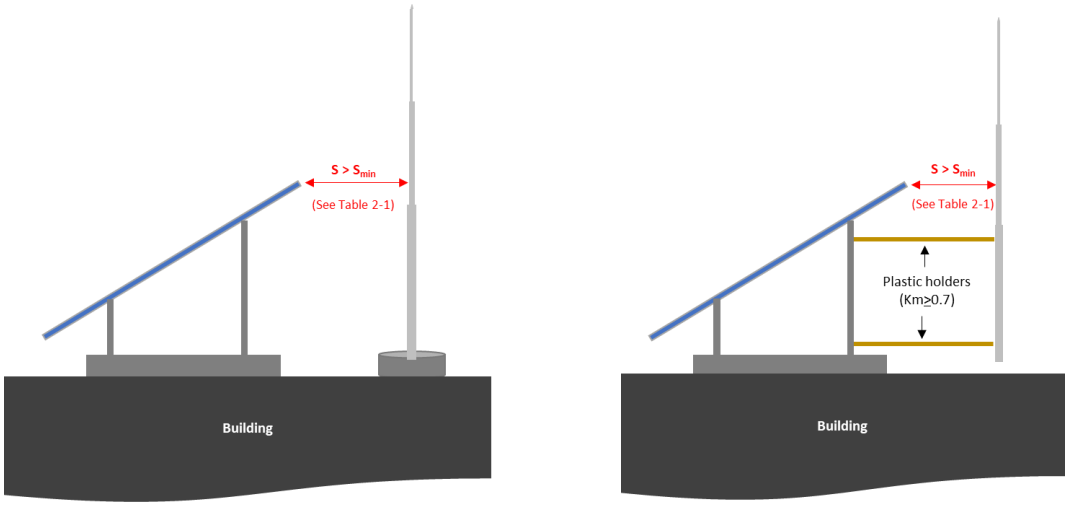


Figure 2-4: Separation distance (S) for roof-mounted installations

For roof-mounted installations, there are two special cases which require the direct connection between the PV mounting structure and the air-termination system with copper conductor having a cross-section of at least 16 mm^2 or equivalent in order to be able to carry lightning currents, as follows:

- In case the roofing is made of metal or if the minimum separation distance cannot be maintained due to space limitation on the roof area or difficult installation conditions of air-terminal rods (i.e. inclined roofs)

- For high buildings, where the minimum separation distance is marked N/A in Table 2-1 (yellow coloured cells, S_{min} > 2 meters), the air-terminal rods shall be mounted without considering the minimum separation distance and the actual separation distance (S) shall be not higher than 1 meter

2.5.1.3 Quantity and Height of the air-terminal rod(s)

There are two cases to consider, depending on the total length L of the PV row (as per Figure 2-1).

- **Case 1**: L is more than 4 meters and less than 14 meters (4m < L ≤ 14m)

  - **Two air-terminal rods** shall be installed as minimum for each row of the PV array. The air-terminal rods shall have a total height sufficient to have the top part standing:

    - <u>For roof-top installations:</u>

      - **one (1) meter** above any part of the PV array if the separation distance (S) is **inferior or equal** to 1 meter

      - **two (2) meters** above any part of the PV array if the separation distance (S) is **superior** to 1 meter

