KAHRAMAA الموسسة العامة القطرية للكهرباء والماء
Qatar General Electricity & Water Corporation

Conservation and Energy Efficiency Department

Guideline Specifications for Standalone Solar PV Systems

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البرنامج الوطني للترشيد وكفاءة الطاقة
NATIONAL PROGRAMME FOR CONSERVATION AND ENERGY EFFICIENCY

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Foreword

Qatar General Electricity and Water Corporation “KAHRAMAA” was established in July 2000 in terms of Law # 10 to regulate and maintain the supply of electricity and water to customers. KAHRAMAA has the privilege of being the sole transmission and distribution system owner and operator (TDSOO) for the electricity and water sector in Qatar.

In alignment with Qatar National Vision 2030 and KAHRAMAA’s commitment to the provision of high quality and sustainable electricity through renewable energy, the Conservation and Energy Efficiency Department has developed technical specifications and guidelines for standalone solar PV systems. This guidelines document serves as benchmark for quality assurance and safety for standalone solar PV systems to be followed by all concerned stakeholders in KAHRAMAA’S projects. This document also serves as a foundation for the development of the local renewable energy market by defining important technical specifications and standards based on best international and regional experiences.

An online version of this document is available in KAHRAMAA’s website at: www.km.qa.

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Definitions

BCI	Battery Council International
Bypass diode	A diode connected across a number of PV cells that prevents hot spots and damage to the PV cell by allowing the current to bypass a broken or shaded cell
CE certification	A certification that indicates compliance to the European Economic Area (EEA) standards for health, safety, and environmental protection
Competent person	A person who has acquired specialized knowledge, experience, qualifications or a combination of these in all aspects relating to standalone solar PV systems that enables them to conduct the task required proficiently
DIN	German National Organization for Standardization
ELCB	Earth-leakage circuit breaker
EN	Technical European Standards drafted by the European Committee for Standardization
IEC	International Electrotechnical Commission
Inverter	A device that converts d.c. voltage and current in to a.c. voltage and current
ISO	The International Organization for Standardization
Kahramaa	Qatar General Electricity & Water Corporation
Lightning protection system (LPS)	A system that minimizes damage to a structure due to lightning flashes
Low-voltage (LV)	Voltage less than 1000 V a.c. or 1500 V d.c.
Power conversion equipment (PCE)	A device that converts electric power from one form into another with respect to voltage, current, and frequency. This includes inverters and charge controllers.
PV array	The assembly of electrically connected PV modules, strings, or sub-arrays alongside all equipment until the input point to the inverter or power conversion equipment
PV module	A complete and protected assembly of interconnected PV cells
RFID	Radio frequency identification tag

Shall	Indicates a mandatory statement
Should	Indicates a recommendation
Solar charge controller	A device that controls the charging and discharging of a battery in a standalone solar PV system
Standalone solar PV system	A complete solar PV system that is not connected to Kahramaa's distribution network
Surge protective device	A device that limits transient overvoltage and diverts surge current
Main switchboard	The switchboard from where the electric supply to the installation is controlled

1. Introduction

1.1 Objective and Scope

The objective of this document is to provide technical guidelines for the design, installation, safety, and operation and maintenance of standalone solar PV systems used for the supply of low voltage electric power for Kahramaa projects. This document also covers quality assurance specifications for equipment used in these systems. The guidelines mentioned in this document shall be followed by all concerned stakeholders involved in the design, construction, testing, and operation and maintenance of standalone solar PV systems.

The scope of this document is standalone solar PV systems, which are solar-electric generation systems supplying power to a load(s) **but are not connected to Kahramaa's electricity distribution grid**. Examples of standalone solar PV systems are:

- Solar-powered street lighting
- Solar-powered water pumping
- Rooftop solar installation on buildings (for local energy consumption), where the PV system would connect to the building's main switchboard.
- Solar PV systems coupled with battery storage
- Hybrid solar PV systems (combining solar with other energy sources (e.g. diesel generators))

The specifications and requirements in this document cover the following components: PV modules (and arrays) and mounting systems, inverters, power conversion equipment, batteries, and balance of system components (wiring, junction boxes etc). For all components, minimum quality certifications are defined in this document, alongside installation guidelines, electrical safety requirements, and system documentation. Recommended electrical design and mechanical and civil design procedures are also included.

