नेपाल सरकार

ऊर्जा, जलस्रोत तथा सिंचाइ मन्त्रालय

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दररेट पेश गर्ने सम्बन्धी सूचना

(प्रकाशित मिति : २०८३ भाद्र १५ गते)

उपरोक्त बिषयमा भोटेकोशी तथा त्रिशूली नदीमा आएको बाढी तथा पहिरोबाट प्रभावित विपद् सङ्कटग्रस्त क्षेत्रमा 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 सार्वजनिक खरिद नियमावली बमोजिम यस केन्द्रबाट 2kWp -Institutional Solar Photovoltaic System खरिद गरी वितरण तथा जडान गर्ने प्रयोजनको लागि योग्य तथा इच्छुक उत्पादक/आपूर्तिकर्ता/फर्महरूबाट मू.अ. कर बाहेकको प्रति एकाई दर उल्लेख गरि मिति २०८३ भदौ १६ गते अपरान्ह २:०० भित्र इमेल (info@aepc.gov.np) वा पत्र मार्फत केन्द्रमा उपलब्ध गराईदिनु हुन यो सूचना प्रकाशित गरिएको छ।

तपसील

क्र.स.	संक्षिप्त विवरण	आवश्यक अनुमानित परिमाण	उपलब्ध गराउन सक्ने परिमाण	दर रेट (मू.अ. कर बाहेक रु.)	कैफियत
१	Supply and Installation of 2kWp -Institutional Solar Photovoltaic System as per attached Specification	40 Set			
२	Additional Supply and Installation of Accessories (Each set must have 18 Watt LED Bulb-5Pcs, Bulb Holder- 5Pcs, Bed Switch – 5Pcs, 1.5sq.mm wire - 50 meter, Multiplug (extension cord) -2000watt having at least 1.5m cable -3 Nos.)	40 Set			
३	Road Transportation up to the sites within flood affected area	40 Set			

द्रष्टव्य :

- कार्यादेश दिएको ७२ घण्टा भित्र केन्द्रलाइ उपलब्ध गराउन सक्ने परिमाण उल्लेख गरी दरभाउ उपलब्ध गराउनुपर्नेछ। विपत्तिको समयमा राहत स्वरुप माथि उल्लेखित सामाग्रीहरु तुरुन्तै वितरण हुने हुँदा सो सामानहरु कम्पनीमा उपलब्ध रहेको सुनिस्चित गरेर मात्र दर रेट पेश गर्नुपर्ने छ।
- आवश्यकता तथा मागको मात्र आधारमा सामग्री खरिद गरिनेछ।
- सामग्री उपलब्धताको आधारमा एक वा एक भन्दा बढी व्यवसायी छनौट हुन सक्नेछन।
- सामग्री जडान भए पश्चात केन्द्रबाट रकम भुक्तानी हुनेछ।
- केन्द्रको मिति २०८३ भाद्र १० गतेको सूचना अनुसार प्राप्त दरभाउ मध्ये छनौट नभएका तथा छनौट भई कार्य सम्पादन हुन नसकेका सबै दरभाउ रद्द गरिएको छ।

Technical Specification of 2 kWp Institutional Solar PV System (ISPS) for flood relief

1. SCOPE OF WORK

The scope encompasses the design, supply, and installation of a resilient, plug-and-play solar power system intended for deployment within institutions located in flood-affected areas. The overall system architecture must be engineered for rapid, hassle-free deployment and user-friendly operation, requiring minimal technical expertise to commission. The system shall consist of a solar array, a battery bank, a charge controller, and an inverter. As the system is going to be transported and installed in difficult flood affected regions, the packing of the components of the system should have proper robust packaging. To ensure modularity and safety, the battery bank must be enclosed in a proper, secure battery case equipped with an inbuilt Battery Management System (BMS). Furthermore, the solar modules must utilize quick-connect connectors to facilitate seamless plug-and-play interconnection within the array and directly into the charge controller. The scope also includes the provision of a robust mounting structure, a comprehensive earthing and protection system, and all other necessary accessories and hardware required to deliver a fully operational, safe, and easily maintainable power solution. The selected company must provide after-sales service for a period of two years from the date of commissioning.