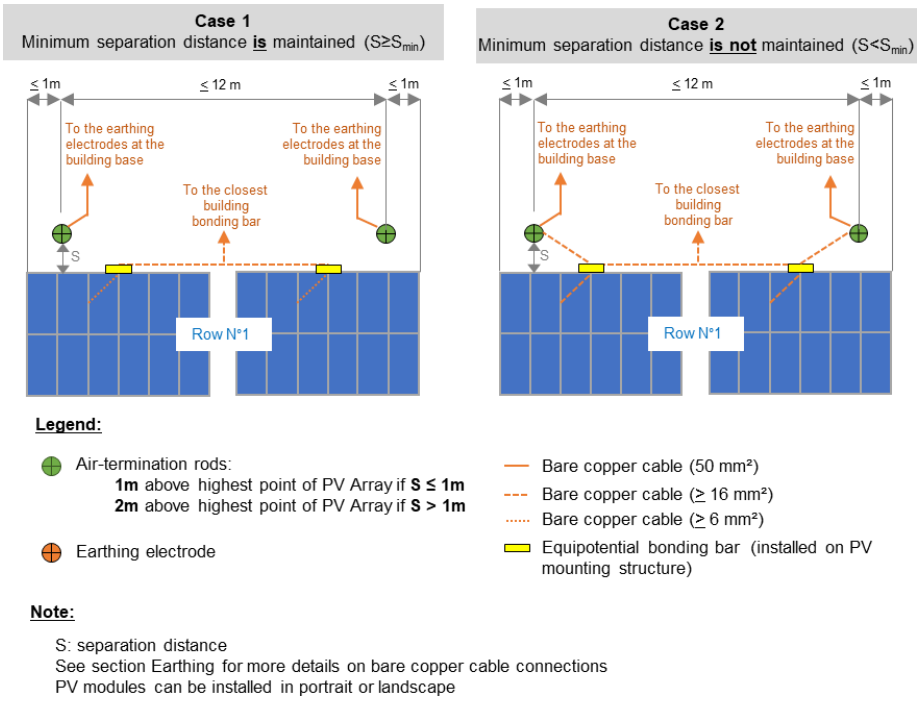


Figure 2-5: LPS design for PV array length comprised between 4m and 14m (roof-mounted installations)

- For ground-mounted installations:
  - **one (1) meter** above any part of the PV array

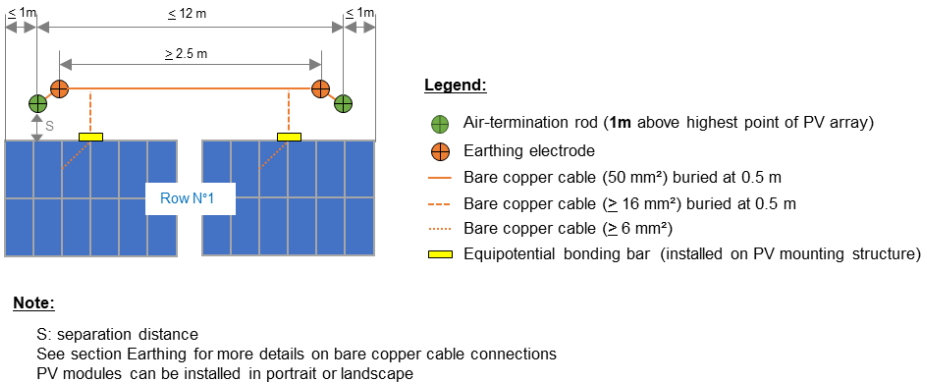


Figure 2-6: LPS design for PV array length comprised between 4m and 14m (ground-mounted installation)

- The distance between the two air-terminal rods along the same row shall be maximum 12 meters. The first and the last air-terminal rods shall have a distance from the edge of the row (first and last PV module) not more than 1 meter. In case this is not possible to achieve (L > 14 m), additional air-terminal rod(s) shall be placed in between.

- **Case 2**: L is less than 4 meters (L ≤ 4m)
    - **One air-terminal rod** shall be installed as minimum for each row of the PV array. The air-terminal rod shall have a total length sufficient to have the top part standing **two (2) meters** above any part of the PV Array. The rod shall be installed at equal distance from the extremities of the PV array.