This document applies to:

- Projects developed for Kahramaa
- Systems with a nominal max. power of 240 W up to 240 kW (although the requirements of this document may be applied to larger systems).
- Solar inverters that comply with IEC 62109-1 and IEC 62109-2 and power conversion equipment that comply with IEC 62109 series.
- Battery systems with a nominal voltage between 12 V d.c. and 1500 V d.c. and with a rated capacity of more than or equal to 1 kWh but less than 200 kWh.

1.2 Application

This guidelines document shall be read in conjunction with any relevant standards or codes in the State of Qatar that relate to electrical installations, electrical safety, mechanical and civil works, and any other aspects related to standalone solar PV systems. All standalone solar PV systems shall comply with the latest version of Kahramaa's Electricity Wiring Code 2016 to the extent applicable. All equipment used in these systems shall comply with the quality, health, and safety requirements of the relevant authorities in the State of Qatar.

1.3 Referenced Documents

The following documents are relevant for the design, testing, and operation of standalone solar PV systems and should be referred to in all projects. The latest version of each document shall be referred to in all cases.

- Kahramaa's Low Voltage Electricity Wiring Code 2016
- IEC 61730-1 & IEC 61730-2: Photovoltaic (PV) module safety qualification
- IEC 61215-1 & IEC 61215-2: Terrestrial photovoltaic (PV) modules - Design qualification and type approval
- IEC 60364-7-712: Low voltage electrical installations - Part 7-712: Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems
- IEC 62124: Photovoltaic (PV) standalone systems - Design verification
- IEC 62548: Photovoltaic (PV) arrays - Design requirements
- IEC 60896: Stationary lead-acid batteries
- IEC 62109: Safety of power converters for use in photovoltaic power systems
- IEC 62509: Battery charge controllers for photovoltaic systems - Performance and functioning
- IEC 62093: Balance-of-system components for photovoltaic systems – Design qualification natural environments
- IEC 61427: Secondary cells and batteries for renewable energy storage - General requirements and methods of test
- IEEE Std. 937-2007: IEEE recommended practice for installation and maintenance of lead-acid batteries for photovoltaic (PV) systems
- UL 1741: Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources
- UL 2703: Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat-Plate Photovoltaic Modules and Panels

2. Specifications, Installation, and Safety Guidelines

2.1 Overview

Standalone solar photovoltaic systems are composed of a collection of interconnected electrical components, which can generate electricity from sun-light and satisfy our daily energy requirements in an environmentally friendly way. Standalone solar PV systems are those not connected to Kahramaa's distribution grid and can be connected directly to a single load or to an electrical installation via the main switchboard (where all solar-generated electricity will be consumed internally).

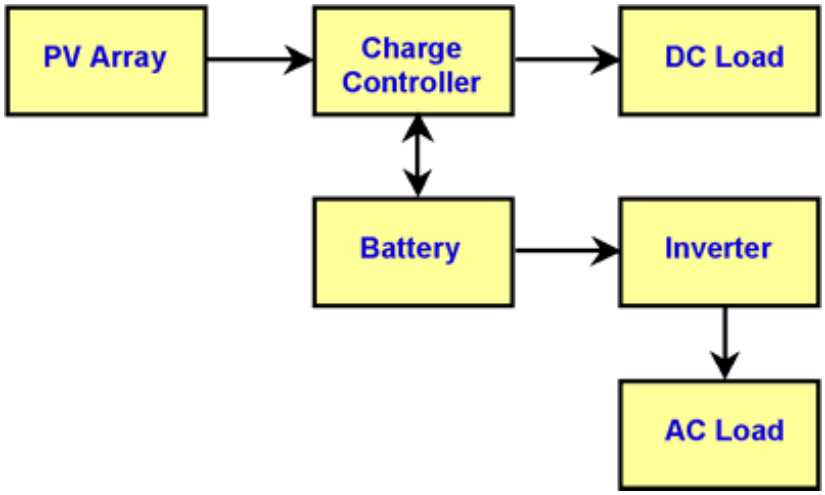

Figure 1 Schematic of a typical standalone solar PV system

A typical standalone solar PV system consists of a PV array, PV array support structure, string/array combiner boxes, d.c. cabling, d.c. distribution box, charge controller, battery, inverter, a.c. cabling, a.c. distribution box, and system a.c. energy meter. Some of these components are optional and are not required in some applications (e.g. batteries are not mandatory for solar water pumping systems). Figure 1 shows a schematic of a standalone solar PV system and the interconnection of the system components.