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: at least 2,000 Wp
2	Solar Charge Controller (SCC) compatible with Lithium Ion Battery	DC Input: at least 2,800 Wp
3	Battery Bank with suitable BMS	Capacity: at least 10,000 Wh (C10)
4	Inverter compatible for Lithium Ion Battery	Nominal Power: at least 3,000 VA

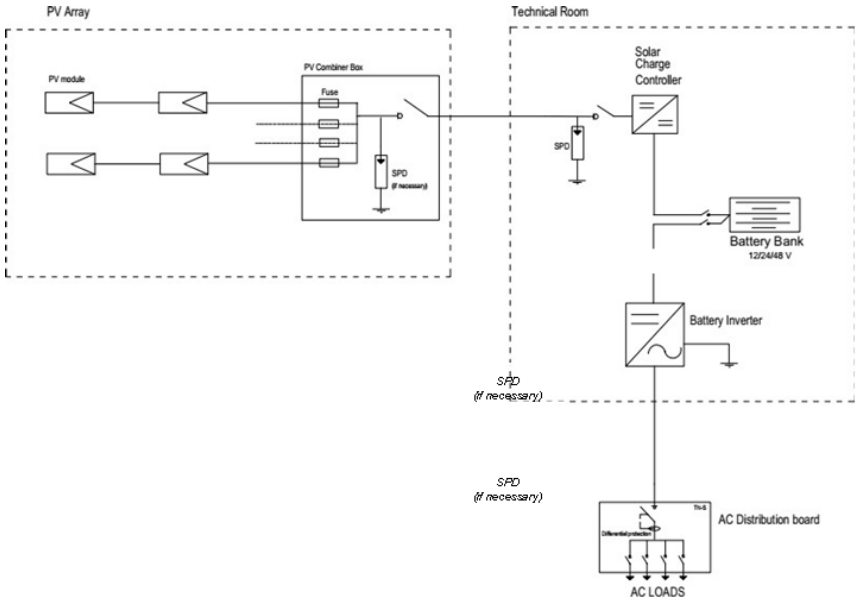


Figure 1-1: ISPS typical Single Line Diagram (indicative only)

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 ≥ 200 Wp Crystalline Silicon (c-Si) technology See section 2.1
2	Solar Charge Controller (SCC)	DC Input: 2,800 Wp MPPT Type. Lithium ion compatible See section 2.3
3	Battery Bank	Capacity: 10,000Wh (C10) Lithium Ion 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: Mild steel coated with red oxide primer and black paint 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	System voltage to be designed by the installation company as per the proposed components and design compatibility with all system components shall be ensured

2. SPECIFIC TECHNICAL SPECIFICATIONS

Compliance with the technical requirements will be verified by RETS. The bidding company must submit technical verification certificate from RETS. If the company fails to submit the RETS verification certificate within the time as agreed in contract or if the proposed components fail to meet the minimum requirements, company will not be eligible for payment.

The bidder must submit the technical specifications, catelogues and required certification along with the bid.

2.1 PV Modules

- Individual PV module capacity shall be more than 200 Wp
- PV module technology shall be crystalline silicon (c-Si - mono or poly);
- PV modules shall be certified (by an independent accredited laboratory) compliant with:
  - The PV modules must have and IEC 61215-2:2021: Terrestrial photovoltaic (PV) modules - Design qualification and type approval – Part 1: Test requirements and Part 2: Test procedures
  - The PV modules must have IEC61730-1:2016, IEC 61730-2:2016 - Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction and Part 2: Requirements for testing
  - The PV modules must have IEC62804-1:2015- Photovoltaic (PV) Modules – Test methods for the detection of potential induced degradation - Part 1: Crystalline silicon (For PV Module above 350Wp) IEC 61215-1:2021
  - The PV modules must have IEC 61701:2020 – Photovoltaic (PV) Modules – Salt mist corrosion testing (For PV module above 350Wp)
  - The PV modules must have IEC 62716:2013 – Photovoltaic (PV) Modules - Ammonia corrosion testing (For PV module above 350Wp)
  - 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)
- The Crystalline PV module must have positive power tolerance within 0 to +10% greater than 100Wp to 200Wp and 0 to +3% above 200Wp.
- The module efficiency for crystalline module must be at least 18% for above 150Wp to 350Wp and at least 21% for above 350Wp.
- Crystalline PV modules must have inbuilt bypass diodes. The junction box must have at least IP65 protection according to IEC 60529.
- The PV connector type supplied by the module manufacturer or approved by the module manufacturer must be used and must comply with IEC 62852. Degree of protection at least IP67 according to IEC 60529.
- The serial number must be laminated inside the glass of the PV Module.
- The Product Warranty must be minimum 10 years
- The Power Output Warranty must be:
  - first year: ≥ 97% of STC power
  - 10 years: ≥ 90% of STC Power
  - 25 years: ≥ 80% of STC Power
  - and linear warranty ≤ 0.8% per year from year 2 and onwards
- The PV module must be provided with nameplate label consisting of indelible markings at the back of module. The nameplate must contain the following information.
  - Nominal Power in Wp
  - Name of the manufacturer