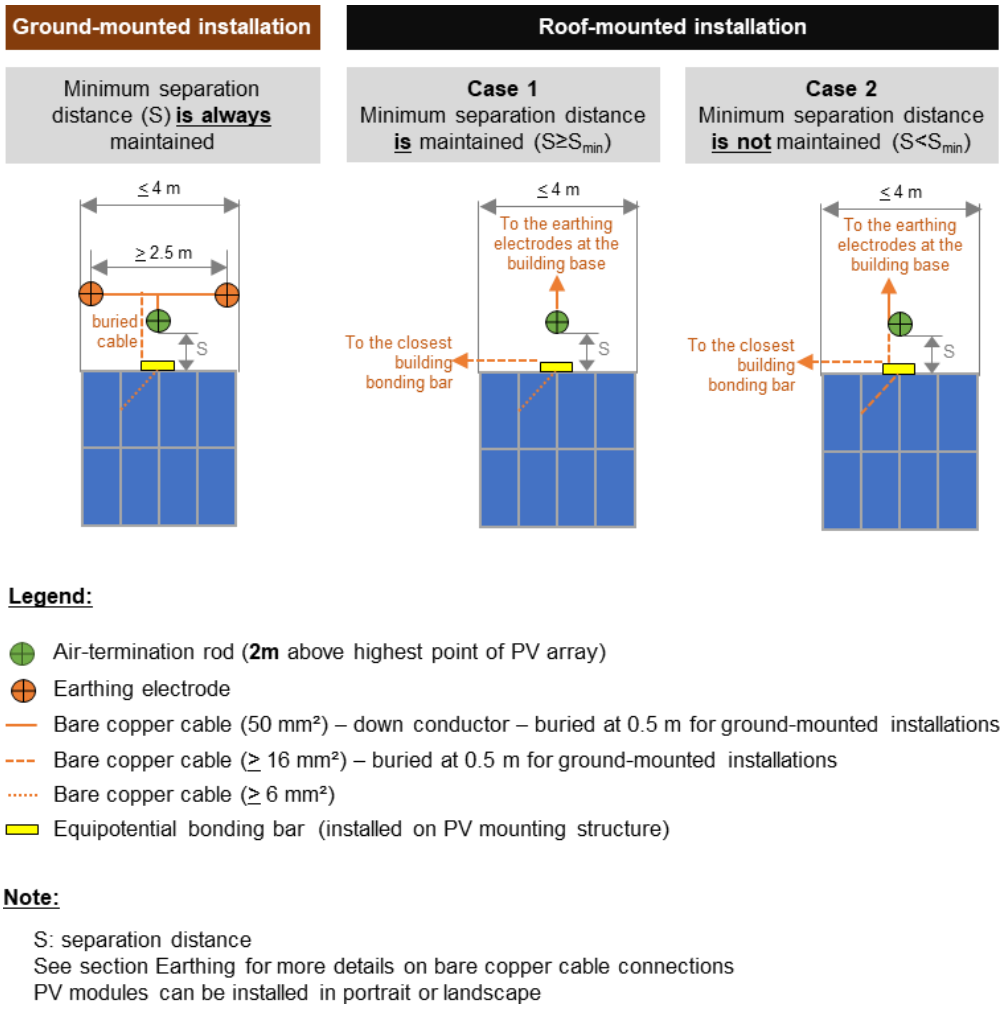


Figure 2-7: LPS design for PV array length lower or equal to 4m

As alternative (not showed on Figure 2-7), it is also acceptable to install **two air-terminal rods** as minimum for each row of the PV array. With two air-terminal rods, the air-terminal rods shall have a total length sufficient to have the top part standing **one (1) meter** above any part of the PV Array mounting structure. The rods shall be installed at the two extremities of the PV array.

2.5.1.4 Other recommendations

- Due to the inductive coupling of interference, it is advisable to install PV combiner boxes (if any) as far as possible from air-terminal rod(s) but still under the PV modules on the mounting structure;
- In case of a two-row (or more) configuration, a sufficient distance shall be kept between the rows to avoid that the air-terminal rod causes core shadows on the PV array;
- Earth-termination system shall be installed in such a way to reach an earth resistance **below 10 Ohms**.

2.5.2 Technical Requirements

2.5.2.1 Air-termination system

- The air-terminal rod(s) shall be installed on a separate concrete base as a free-standing mast. It can also be installed and fixed on the PV mounting structure by mean of with insulating support/spacer holders made of glass-fibre reinforced plastic (diam. 16 mm and material factor km = 0.7), as illustrated on Figure 2-3 and Figure 2-4;
- The separation distance (S) shall be kept as per the requirements described in **2.5.1.2**;
- The tip of the air-terminal rod shall stand with a minimum height above the highest point of the PV mounting structure as per requirements described in section **2.5.1.3**;
- The quantity of air-terminal rod(s) to be installed is depending on the length L of the PV array and shall be as per requirements described in section **2.5.1.3**;
- The material of the air-terminal rod shall be Aluminium. The minimum thickness of the 1-meter top part shall be 10 mm. Larger diameters shall be used for the lower parts of the air-terminal rods. The rod shall be rated to withstand 200kA standard lightning impulse;
- The air-termination system shall have as few joints in it as possible. Where joints are necessary, they shall be mechanically and electrically effective and shall be so made as to exclude moisture completely. The joints may be clamped, screwed, bolted, crimped, riveted or welded. With overlapping joints, the length of the overlap should not be less than 20 mm for all types of conductors;
- The upper extremity of the air-terminal rod(s) shall be pointed for better caption of lightning. Air-termination tip in ZDC material can be used for sealing the ends of air-terminal rod(s);
- The air-termination system shall have no moving parts and will have no dependence on external power supply or batteries;
- The air-terminal rod shall allow at its lower extremity a direct connection of the rod to the earth-termination system via a bare copper cable of minimum 50 mm^2 cross section (down conductor). This direct connection shall be made with the use of compression lug (or equivalent);
- If not specified different, all accessories of the air-termination system shall be made of stainless steel. When two different materials are in contact (i.e. air-terminal rod and fixation accessories

for support, air-termination tip and rod itself) it shall be insured that compatible material shall be used to avoid galvanic corrosion.