2.2 General Safety Requirements

The selection and installation of all components in standalone solar PV systems shall comply with Kahramaa's Electricity Wiring Code 2016 and any other relevant codes or standards in the State of Qatar. All design, installation, and commissioning activities shall be done by competent persons.

The PV array and its associated components shall be rated for d.c. use, have a voltage rating equal to or higher than the PV array maximum voltage, and be rated for the maximum possible current in the electrical circuit. PV arrays, charge controllers, inverters, and batteries shall be located as close as possible to each other to reduce d.c. wiring

losses. If the standalone solar PV system is designed to connect to a building's main switch board, then an appropriate changeover switch and overcurrent protection shall be applied. Batteries shall have proper ventilation and shall be located at an appropriate distance from nearby equipment. Appropriate protection and safety procedures shall be applied for hazards associated with batteries, which include: electrical hazards, mechanical hazards, chemical hazards, fire hazards, energy hazards, explosive gas hazards, and toxic fume hazards.

The a.c. output voltage of the standalone solar PV system shall be in accordance with declared voltage in the State of Qatar as stated in clause 1.4 in Kahramaa's Electricity Wiring Code 2016. The main incomer protection for the distribution board at the a.c. side of the installation shall have an ELCB (earth-leakage circuit breaker) of 30 mA rating for earth leakage and appropriate load rating.

There should be signs that clearly identify the standalone solar PV system components and the possible electric hazards and/or risks. Clear instructions on system shutdown procedure and response required for emergencies shall be provides, alongside any necessary sketches or electric line diagrams. All equipment with moving parts and subject to elevated temperatures (above 70^{o}C) shall be mechanically and thermally protected. All wires shall be protected in accordance with Kahramaa's Electricity Wiring Code. Batteries shall have overcurrent protection.

All components in the standalone solar PV system exposed to outdoor conditions shall be IP65 rated as a minimum and shall be UV resistant. Enclosures such as combiner and junction boxes and battery storage boxes shall be at least IP65 rated.

2.3 Equipment Country of Origin

With the exception of solar panels, **all equipment used in standalone solar PV systems shall be made by U.S. or European manufacturers, unless otherwise exempt by Kahramaa.**

2.4 System Design Procedures

The design of standalone solar PV systems shall be done by competent persons and in accordance with applicable international standards and practices. The final system design shall be robust, meet the user requirements, optimize components, ensure safe system operation, and comply with local standards and regulations. The following factors should be carefully considered in the design process:

- The system autonomy should be chosen to suit the load characteristics and the local weather conditions
- The PV array positioning (azimuth angle and tilt angle) should be decided based on computer simulations by the system integrator

2.5 Solar PV Array

2.5.1 PV Modules

2.5.1.1 General Requirements

- Modules to be used shall be reliable modules with a proven track record in performance and operation from an established manufacturer.
- Modules shall comply with IEC 61215 and IEC 61730-1,2. Modules shall only be used in applications corresponding to their declared class ratings.
- Only PV modules of class II as described in IEC 61730 shall be used.
- PV modules installed in coastal areas shall comply with IEC 61701 for salt mist corrosion.
- All modules to be supplied shall be of the same type and from a single manufacturer. The Contractor shall be responsible for modules' arrangement to minimize the losses due to mismatching and maintain maximum power. Moreover, the quality of equipment supplied shall be generally controlled to meet the guidelines for engineering design included in the standards and codes listed in the relevant IEC and other standards.
- PV arrays with voltages greater than 50 V d.c. shall have bypass diodes, unless the manufacturer doesn't require them or if shading is not possible due to the design or the location characteristics.
- All transportation, storage, handling and installation of the modules shall be done in accordance with the manufacturer specifications, so as to not to void the module manufacturer's warranty.