- Brand, Model and Type
- Voltage at maximum power

2.2 Battery

- The battery must be Lithium-Ion type
- Following certificate/document must be submitted
  - The Battery test certificates/reports from IEC accredited laboratory must be provided according to: IEC 62619:2022 - Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications (including battery pack)
  - The Battery must be certified by Certification Body Testing Laboratory (CBTL) or Renewable Energy Testing Laboratory (RETL) or National Certification Body (NCB) or Renewable Energy Certification Body (RECB) enlisted in the IECEE website or IECRE website
  - Catalogue and technical datasheet of Battery
- 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. Evidence 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 life cycle of battery must be at least 3,000 cycles at 80% DoD. However, for battery packs with capacities below 2 kWh, 2,000 cycles at 80% DoD shall be accepted.

- The battery must have positive capacity tolerance of 0 to +20% within 5 cycles of test.
- Battery C-Rate must be at least 0.2C for Lithium Ion Battery.
- All batteries to be installed shall be of same type, same model and same capacity rating (from same manufacturer) for each individual site;
- A Battery Management System (BMS) must be included by the battery manufacturer to ensure safety protection (voltage, current and temperature control at cell level). Safety protection against thermal runaway, over charging and over discharging shall be ensured by the battery manufacturer.
- The round-trip efficiency must be at least 85%.
- The warranty of the battery must be of at least 5 years for Lithium Ion-Battery with BMS
- The battery pack/bank along with BMS must be enclosed in casing and should be plug and play type.
- The following information must be included on the label of the battery and the label must be printed on the battery. The label must contain the following information:
  - Name of the manufacturer
  - Brand, Model and Type
  - Rated capacity
  - Nominal voltage
  - Serial number

2.3 Solar Charge Controller (SCC)

- The charge controller must be MPPT or PWM charge controller
- The Charge Controller must have deep discharge protection and must be compatible with Lithium Ion and should be compatible with deep discharge protection managed by BMS
- HVD must be at 4.2X, V for X for X number of 3.7 V cells Lithium Cobalt Oxide ($LiCoO_2$) in series and 3.6X, V for X number of 3.2V cells Lithium Ferrous Phosphate ($LiFePO_4$) in series. Setting point must be within +/-2% of Manufacturer's claim at 25°C. Other than above mentioned voltage system for Lithium Ion, the HVD must be in the range of 13% to 21% higher than nominal voltage. Where X is a natural number with the same value.
- Using electro-mechanical relays is not permitted.
- The charge controller enclosure must have at least IP20 protection according to IEC 60529.
- The efficiency of MPPT charge controller must be at least 95% and for PWM the efficiency must be at least 90%.
- The Charge Controller must include
    - Protection against reverse polarity must be provided in both the PV module and battery sides.
    - Short circuit protection on load side must be provided.
    - Over current protection on the load side and surge protection on module side must be provided.
    - 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. Evidence shall be provided with the quotation
- SCC shall have a display indicating the battery voltage/the state of charge, charging and discharging currents, current functioning status, and alarms;
- For PWM based controllers, the quiescent current consumption must not exceed:
    - 20mA at nominal voltage (the non-critical indicators are turned off) for charge controller sized up to 20A.
    - 25mA at nominal voltage (LCD Display) for charge controller sized up to 20 A.

- For MPPT based controllers, the quiescent current consumption must not exceed
    - 25mA at nominal voltage (the non-critical indicators are turned off) for charge controller sized up to 20A.
    - 35mA at nominal voltage (LCD Display) for charge controller sized up to 20 A.
    - 40mA at nominal voltage for CC (LED indicators) above 20A and up to 60A and 60mA at nominal system voltage for CC (LCD display) above 20A and up to 60A.
    - 100mA at nominal voltage for CC above 60A.