2.5.2.2 Down conductor

- The down conductor consists of a bare copper conductor of 50 mm^2 cross section connecting the lower extremity of the air-terminal rod to the earthing electrode of the earth-termination system:
    - At ground level, this cable shall be buried at 0.5 meter, unless the earthing electrode is adjacent to the air-terminal rod (for ground-mounted installation only)
    - For rooftop installation, the down conductor shall be installed in such a way that the distance to the earth-termination system is kept to a minimum and shall be fixed to the building structure with roof- and wall- mounted conductor holders of stainless steel material (min. 2 mm thickness). The bare copper down conductor shall be installed within PVC pipe for the last three meters above ground, in order to protect persons from accidental touch and to mechanically protect the down conductor
- Connection shall be done with the use of copper compression lug, as per requirement mentioned in section 2.5.2.5, especially with regard to anti galvanic corrosion measures.

2.5.2.3 Earth-termination system

The earth-termination system shall be installed so that the final earth resistance (resistance between the earth-termination system and the ground) does not exceed **10 Ohms** (low frequency measurements).

Keeping the above value of resistance as main objective of the earth-termination system, following minimum requirements shall also apply:

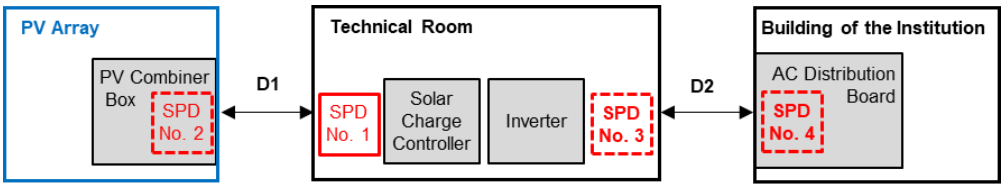
- For ground-mounted installations, at the foot of each air-terminal rod, one earthing electrode shall be installed with its own inspection pit. This earthing electrode shall be connected to the other earthing electrode(s) of the system with a bare copper conductor (minimum cross section of 50 mm^2) buried at a depth of 0.5 meter;
- For roof-mounted installations, each air-terminal rod shall be connected through down conductors to the earthing electrodes to be installed at the base of the building (at ground level), each with its own inspection pit. As minimum, two earthing electrodes shall be installed preferably at the opposite side of the building. Each earthing electrode at the base of the building, shall be connected to the other earthing electrode(s) of the system and to the building bonding bar with a bare copper conductor (minimum cross section of 50 mm^2) buried at a depth of 0.5 meter;
- The length of each earthing electrode shall not be less than 2.5 meters;
- At least two earthing electrodes shall be placed (even for small PV array requiring only one air-terminal rod). The distance between the earthing electrodes shall be not lower than the length of the electrode itself (i.e. 2.5 meters);
- Earthing electrodes shall be of Pipe-in-Pipe technology;

- Earthing electrodes shall be made of copper or of hot dipped galvanized iron. The hot dipped galvanization of the earthing electrodes shall be 70 microns to 100 microns;
- Earthing electrodes shall not have an outer diameter less than 48 mm and an inner diameter less than 27;
- To install the earthing electrode, a hole of minimum 100 mm (or as per manufacturer recommendations) diameter shall be dug for the length of the electrode. Certified low resistivity earth enhancement material shall be used to fill the hole with the electrode. The earth resistivity enhancement material shall be not less than 30 kg for each earthing electrode;
- Earthing inspection pit of each earthing electrode shall be made of solid concrete with minimum dimension of 320 mm x 320 mm x 320 mm. Cover shall be marked with word “EARTH” or acceptable earthing marking.

2.5.2.4 Surge Protection Devices (SPD)

In case of a lightning strike to the external LPS, high voltage impulses are induced on all electrical conductors and partial lightning currents flow into all sort of cables (DC and AC if any). Surge Protective Devices (SPDs) must be installed to protect the electrical components.

SPDs shall provide an overvoltage protection for the PV modules, the solar charge controller and the inverter. There are two types of SPD: Type 1 and Type 2. SPD Type 1 have the capability to carry lightning currents of 10/350 µs wave form without destructing the equipment and protects against direct lighting strikes. SPD Type 2 is characterized to withstand 8/20 µs current wave form and aims to prevents the spread of overvoltage spikes. Combined Type 1+2 is a single device which combines both protections of Type 1 and Type 2. The selection of SPD type depends on the overall LPS design. Figure 2-8 presents the SPD locations and characteristics depending on the installation configuration.



