TECHNICAL SPECIFICATIONS
OF
HYBRID
SOLAR PV POWER PLANTS

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1. SCOPE OF THE WORK

The scope includes guidelines and practices for the Design, Supply, Installation, Testing and Commissioning of Hybrid rooftop/ Ground Mounted PV power plants.

All the necessary approvals from Supervision committees, necessary civil works, Mounting of Module Structures, PV Module Installation, Inverters Installation, Battery Bank, DC/AC Cabling and interconnections, Connecting all the package components with the Earthing System (All the components of the package should be connected properly by means of sized cable with the existing earthing system) as per the standards, Net Metering, Arranging all the necessary inspections from Electrical Inspectorate as part of Pre-Commissioning if any, Commissioning of the PV Power Plant, are coming under the scope of the contractor.

2. LOCATION

On the top of the engineering department- Kirkuk University.

3. DEFINITION

A Hybrid Solar PV power plant system comprises of Mono Crystalline C-Si (Crystalline Silicon)/ Thin Film Solar PV modules with intelligent Inverter having MPPT technology and Intentional- Islanding feature and associated power electronics, which feeds generated AC power to the Grid and engineering department (Essential load will be defined by the end-user) when the Grid is not available. Other than PV Modules and Inverter/Inverters,the system consists of a Battery Bank, Module Mounting Structures, appropriate DC andAC Cables, Array Junction Boxes (AJB) / String Combiner Boxes (SCB), AC and DC Distribution Box, Net meter, etc.

4. SOLAR PV MODULE

The Contractor shall use only the PV modules that are approved by the project engineers. The List of PV modules under various categories have to be submitted for review/ approval. However, the specifications for the PV Module is detailed below:

1. The PV modules must be PID compliant, salt, mist & ammonia resistant and should withstand weather conditions for the project life cycle.
2. The back sheet of PV module shall be minimum of three layers with outer layer (exposure to ambience) and shall be made of PVDF or PVF. The Back sheets for PV Module with 2 layered or 3 layered Polyester types or the back sheets with Polyester (PET type) at Air side material are not permitted for the empanelment; The minimum thickness of the core layers (without adhesive and inner EVA coated) must be 300 microns. The maximum allowed water vapor transmission rate shall be less than 2 g / m^2/day and shall have a Partial Discharge > / = 1500V DC
3. The front glass shall meet the following specifications:
    a. The facing glass must be Tempered, PV grade with Low iron and high transmission.
    b. The transmission shall be > 93 %
    c. Thickness shall be min 3.0 mm
    d. Textured to trap more light
    e. The glass shall have an Anti-reflective coating for the better transmission and light absorption.
    f. Tempered glass to meet the external load conditions
4. The encapsulant used for the PV modules should be UV resistant in nature. No yellowing of the encapsulant with prolonged exposure shall occur. The sealant used for edge sealing of PV modules shall have excellent moisture ingress Protection with good electrical insulation and with good adhesion strength. Edge tapes for sealing are not allowed.
5. Anodized Aluminum module frames of sufficient thickness shall be used which are electrically & chemically compatible with the structural material used for mounting the modules having provision for earthing.

6. UV resistant junction boxes with minimum three numbers of bypass diodes and two numbers of MC4 connectors or equivalent with appropriate length of 4 sq.mm Cu cable shall be provided. IP65 degree of protection shall be used to avoid degradation during Life. .

7. Shading correction/ bypass diode for optimizing PV out to be incorporated in each solar module or panel level.

8. Each PV module used in any solar power project must use a RF identification tag (RFID). The RFID can be inside or outside the module laminate but must be able to withstand harsh environmental conditions, The RFID must contain the following information:

   a) Name of the manufacturer of PV Module.

   b) Name of the manufacturer of Solar cells.

   c) Month and year of the manufacture (separately for solar cells and module).

   d) Country of origin (separately for solar cell and module).

   e) I-V curve for the module.

   f) Peak Wattage, I_M, V_M and FF for the module.

   g) Unique Serial No. and Model No. of the module.

   h) Date and year of obtaining IEC PV module qualification certificate.

   i) Name of the test lab issuing IEC certificate.

   j) Other relevant information on traceability of solar cells and module as per ISO 9000 series.