- The warranty of the charge controller must be of at least 3 years
- The following information must be included on the label of the controller. The label must contain the following information:
    - Name of the Manufacturer
    - Brand, Model and Type
    - Rated capacity
    - Voltage range
    - Serial Number
    - Maximum wattage

In-built solar charge controllers in the inverter are accepted as long as they meet the technical requirements as mentioned above.

2.4 Inverter

- The inverter shall deliver a pure sine wave voltage (AC output voltage of 230 V, 50 Hz);
- The Battery Inverter must be compatible with Lithium Ion Battery.
- The inverter must be Stand-alone or Off-grid Inverter (DC-AC Inverter)
- The Inverter must have a rated AC output voltage of Single Phase 230 ±10% VAC (L-N)
- The Output frequency of the inverter must be 50Hz ± 2.5%.
- The efficiency of inverter must be at least 85% at full load at nominal voltage with transformer topology and must be at least 90% at full load at nominal voltage with transformer less topology.
- The efficiency when operating loads at power levels between 40% to 90% of the rated load must be greater than 90% for transformer less topology.
- The efficiency when operating loads at power levels between 40% to 90% of the rated load must be greater than 80% for transformer topology.
- The no load loss must be less than 1% of rated power for transformer less topology.
- The no load loss must be less than 2% of rated power with transformer topology.
- The total harmonic distortion (THD) must be less than 5% at full load.
- The inverter must maintain the power factor between 0.8 Lagging to 0.8 Leading.
- The inverter must have at least IP21 protection according to IEC 60529.
- The inverter must not produce noise more than 60db at 2meter distance.
- Hybrid Inverter must have solar charging priority.
- Inverter or Inverter circuits must include
    - Reverse polarity protection on DC input terminals.
    - Short Circuit protection of the output terminals.
    - Appropriate indicators main, charging, inverter ON, short circuit and overload.
- The inverter must have either cooling system with fan or appropriate heat sink to avoid excessive heating
- Inverter must be capable of operating safely for at least 2 seconds at 150% of rated power.
- For Inverter with inbuilt charge controller, the charging side of charge controller will be tested as per provision stated in charge controller section and load side parameters of charge controller will not be tested
- The warranty for the battery inverter must be at least: 3 years
- The following minimum information must be included on the label of the inverter. The label must contain the following information:
    - Name of the manufacturer

- Brand/Model
- Rated power in watt or VA
- Input and output voltage in Volt and Frequency in Hz
- Serial Number

- 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. Evidence shall be provided with the quotation
- 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.

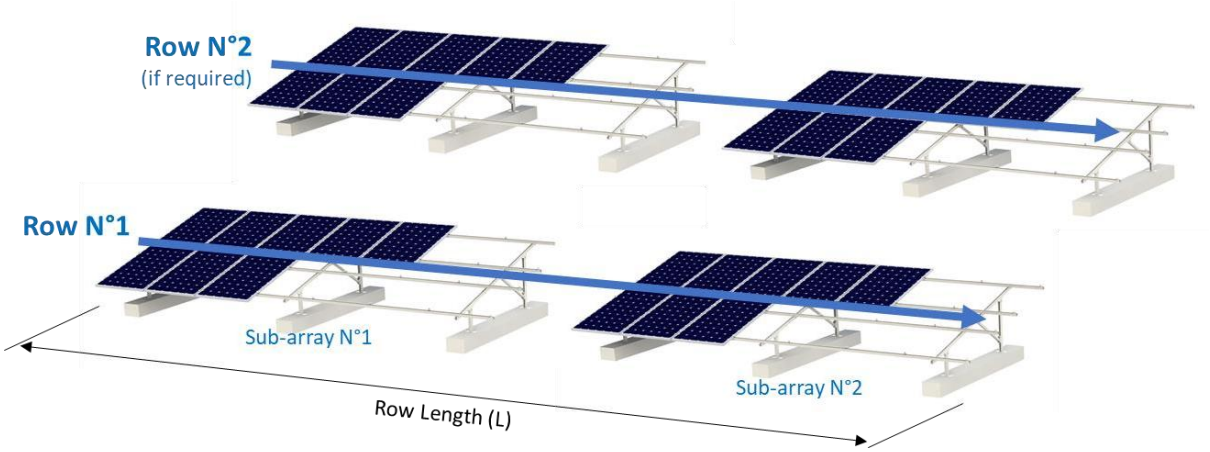


Figure 2-1: PV array layout and definition (valid for ground-mounted or rooftop installations)