D1: distance between DC Combiner Box (at PV Array) and the Solar Charge Controller
D2: distance between the Technical Room (inverter) and the building where the AC distribution board is installed

Legend:

- – – – SPD required under certain conditions only – see below table
- ——— SPD always required

SPD No.	Current	Required	SPD type	
			Case 1 Minimum separation distance **is** maintained	Case 2 Minimum separation distance **is not** maintained
SPD No. 1	DC	Always	Type 2	Combined Type 1+ 2
SPD No. 2	DC	Only if D1 > 10 meters		
SPD No. 3	AC	Only if D2 > 10 meters		
SPD No. 4	AC	Only if D2 > 10 meters		

*Note: SPD No. 3 and No. 4 are **not required** if the Technical Room (Solar Charge Controller and Inverter) are installed in the **same building** of the Institution where the AC Distribution Board is installed*

Figure 2-8: SPD requirements (location and type)

The following table presents the minimum SPD requirements regarding nominal discharge current and impulse current.

Table 2-2: SPD characteristics

Type	Minimum current requirements
Type 2	8/20 µs wave form: - Nominal discharge current I_n ≥ 5 kA - Maximum discharge current I_{max} ≥ 20 kA
Type 1+2	8/20 µs wave form: - Nominal discharge current In ≥ 5 kA Maximum discharge current I_{max} ≥ 20 kA 10/350 µs wave form: - Lightning impulse current I_{imp} ≥ 12.5 kA

The following additional requirements apply:

- SPD No. 1 and No.2 (when applicable) shall be suitable for Direct Current and specific to PV application compatible with the voltage range and rating of the PV array:
    - U_p (voltage protection level) shall be at least 20% lower than the rated impulse withstand voltage (U_w) of the equipment to protect
    - U_c (maximum continuous voltage) shall be 20% more than open circuit voltage of the PV array
    - I_{scpw} (short circuit current rating) shall be more than the maximum current which can be delivered by the PV array (more than short circuit current I_{sc} of the PV array)
- SPD shall have visual status indication;
- SPD shall be compatible in mounting on DIN Rail Channel;
- The earthing cable for the SPD shall be connected to the equipotential bonding bar located at PV array for SPD No. 2, at the technical room for SPD No.1 and SPD No.3 and at the building bonding bar for SPD No. 4 and shall be of copper with a minimum cross section of:
    - 6 mm² if the minimum separation distance has been maintained
    - 16 mm² if the separation distance could not be maintained
    - Other earthing connections are described at paragraph 2.5.3
- All cables must be routed in such a way that large conductor loops are avoided;
- AC SPD shall be compliant with IEC 61643-11 and DC SPD with EN 50539-11.

2.5.2.5 Lugs

- The material of the lugs used to connect air-terminal rods and earthing electrodes with down conductors and earthing cables shall be copper in order to avoid galvanic corrosion due to the interaction of different materials;
- If due to manufacturing limitations, it cannot be avoided to have two different metals in contact at an electrical connection, the use of bi-metallic washers or equivalent galvanic corrosion mitigating measures shall be used;
- Earth entries in the ground made of galvanized steel material must be protected against corrosion over a distance of at least 0.3 meter above and below the surface of the earth. Generally, bituminous coatings are not sufficient. A moisture proof sheath, e.g. butyl rubber strips, heat-shrinkable sleeves or preferably stainless steel, provides protection.

2.5.3 Earthing

- All electrical equipment and metallic structure of the PV array, including mounting structures, shall be connected to the earth-termination system to form an equipotential system;
- The connection of the PV mounting structure to the earth shall be established at the lower level of the mounting structure, by means equipotential bonding bar(s) installed on the PV mounting structure. Each sub-array shall have its own equipotential bonding bar, as shown on Figure 2-5, Figure 2-6 and Figure 2-7. Each equipotential bonding bar installed on the PV mounting structure bar shall be connected:
    - to the metallic part of the PV mounting structure with bare copper conductors of minimum cross section of:
        - 6 mm^2 for ground mounted installations or for roof-top installations when the minimum separation distance could be maintained
        - 16 mm^2 for roof-mounted installation when the minimum separation distance could not be maintained
    - to the earth-termination system with bare copper conductors of minimum cross section of 16 mm^2 by connection to:
        - the earthing electrodes or to the buried 50 mm^2 bare copper conductor connecting the earthing electrodes for ground-mounted installations
        - the closest down conductor for roof-mounted installations (the down conductor is then connected to equipotential bonding bar of the building)

Earthing connections are summarized on Figure 2-9.