9. The following details should be provided on the module

   a) Name of the manufacture
   b) Serial Number.
   c) Month and year of manufacture.
   d) Rated Power at STC.
   e) VMP, IMP, VOC, Isc.

10. The successful bidder shall arrange an RFID reader to show the RFID details of the modules transported to sites, to the site Engineer in charge up to their satisfaction, which is mandatory for the site acceptance test.
11. The PV modules must qualify (enclose Test Reports/Certificates from accredited laboratory) as per relevant IEC standard. The Performance of PV Modules at STC conditions must be tested and approved by one of the approved Accredited Testing Laboratories.
12. PV modules used in solar power plant/ systems must be warranted for 12 years for their material, manufacturing defects, workmanship. The output peak watt capacity which should not be less than87% at the end of 20 years and 60% at the end of 25 years
13. Original Equipment Manufacturers (OEM) Warrantee of the PV Modules shall be submitted by the successful bidder when the materials delivered at site.
14. The PV modules shall conform to the following standards:

- **IEC 61215 / IEC 61646**: c-Si (IEC 61215): Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval Thin Film (IEC 61646): Design, Qualification & Type Approval
- **IEC 61730-1**: Photovoltaic Module safety qualification- Part 1: Requirements for construction
- **IEC 61730-2:** Photovoltaic Module safety qualification- Part 2: Requirements for testing
- **IEC 61701:** Salt mist corrosion testing of photovoltaic modules.
- **IEC 62716:** Test Sequences useful to determine the resistance of PV Modules to Ammonia (NH_3)

INVERTER

The Inverters shall be String Inverter with power exporting facility to the Grid. The detailed specification for the inverter should be submitted for review/approval. However, the specifications for the Hybrid Inverters are detailed below:

General Specifications:

1. All the Inverters should contain the following clear and indelible Marking Label & Warning Label. The equipment shall, as a minimum, be permanently marked with:

   a. The name or trademark of the manufacturer or supplier.

b. A model number, name or other means to identify the equipment.

c. A serial number, code or other markings allowing identification of manufacturing location and the manufacturing batch or date within a three-month time period.

d. Input voltage, type of voltage (A.C. or D.C.), frequency, and maximum continuous current for each input.

e. Output voltage, type of voltage (A.C. or D.C.), frequency, maximum continuous current, and for A.C. outputs, either the power or power factor for each output.

f. The Ingress Protection (IP) rating

2. The Hybrid inverter output shall be 400 VAC, 50 Hz, 3 phases.

3. The Hybrid inverter should have all the technical requirements for connecting to the Grid and Engineering Department with facility for connecting to a battery bank

4. The Hybrid inverter shall include appropriate self-protective and self-diagnostic feature to protect itself and the PV array from damage in the event of inverter component failure or from parameters beyond the inverter's safe operating range due to internal or external causes.

5. The layout of Inverter accommodation shall be designed to enable adequate heat dissipation and availability. Mount within the existing infrastructure available in consultation with the Site in charge. String Inverters may be installed with Canopy type structure over it to protect
it from frequent monsoon and weather changes.

6. The IEC Certifications of On-Grid Inverters are summarized below:

Standard	**Description**
IEC 61683	Photovoltaic systems – Power conditioners – Procedure for measuring efficiency
IEC 61727 or VDE-AR-N 4105	Photovoltaic (PV) systems- Characteristics of the utility interface
IEC/EN 62109-1	Safety of power converters for use in photovoltaic power systems – Part 1: General requirements
IEC/EN 62109-2	Safety of power converters for use in photovoltaic power systems – Part 2: Particular requirements for inverters