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:

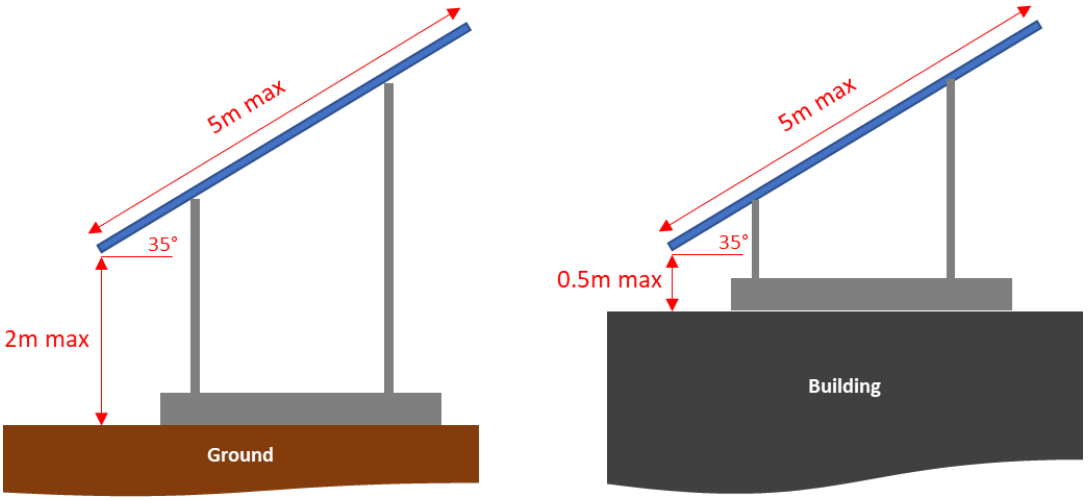


Figure 2-2: Maximum size of the PV array (profile view) for the proposed LPS design

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 (Smin)

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 (Smin)** when the air-terminal rod is installed on its own concrete base (or foundation) with support accessories or more than **0.60 meter (Smin)** 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 should 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.