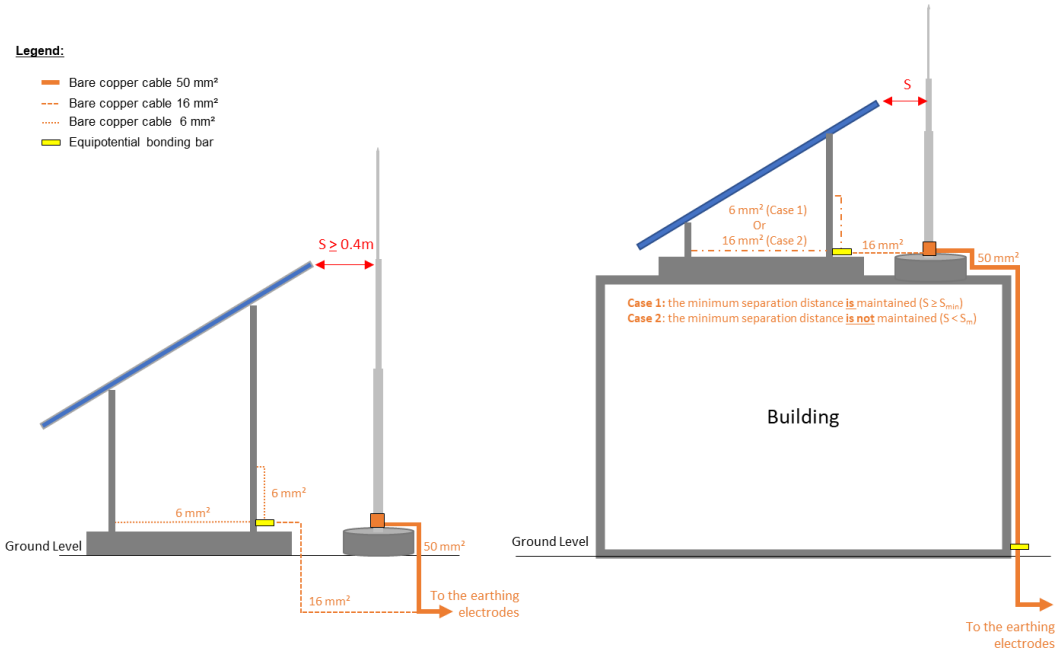


Figure 2-9: Earthing requirements

- All earthing electrodes shall be connected together by a bare copper conductor of 50 mm² cross section buried at least at 0.5 meter depth;
- In the technical room where the solar charge controller and the inverter are installed, an equipotential bonding bar shall be installed (wall-mounted) and connected to the earth-termination system with a bare copper conductor or yellow/green cable of at least 16 mm²;
- The metallic structure of the solar charge controller and the inverter shall be connected to the technical room equipotential bonding bar with a minimum cross section of:
    - 6 mm² for ground mounted installations or for roof-top installations when the minimum separation distance could be maintained
    - 16 mm² for roof-mounted installation when the minimum separation distance could not be maintained
- For ground-mounted installation, a bare copper conductor of 50 mm² cross section shall be buried between the PV array and the technical room and connected to the earth-termination system of the building;
- The equipotential bonding connections shall be made as direct and straight as possible.

2.6 Installation

The installation shall follow for the applicable parts the Electrical Design Requirements for public buildings, which is part of the National Building Code (NBC 207:2003).

2.6.1 General

- All components shall be installed according to manufacturer instructions;
- The Installation Company is required to coordinate with the Institution, AEPC and its representatives, financing institutions and other relevant stakeholders during the installation (when required);
- Inverter and SCC shall be installed next to each other and the distance to the battery bank shall be kept as minimum as possible;
- Preferably, all components shall be installed in one dedicated separate technical room provided that i) a safety clearance of minimum 0.5 meter is observed between the battery bank and any electrical device (SCC and inverter) and ii) the technical room is not a confined area and is ventilated according to the battery manufacturer recommendation. A recommended configuration consists in installing the battery bank in an adjacent room on the other side of the wall where the inverter and SCC are installed. In all cases, the battery and technical rooms shall be ventilated as per recommendations of the component manufacturer to prevent the formation of an explosive hydrogen concentration (mainly applicable for flooded lead acid batteries). The ventilation shall also ensure an ambient temperature compatible with operating range of the different components. This technical room shall be locked and clearly identified with specific label on the door.
    - In case, it is not possible to dedicate a technical room for the system due to the building arrangement, the components shall be installed in a room where the presence of Institution staff is limited to short periods of time. In all cases, this installation room shall have sufficient ventilation and the room shall have a secure access (lockable door) and a label on it indicating the presence of the system.
- The following warning stickers shall be installed in the room where the components are installed (especially close to the battery bank)