IEC/EN 61000-3-3/ 3-11/ 3-5	Electromagnetic compatibility (EMC) – Part 3-11; Limits; Limitation of Voltage Change, Voltage Fluctuations and Flicker in Public Low- Voltage Supply Systems; Rated Current <16A / >16A and <75A / >75A per Phase respectively
IEC/EN 61000-3-2/ -3-12/ -3-4	Electromagnetic compatibility (EMC) – Part 3-12; Limits; Limits for Harmonic Currents produced by equipment connected to the public low voltage systems with Rated Current <16A / >16A and <75A / >75A per Phase respectively
*IEC/EN 61000-6-1 / 6-2	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for residential and commercial / industrial environments
IEC/EN 61000-6-3 / 6-4	Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for residential and commercial / industrial environments
IEC 62116 /IEEE 1547 or IEEE 1547.1 / UL 1741	Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures
IEC 60068-2-1	Environmental testing – Part 2-1: Tests – Test A: Cold
IEC 60068-2-2	Environmental testing – Part 2-2: Tests – Test B: Dry heat
IEC 60068-2-14	Environmental testing – Part 2-14: Tests – Test N: Change of temperature
IEC 60068-2-30	Environmental testing – Part 2-30: Tests – Test Db:, Damp heat, cyclic (12 h + 12 h cycle)

6. BATTERY BANK

1. The battery bank must be Lithium. The Contractor shall use only the Batteries that are approved. However, the specifications for the Batteries are detailed below:

Technical Requirements

S.No:	Parameters
1.	Nominal Capacity (Ah) shall be rated
2.	Minimum Nominal voltage (V):
3,	Self-discharge (less than 3% per month at 30°C) .
4	A 1 hour backup of MNRE requirement is required for Hybrid Power Plant and is estimated as 30.7 kWh

2. General Specifications:

a. Test certificate submitted should qualify the minimum requirements as per above standards for capacity test, ampere-hour efficiency test, watt-hour efficiency test, self- discharge test.

b. Battery shall have a warrantee of minimum 5 years.

c. Battery capacity is rated at 25°C

d. Original Equipment Manufacturers (OEM) Warrantee of Battery shall be submitted

4. STANDARDS AND CERTIFICATIONS

Major IEC Certification for LMLA/VRLA / Lithium Ferro Phosphate batteries are listed below:

Standard	**Description**
IEC 61427	IEC 61427 – This series gives general information relating to the requirements for the secondary batteries used in photovoltaic energy systems (PVES) and to the typical methods of test used for the verification of battery performances.
IEC 60896	This part of IEC 60896 applies to all stationary lead-acid cells and Monobloc batteries of the valve regulated type for float charge applications, (i.e. permanently connected to a load and to a d.c. power supply), in a static location (i.e. not generally intended to be moved from place to place) and incorporated into stationary equipment or installed in battery rooms for use in telecom, uninterruptible power supply (UPS), utility switching, emergency power or similar applications.
IEC 62133: 2012	Defines requirements and tests for the safe operation of portable sealed secondary cells and batteries containing alkaline or other non-acid electrolyte, under intended use and reasonably foreseeable misuse.
IEC 61056	IEC 61056-1:2012 specifies the general requirements, functional characteristics and methods of test for all general-purpose lead-acid cells and batteries of the valve-regulated type
IEC 61056	IEC 61056 defines the general requirements, functional characteristics and methods of test for all general-purpose lead-acid cells and batteries of the valve- regulated type.
IEC 62133-2: 2017	IEC 62133 requirements and tests for the safe operation of portable sealed secondary lithium cells and batteries containing non-acid electrolyte, under intended use and reasonably
IEC 62620:2014	IEC 62620 defines marking, tests and requirements for lithium secondary cells and batteries used in industrial applications including stationary applications.