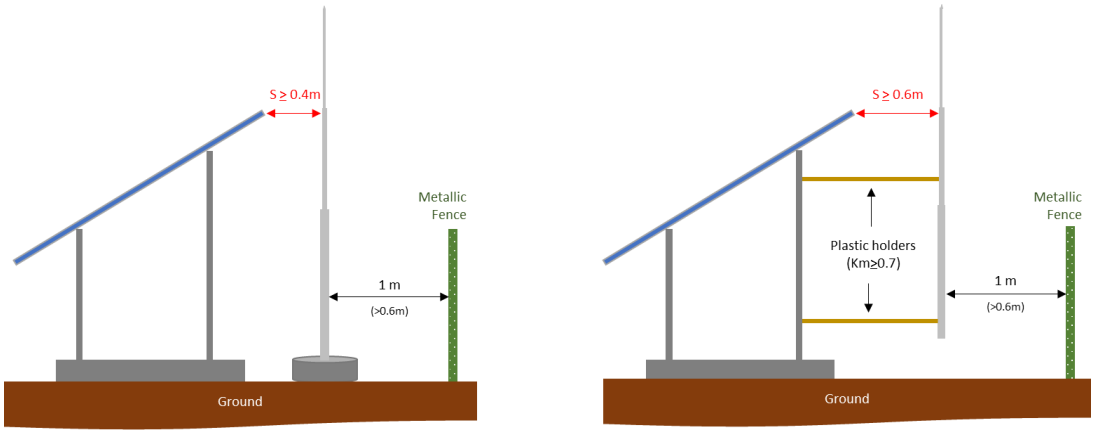


Figure 2-3: Separation distances (S) for ground-mounted installations

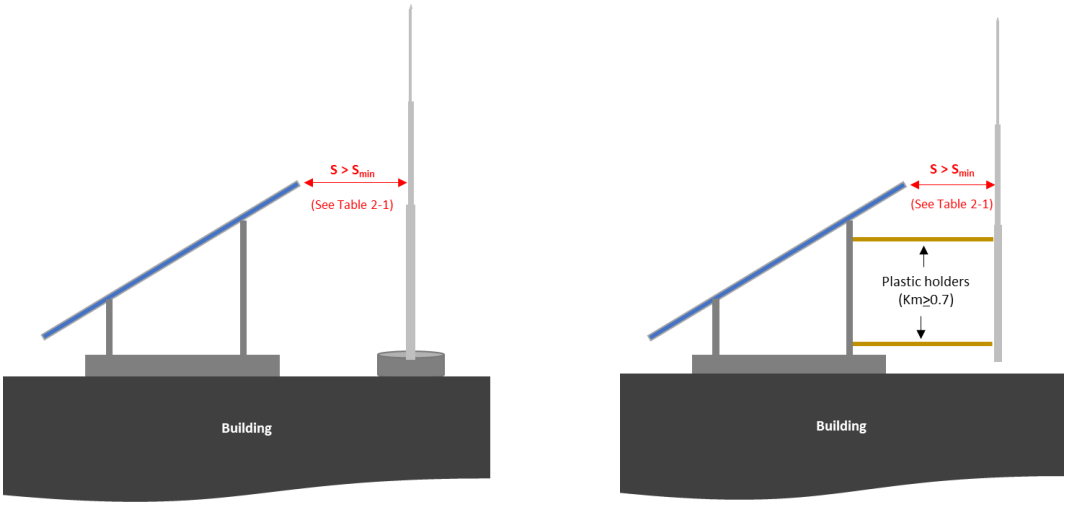


Figure 2-4: Separation distance (S) for roof-mounted installations

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 colored cells, Smin > 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

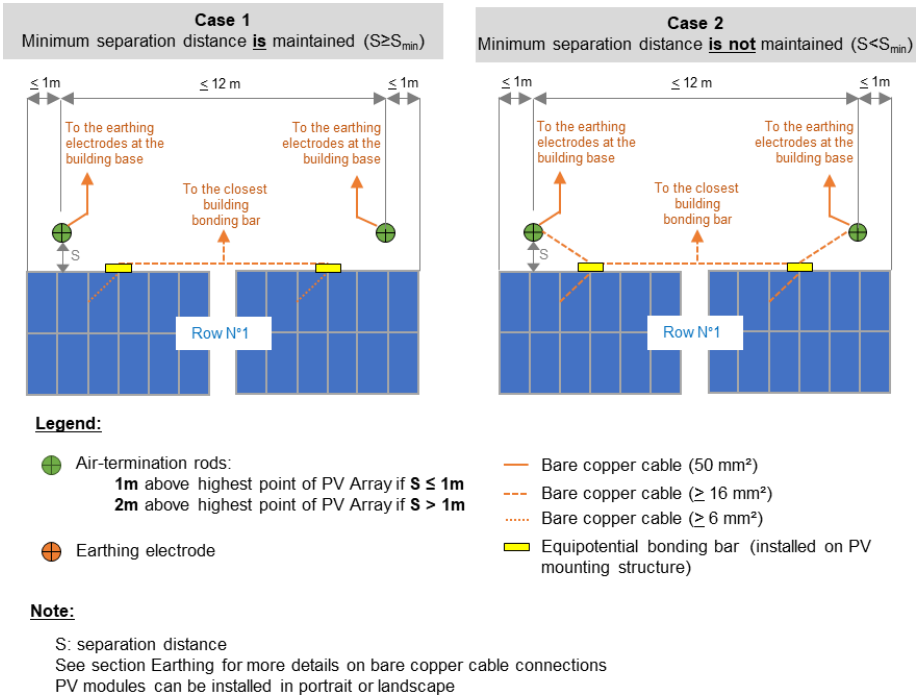


Figure 2-5: LPS design for PV array length comprised between 4m and 14m (roof-mounted installations)

- For ground-mounted installations:

  - **one (1) meter** above any part of the PV array

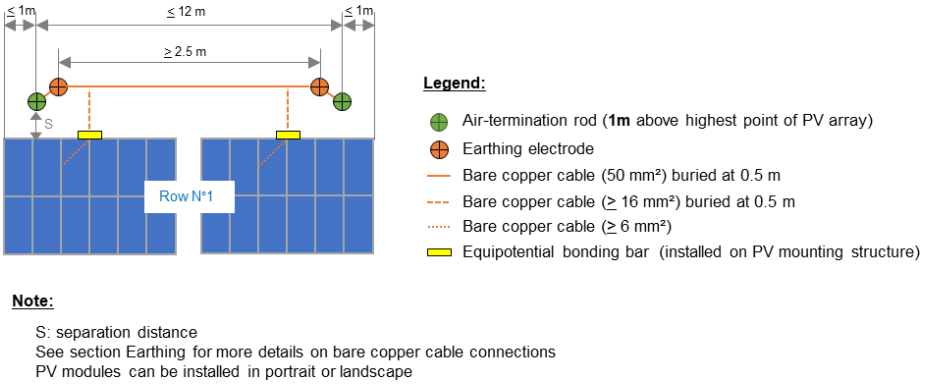


Figure 2-6: LPS design for PV array length comprised between 4m and 14m (ground-mounted installation)

- 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.

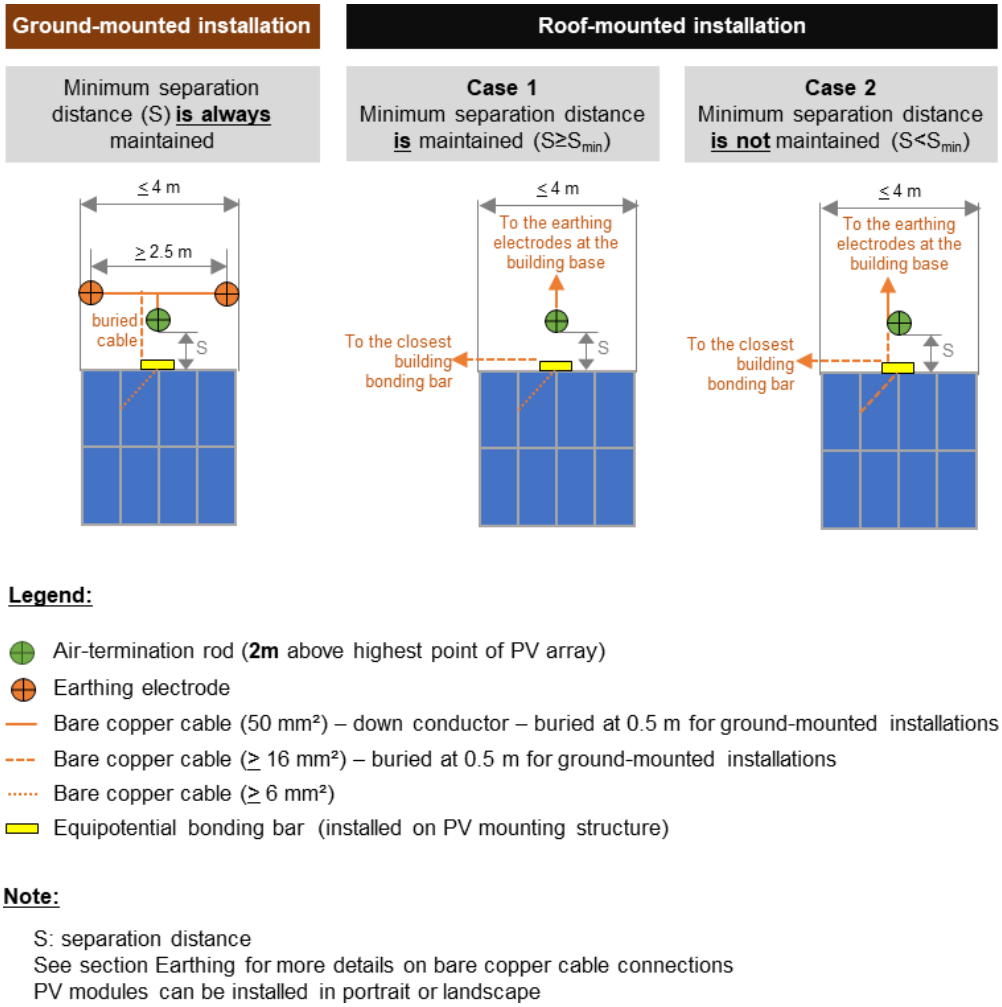


Figure 2-7: LPS design for PV array length lower or equal to 4m

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;