Figure 2-10: Warning stickers to be installed close to the battery bank in the technical room

- The installation shall be free of any major defects. A system will be considered to have major defects, if there is:
    - Broken, cracked, bent, misaligned or torn external surface of any component (PV module, battery, charge controller, inverter, other balance of system components)
    - Loss of mechanical integrity, to the extent that the installation and/or operation of the system would be impaired
    - Browning of any printed circuit boards
    - Signs of overheating and corrosion
    - Electrolyte leakage from the batteries
    - Deterioration of wiring insulation
    - Failure to function any component
- A permanent sticker with the name and contact details (phone number and email) of the Installation Company and the date of the system commissioning shall be fixed visibly on one of the key components in the technical room;
- A permanent sticker with all instructions to safely shut down the system (isolating PV array and battery bank) shall be fixed to the wall in the vicinity of the SCC and inverter.

2.6.2 PV Array

- The PV array can be installed either on the ground or on the roof. The location of the PV array shall be decided jointly between the IC and the Institution:
    - PV array installation shall be made in such a way that PV array is accessible for regular cleaning and maintenance
    - PV array installation shall be in area free of potential shading from trees or any other obstacles (as much as possible), slopped with optimum tilt of **30°** and oriented towards the **South**
    - PV modules shall be installed according to recommendations from the manufacturer described in the installation manual and shall respect a minimum space (e.g. 1 to 2 cm) between adjacent modules
- In case rooftop installation, the following conditions shall be verified:
    - the roofing surface is in good conditions
    - the roof structure is solid/resistant enough to bear the weight of the system
    - the roof is accessible with a secure access
    - in case of inclined roof, it is possible to correct the inclination and orientation of the PV array to 30° tilt towards the South

- the space is sufficient, including a secure path of 1 meter all around the PV array to ensure operation and maintenance activities

- A minimum space (preferably 20 cm but at least 15 cm) between the PV module rear side and the roof surface to allow natural ventilation and cooling of the PV modules

- Mounting structure and foundations:

  - The PV mounting structure (ground-mounted or roof top) shall be made of aluminium or hot dip galvanized steel with a minimum coating thickness of 70 µm

  - All fastening accessories (including screws) shall be made of aluminium or stainless steel (SAE 304). The design lifetime of the mounting structure shall be 20 years

  - If installed on the roof, the anchorage system of the mounting substructure on the roof shall be performed without drilling the roof slab or any other method injuring the waterproofing layer of the roof. The Installation Company shall implement during the works all the necessary measures to maintain the water tightness of the roof

  - If PV array is installed at ground level, concrete foundations shall be used, and an appropriate fence with barbed wire shall be installed all around the PV array to prevent any unauthorized persons to enter the PV array area. A warning sign regarding electrical hazard shall be fixed on the fence around the PV array.

  - If PV array is installed at ground level, the mounting structure shall have a minimum necessary clearance distance between ground level and bottom edge of PV modules of **0.5 meter**

  - If PV array is installed on a flat roof (with an inclined mounting structure), the mounting structure shall have a minimum necessary clearance distance between roof level and bottom edge of PV modules of **0.2 meter** (and a maximum of 0.5 meter)

  - The mounting structure and foundations shall be designed to withstand **180 km/hr** wind speed. Calculation note shall be provided with project documentation

- PV connectors:

  - The connectors used to form PV strings shall be compatible with the original PV module connector. Only the connector type approved by the module manufacturer shall be used and it shall be designed according to maximum current in the circuit

  - All PV connectors shall be suitable for outdoor installations at site condition with minimum protection of IP65 according to IEC 60529

- One PV combiner box shall be installed at the PV array to connect the different strings in parallel. The box shall be suitable for outdoor installation, shall be protected from direct sunlight and rain during installation and shall be rated minimum IP65 according to IEC 60529. In addition, the PV combiner box shall:

  - include a DC disconnect switch (isolation switch to isolate the PV array from the SCC) and a SPD if distance to the SCC is more than 10 meters (see more details in section 2.5.2.4)