DATALOGGING

A data logging system (Hardware and software) for monitoring the plant shall be provided (can be provided with the inverter) has embedded data logging system. The following weather parameters are to be measured as part of the datalogging system.

a) Solar Irradiance:

A Pyranometer/ Solar cell-based irradiation sensor (along with calibration certificate) shall be provided, with the sensor mounted in the plane of the array. Readout shall be integrated with data logging system: from 25kWp to less than 100kWp

Pyranometer (Class II or better) shall be provided with the sensor mounted in the place of the array. Readout shall be integrated with data logging system: for 100kWp and above.

b) Temperature: Integrated temp, sensors for measuring the module surface temp., inverter inside enclosure temp, and ambient temp to be provided complete with readouts integrated with the data logging system.

2. It is recommended that the following important parameters shall be accessible through the Data Logging Facility.

a) AC Voltage
b) AC Output current
c) Output Power
d) Energy in kWh
e) DC Input Voltage
f) DC Input Current
g) Temperatures (C)
h) Invertor Status
i) Irradiation
j) Module temperature
k) String Voltage & Current (For PV Plants from 100kWp onwards)

3. Provision for Internet monitoring and download of historical data shall be incorporated. GSM Modem/Wi Fi modem in case GSM connectivity is used or Wireless Router + modem in case Ethernet connection is being used for remote access must be provided.

4. The data from the above data monitoring system will be used for calculating the Performance Ratio (PR) of the power plant as per IEC 61724 for plants above 225-250kWp.capacity Hybrid PV Plant.

MODULE MOUNTING STRUCTURE

- Photovoltaic arrays must be mounted on a stable, durable structure that can support the array and withstand wind, rain, snow and other adverse conditions. The modules will be fixed on structures with fixed arrangement.

- The module mounting structures and car parking shall have adequate strength and appropriate design suitable to the locations, which can withstand the load and high wind velocities. Stationary structures shall support PV modules at a given orientation, absorb and transfer the mechanical loads to the surface properly.

- Each structure with fixed tilt should have a tilt angle as per the site conditions to take maximum insolation which will be approximately equal to the latitude of the location facing true South. The tilt angle can vary from 25 degree to 35 degree based on the location's latitude in Ninawa

- The PV module mounting structures and car parking and shall have a capacity to withstand a wind velocity of 120km/hr.

- Suitable fastening arrangement such as grouting and calming should be provided to secure the installation against the specific wind speed. The PV array structure design shall be appropriate with a factor of safety of min 1.5. The STAAD / Equivalent structural design report must be attached along with the technical bid.

- The materials used for structures shall be Hot dip Galvanized Mild Steel conformed to IS 2062:1992 or aluminum of suitable grade minimum alloy 6063 or better.

- The minimum thickness of galvanization for hot dip Galvanized Mild Steel should be at least 180 microns.

- The Bolts, Nuts, fasteners, and clamps used for panel mounting shall be of Stainless-Steel SS 304.

- Aluminum structures used shall be protected against rusting either by coating or anodization.

- Aluminum frames should be avoided for installations in coastal areas.

- The structure shall be designed to withstand operating environmental conditions for a period of minimum 25 years. And shall be free from corrosion while installation.

- Screw fasteners shall use existing mounting holes provided by module manufacturer. No additional holes shall be drilled on module frames

- Minimum distance between the lower level of PV Module and the roof ground shall be 0.6m from the roof ground level.

- The PV Panel area shall be accessible for cleaning and for any repair work.

- Sufficient gap needs to be provided between the rows to avoid falling of shadow of one row on the next row.

- Adequate spacing shall be provided between any two modules secured on PV panel for improved wind resistance.
- Installation of structure for solar PV mounting should not tamper with the water proofing of the roofs.
- The above drawing is specific for RCC flat roofs and may vary for slope roofs. However the drawings shall be approved by concerned Site Engineer before installing the plant.

SOLAR METER and NETMETER

Solar Meter:

A separate Energy Meter called Solar Meter shall be provided at the output to record the energy generation from the Solar System. Solar energy meter means a unidirectional meter to be installed at the delivery point of the solar energy system to measure the solar electricity generated. This Energy Meter should be tested along with the Net Meter (Import-Export Meter).