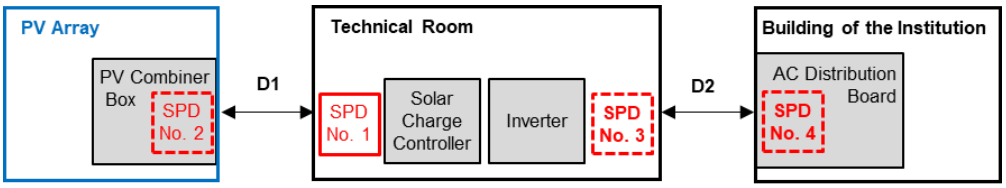
- For roof-mounted installations, each air-terminal rod shall be connected through down conductors to the earthing electrodes to be installed at the base of the building (at ground level), each with its own inspection pit. As minimum, two earthing electrodes shall be installed preferably at the opposite 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 In ≥ 5 kA - Maximum discharge current Imax ≥ 20 kA
Type 1+2	8/20 µs wave form: - Nominal discharge current In ≥ 5 kA Maximum discharge current Imax ≥ 20 kA

	10/350 µs wave form: - Lightning impulse current Iimp ≥ 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:
    - Up (voltage protection level) shall be at least 20% lower than the rated impulse withstand voltage (Uw) of the equipment to protect
    - Uc (maximum continuous voltage) shall be 20% more than open circuit voltage of the PV array
    - Iscpw (short circuit current rating) shall be more than the maximum current which can be delivered by the PV array (more than short circuit current Isc 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.

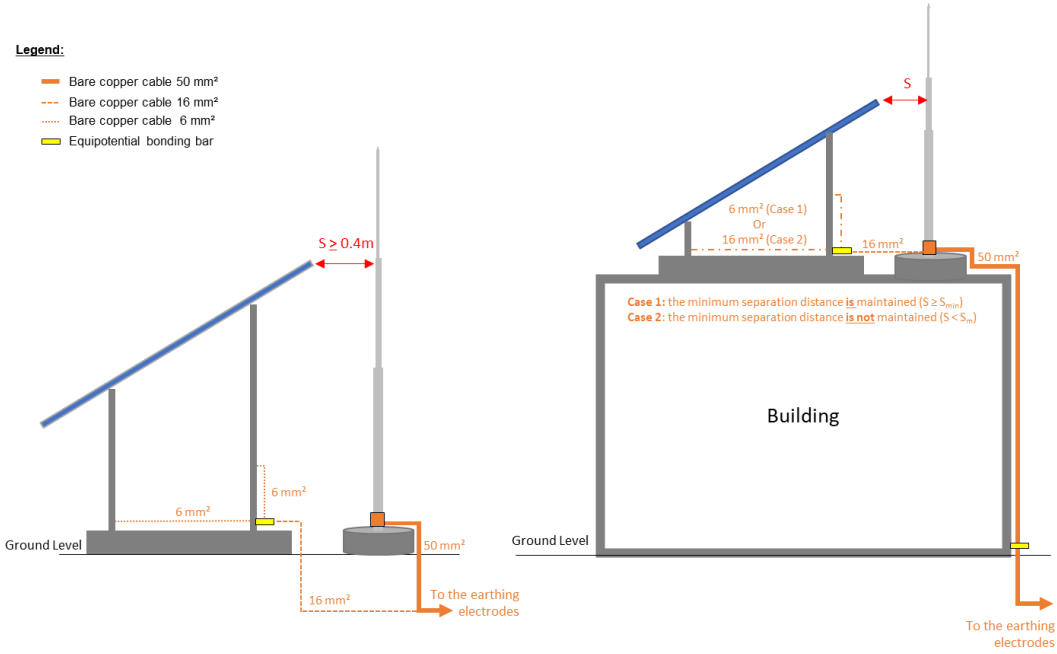


Figure 2-9: Earthing requirements

- All earthing electrodes shall be connected together by a bare copper conductor of 50 mm^2 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 mm^2;
- 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 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
- For ground-mounted installation, a bare copper conductor of 50 mm^2 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 AEPC and the institution where system will be installed;
- Inverter and SCC shall be installed next to each other and the distance to the battery bank shall be kept as minimum as possible;
- 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 of rooftop installation, the following conditions shall be verified:
    - The roofing surface is in good condition.
    - The roof structure is solid/resistant enough to bear the weight of the system
    - The roof is accessible with 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 Mild steel coated with red oxide primer and black paint.
    - 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 mechanical protection for all live components to avoid 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 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 mm^2 - PVC insulated copper stranded cable
    - Power Circuit: 4.0 mm^2 - PVC insulated copper stranded cable
- Cable size shall be designed according to maximum cabling losses.