- include fuse holders and fuses for each string If the PV array is composed of more than 2 strings. Fuse ratings shall be selected according to PV module manufacturer's recommendation on reverse current limit
- have a mechanical protection for all live components to avoid a direct electrical contact by the personal
- have all cable entering/outings into/from sealed properly so that dust and insects, mice cannot enter the box
- have lockable door with a warning sticker for electrical hazard and must be easily accessible

2.6.3 Battery bank

- Flooded lead acid batteries can be supplied charged or dry with the appropriate container of electrolyte. Electrolyte spillage shall be prevented during transportation and installation;
- The battery bank shall be designed with battery terminals cover which allow maintenance whilst minimizing exposure to live parts;
- The battery shall be protected against overcurrent by fuse(s) located as close as possible to the battery terminal(s):
  - Fuses shall be rated as per the conductor size and per the component they are protecting as specified by the manufacturer;
  - Fuses shall be marked with rated current, voltage and current type (AC or DC);
  - Battery fuses shall be rated for DC service in DC applications and suitable for the system voltage of the system.
- Battery system shall be installed on suitable battery racks in a dedicated technical room or enclosure which shall provide sufficient ventilation to prevent the formation of an explosive hydrogen concentration (see more details in section 2.6.1).

2.6.4 Cables

- PV string cables shall:
  - be specific for PV application with double insulation layers
  - not be exposed to direct sun and shall be UV resistant and be suitable for outdoor installation, both, underground and above ground
  - be fixed (tied) with the mounting structure and shall not be hanging and connection shall not be in tension
- Cables shall be selected with an insulation voltage level applicable to the system voltage for which they are used and ampacities suitable for the load being served;
- DC cable between battery terminals and SCC shall be single core and have a double insulation layer;

- Cables shall not be hanging at any part of installation and shall be mechanically protected. Internal house wiring shall be according to best practice and cable routing and fixing shall be neat and clean;

- If installed underground, the cable shall be placed in conduits for mechanical protection and conduits shall be protected from entering insects/animals, water, dirt i.e. the opening ends shall be closed;

- All cables shall be permanent labelled properly indicating the polarity;

- AC cables shall have three conductors (one for the neutral, one for the phase, one for the earthing) and be sized according to the load to be supplied on the circuit, the Miniature Circuit Breakers (MCB) rating and the maximum admissible cabling loss as per Table 2-3. Minimum standard sizes of wiring cable are as follows (item 5.10 of the Nepalese Standard):

    - Light Circuit: 2.5 mm² - PVC insulated copper stranded cable

    - Power Circuit: 4.0 mm² - PVC insulated copper stranded cable

- Cable size shall be defined according to maximum cabling losses indicated in Table 2-3. Although, the table includes recommendations on the cross-sections to be used according to distance and voltage conditions, it is under the IC responsibility to select the final suitable cable size in order to verify the maximum cable loss. A calculation note shall be provided in the project completion report to be prepared by the IC.

Table 2-3: Maximum values of cabling losses (2 kWp system)

<table>
<tr><th>Type of cable</th><th>Maximum cabling loss</th><th colspan="3">Proposed and recommended cross-section cables</th></tr>
<tr><td>AC cable between inverter output and AC distribution board</td><td>3%</td><td colspan="3">As per minimum cross section above and cable length</td></tr>
<tr><td rowspan="2">DC cable between the battery bank and the inverter/SCC</td><td rowspan="2">1%</td><td>24 V System</td><td colspan="2">48 V DC System</td></tr>
<tr><td>Minimum 50 mm² up to a cable length of 2 meters

Minimum 70 mm² up to a cable length of 3 meters</td><td colspan="2">Minimum 16 mm² up to a cable length of 2 meters

Minimum 25 mm² up to a cable length of 4 meters

Minimum 35 mm² up to a cable length of 6 meters</td></tr>
<tr><td rowspan="2">DC cable between PV Array and SCC</td><td rowspan="2">3%</td><td>40V < PV Array mppt voltage < 60V</td><td>60V < PV Array mppt voltage < 80V</td><td>80V < PV Array mppt voltage</td></tr>
<tr><td>Minimum 10 mm² up to a cable length of 5 meters</td><td>Minimum 10 mm² up to a cable length of 10 meters</td><td>Minimum 10 mm² up to a cable length of 20 meters</td></tr>
</table>

Type of cable	Maximum cabling loss	Proposed and recommended cross-section cables		
		Minimum 16 mm² up to a cable length of 8 meters Minimum 25 mm² up to a cable length of 12 meters Minimum 35 mm² up to a cable length of 18 meters	Minimum 16 mm² up to a cable length of 18 meters	