Net meter:

Net metering system is to be provided to the solar consumer. Net meter means the bidirectional energy meter to be installed at the interconnection point of the consumer with the network of distribution licensee

Energy meters shall be installed and maintained in accordance with the provisions of The Central Electricity Authority.

A solar meter and bidirectional energy meter suitable for the installed solar plant shall be supplied and installed by the contractor after testing. Energy Meters must be provided with the necessary data cables if required.

The solar energy meter and net energy meter shall be of accuracy as given and CT and PT shall be utilized accordingly.

Meters shall be microprocessor based conforming IEC 60687 / IEC 6205211 / IEC 62053-22 and solar energy meter or its display shall be placed adjacent to net energy meter.

Display parameters: LCD test, kWh import, kWh export, MD in kW export, MD in kW import, Date & Time, AC current and voltages and power factor (Cumulative kWh will be indicated continuously by default & other parameters through push-button). The solar energy meters and net energy meters should be DLMS compliant and AMR compatible with RS 485 communication port for measurement of specified electrical

parameters.

The solar energy meters shall be provided with two ports for communication of the measured / collected data. One port compatible with RS 485 specifications. The other port shall be an optical port complying with hardware specifications detailed in IEC 62056-21.

10.EARTHING.

The Solar PV Plant should have a dedicated earthing system. The Earthing for array and LT power shall be made as per the provisions of IEC 60364, IEC 60335 and Iraqi Technical specifications for building construction.

1. Earthing System shall connect all non –current carrying metal receptacles, electrical boxes, appliance frames, chassis and PV module mounting structures in one long run. The earth strips should not be bolted. Earthing GI strips shall be interconnected by proper welding.

2. In any case, the cross-section area or the earthing conductor for PV equipment should not be less than 6 mm^2 copper. For the earthing of lightning arrestor, cross-section of the earthing conductor should not be less than 16 mm^2 of copper. The complete Earthing system shall be mechanically & electrically connected to provide independent return to earth.
3. All non-current carrying metal parts shall be Earthed with two separate and distinct earth continuity conductors to an efficient earth electrode.
4. The equipment grounding wire shall be connected to earth strip by proper fixing arrangement. Each strip shall be continued up to at least 500mm from the equipment.

The bidder shall submit the detailed drawings for the Earthing arrangements.

11.ARRAY JUNCTION BOX (AJB)/ STRING COMBINER BOX (SCB)

AJB shall be provided as per the design requirement of the Inverter, if required. AJB comprises of an enclosure, copper busbars, Fuses, Surge Protection Device (SPD) and Isolator. DC generated by the solar modules is transmitted through the appropriate cables from Array Yard to Control facility. AJB bus & panel shall be provided for the incoming DC supply from array yard.

AJB, if required, should be equipped with an adequate capacity indoor DC circuit breaker along with control circuit, protection relays, fuses, etc.

AJB, if required, shall have sheet from enclosure of dust and vermin proof, the bus bar / cables are to be made of copper of desired size.

The Array Junction Boxes are to be provided in the PV array for termination of connecting cables. The Array Junction Boxes shall be made of GRP/FRP/with full dust, water& vermin proof arrangement. All wires/cables must be terminated through cable lugs. The JBs shall be such that input & output termination can be made through suitable cable glands.

1. Suitable markings shall be provided on the bus bar for easy identification and the cable ferrules must be fitted at the cable termination points for identification.
2. Copper bus bars/terminal blocks housed in the junction box with suitable termination threads conforming to IP 65 standard to prevent water entry, Single/ double compression cable glands, provision of earthing. It should be placed at a height suitable for ease of accessibility.
3. Each Junction Box shall have high quality Suitable capacity Metal Oxide Varistors (MOVs)/ SPDs. The Surge Protective Device shall be of Type 2 as per IEC 60364-5- 53
4. The junction Boxes shall have suitable arrangement for the followings (typical): - Combine groups of modules into independent charging sub-arrays that will be wired into the controller. The Junction Boxes shall have arrangements for disconnection for each groups and attest point for sub-group for fault location. AJB/SCB shall be wired with optical fiber cables for enabling data collection for PV Plants from 100kWp onwards.
5. The current carrying ratings of the string combiner box/ junction box shall be suitable with adequate safety factor, to inter connect the Solar PV array.
6. All fuses shall have DIN rail mountable fuse holders and shall be housed in thermoplastic IP65 enclosures with transparent covers.
7. Fuse for both positive and negative inputs of each strings, Isolator of MCB, SPD of type 2 shall be provided.

8. The surge arresters shall be type 2 (with reference to IEC 61643-1) rated at a continuous operating voltage of at least 125 percentage of the open-circuit voltage of the PV string, and a flash current of more than 5A.
9. Not more than two strings can be connected in parallel to a single input of SCB/AJB. One spare input terminal along with connector shall be provided for each SCB/AJB.
10. Every SCB/AJB input shall be provided with fuses on both positive and negative side.
11. DC switch disconnector of suitable rating shall be provided at AJB/SCB output to disconnect both positive and negative side simultaneously.
12. Switches/ circuit breakers/ connectors meeting general requirements and safety measurements as per IEC 60947 part I, II and III.

12.AC DISTRIBUTION BOARD

AC Distribution Board (ACDB) shall control the AC power from inverter and should have necessary surge arrestors.

An ACDB panel shall be provided in between PVU and Utility grid. It shall have MCB/MCCB/ACB or circuit breaker of suitable rating for connection and disconnection of PVU from grid.

1. The connection between ACDB and Utility grid shall be of standard cable/ Conductor with suitable termination. It shall have provision to measure grid voltage, current and power.
2. The incomer shall be selected at required rating. The ACDB enclosure shall be of good protection and suitable for mounting on the trenches / on wall.
3. All the 400 V AC or 230 V AC devices/equipment like bus support insulators, circuit breakers, SFU isolators (if applicable), SPD, etc. mounted inside the switch gear shall be suitable for continuous operation
4. Switches/ circuit breakers/ connectors meeting general requirements and safety measurements as per IEC 60947 part I, II and III.
5. Junction boxes, enclosures, panels for inverters/ Controllers shall meet IP 54 (for outdoor)/ IP 65 (for indoor) as per IEC 529.

13.AC/DC CABLING

Cabling is required for wiring from AC output of inverter to the Grid Interconnection point. It includes the DC cabling from Solar Array to AJB and from AJB to inverter input.

1. All cables of appropriate size to be used in the system shall have the following characteristic:
   a. Shall conform to IEC 60227, IEC 60502 standards and Iraqi Technical specifications.
   b. Voltage rating: 600/1000V
   c. Excellent resistance to heat, cold, water, oil, abrasion, UV radiation
   d. Flexible.

2. Sizes of cables between any array interconnections, array to junction boxes, junction boxes to inverter etc. shall be so selected to keep the voltage drop (power loss) of the entire solar system to the minimum (2%).
3. For the DC cabling, XLPE or XLPO insulated and sheathed, UV stabilized single core flexible copper cables shall be used; Multi-core cables shall not be used.
4. For the AC cabling, PVC or XLPE insulated and PVC sheathed single or, multi-core flexible copper cables shall be used. Outdoor AC cables shall have a UV -stabilized outer sheath IEC 69947.
5. The total voltage drop on the cable segments from the solar PV modules to the solar grid inverter shall not exceed 2%.
6. The total voltage drop on the cable segments from the solar grid inverter to the building distribution board shall not exceed 2%.
7. The DC cables from the PV module array shall run through a UV-stabilized PVC conduit pipe (or Cable trays) of adequate diameter with a minimum wall thickness of 1.5mm.
8. Cables and wires used for the interconnection of solar PV modules shall be provided with solar PV connectors (MC4) and couplers
9. All cables and conduit pipes shall be clamped to the rooftop, walls and ceilings with thermo-plastic clamps at intervals not exceeding 50cm; the minimum DC cables size shall be 4.0mm^2 copper; the minimum AC cable size shall be 4.0mm^2 copper. In three phase systems, the size of the neutral wire size shall be equal to the size of the phase wires.
10. Cable Marking: All cable/wires are to be marked in proper manner by good quality ferule or by other means so that the cable can be easily identified. The following color code shall be used for cable wires
    a. DC positive: red (the outer PVC sheath can be black with a red line marking.
    b. DC negative: black.
    c. AC single phase: Phase: red; Neutral: black.
    d. AC three phase: phases: red, yellow, blue; neutral: black.

e. Earth wires: green.

11. Cables and conduits that have to pass through walls or ceilings shall be taken through PVC pipe sleeve.
12. Cable conductors shall be terminated with tinned copper end ferrules to prevent fraying and breaking of individual wire strands. The termination of the DC and AC cables at the Solar Grid Inverter shall be done as per instructions of the manufacturer, which in most cases will include the use of special connectors.
13. All cables and connectors used for installation of solar field must be of solar grade which can withstand harsh environment conditions including high temperatures, UV radiation, rain, humidity, dirt, salt, burial and attack by moss and microbes for 25 years and voltages as per latest IEC standards. DC cables used from solar modules to array junction box shall solar grade copper (Cu) with XLPO insulation and rated for 1.1 kV as per relevant standards only.
14. Bending radius for cables shall be as per manufactures recommendations.
15. For laying/termination of cables latest IEC standards shall be followed.

14.CIVIL WORKS

Existing shade-free roof-top space shall be used to install Solar PV array. While installing solar power pants on rooftops, the physical condition of the rooftop, chances of shading, chances water level rise in the rooftop during raining due improper drainage in the roof-top should be taken in to consideration.

1. PV array shall be installed in the terrace space free from any obstruction and/or shadow and to minimize effects of shadows due to adjacent PV panel rows.
2. PV array shall be oriented in the south direction in order to maximize annual energy yield of the plant.
3. The solar PV array must be installed on the rooftop in such a way that there is sufficient space on the rooftop for maintenance etc.
4. There should not be any damage what so ever to the rooftop due to setting up of the solar power plant so that on a later day there is leakage of rainwater, etc. from the rooftop.

   Some civil works are inevitable for erecting the footings for the module mounting structure as discussed in Module Mounting Structure section. The roof top may be given a suitable grading plaster with suitable leak proof compound so as to render the roof entirely leak proof.
5. While cabling the array, care must be taken such that no loose cables lie on the rooftops.

6. The roof top should look clean and tidy after installation of the array.
7. Neatness, tidiness and aesthetics must be observed while installing the systems.
8. RCC Works - All RCC works shall be as per Iraqi technical Specification and the materials used. Cement reinforcement, steel, formwork etc. shall be as per relevant Iraqi technical Specification.
9. Display of mandatory items- Single Line Diagram and layout diagram of modules and interconnection at installation site.
10. All Civil works required for the installation of the PV Plant and other civil and electrical work in evacuation infrastructure, wherever necessary, shall be within the scope of the bidder.

15.OPERATION MANUAL

An Operation, Instruction and Maintenance Manual, should be provided with the system. The following minimum details must be provided in the manual:

- About solar power plant – its components and expected performance.
- Cleaning of Solar PV Modules in regular intervals
- Clear instructions on regular maintenance and troubleshooting of solar power plant
- AS built Drawings for the Installation
- OEM Warrantee Certificates of Inverters, PV Modules, Batteries etc.
- Specification of PV Plant
- Data Sheets of major equipment like PV Module, Inverter etc.

16. Site training for operation and maintenance:

Provide necessary manpower and documents for site operating and maintenance training for the end-user team (10 persons) for the solar system for (5 days, 7 hours per day) to ensure improving the level that qualifies the attendances to carry out the routine operation and urgent maintenance. A final evaluation of participants at the end of the course will be required. Training plans, schedules, and manuals must be provided. Training must be carried out by a certified trainer, a CV for the trainer has to be provided for review and approval.