2.5.1.2 Identification and Traceability

Each PV module must use a Radio Frequency Identification Tag (RFID), which must contain essential information about the module. The RFID shall be inside the module's laminate, to be able to withstand harsh environmental conditions. The RFID tag shall contain:

- Name of the manufacturer
- Name of the manufacturer of solar cells
- Unique serial number and model no of module
- Month and year of the manufacture (separately for solar cells and module)
- Country of origin (separately for solar cells and module)
- I-V curve and NOCT for the module
- Peak power (P_{mp}), maximum power current (I_{mp}), and maximum power voltage (V_{mp})
- Date of obtaining IEC PV module qualification certificate

- Name of the test lab issuing IEC certificate
- Other relevant information on traceability of solar cells and modules as per ISO 9000 series

2.5.1.3 PV Module's Technical Requirements

The following table shows Kahramaa's minimum technical requirements for PV modules.

Table 1 PV module technical requirements

No	Parameter	Requirement
Characteristics		
1	PV technology	Crystalline silicon technology (mono or poly)
2	Array rated power	≥ 240 W_p
3	Module efficiency	≥ 15%
4	Temperature coefficient on P_{mp}	≤ -0.45%/°C
5	Nominal power tolerance from module manufacturer (used for acceptance of modules)	+3%
6	Array maximum system voltage	1,500 V d.c.
Product warranty and performance guarantee		
7	Workmanship/product replacement	Minimum 10 years
8	Power output guaranteed during the first year of operation	Minimum 97%
9	Degradation until year 25	Linear
10	Linear degradation coefficient from year 2 to year 25	Maximum 0.7%/year
11	Guaranteed output of the nominal power after 10 years	Minimum 90%
12	Guaranteed output of the nominal power after 25 years	Minimum 80%
13	Product warranty against manufacturing defects	Minimum 10 years
14	Wind load rating	Minimum 2400 Pa
Module and factory certifications		
15	Module certifications	IEC 61215 IEC 61730-1,2 IEC 61701 (for coastal installations)

		IEC 60068-2-68
16	Manufacturer certifications	ISO9001:2008 ISO14001:2004 OHSAS18001

2.5.1.4 Array Mounting Structure Requirements

- The array mounting structure should comply with UL 2703 standard for safety.
- Modules shall be mounted on a corrosion-resistant support structure made of suitable materials capable of maintaining structural integrity.
- There shall be the minimum necessary clearance between top roof (if used) level and bottom edge of PV modules.
- The array structure shall be designed to occupy minimum space without sacrificing the output from PV panels due to shadowing, orientation or tilt at the same time.
- Support structural material shall be corrosion resistant and electrolytically compatible with the materials used in the module frame, its fasteners, nuts and bolts, and mounting clamps should be stainless steel. The support structure shall be free from corrosion when installed.
- Adequate spacing shall be provided between two panel frames and rows of panels to facilitate personnel protection, ease of installation, replacement, cleaning of panels and electrical maintenance.
- Minimum clearance between lower edge of PV panel and ground/roof top ground level to allow ventilation for cooling, also ease of cleaning and maintenance of panels as well as cleaning of ground/roof top.
- The supplier shall specify installation details of the PV modules and the support structures with appropriate diagrams and drawings. Such details shall include, but are not limited to, the following;
  - Determination of true south at the site
  - Array tilt angle to the horizontal, with permitted tolerance
  - Detailed drawings for fixing the modules
  - Detailed drawings of fixing the junction/terminal boxes
  - Interconnection details inside the junction/terminal boxes
  - Structure installation details and drawings
  - Electrical grounding (earthing)
  - Inter-panel/Inter-row distances with allowed tolerances
  - Safety precautions to be taken

The technical specifications for the PV array mounting are given in Table 2.

Table 2 Array mounting structure techical specifications

No	Parameter	Requirement
1	Installation method	Fixed installation
2	Module installation	Portrait or landscape orientation. Must respect row-to-row shadowing and cell (and bypass diode) connections of the PV module
3	Row to row distance	Minimum distance of 0.5 m between the back of one row and the front of the next row to allow O&M service
4	Distance to parapet	Minimum distance of 2 m
5	Fixation onto the ground (if used)	Using concrete pile or raft foundations
6	Fixation onto the roof (if used)	Via ballast, no penetration of the roof, with no impact on waterproofing of the roof structure
7	Life time	≥ 25 years
8	Warranty	≥ 10 years
9	Standard for safety	UL 2703
10	Workmanship warranty	Minimum 10 years
11	Installation warranty	Minimum 10 years

2.6 Power Conversion Equipment (PCE)

Power conversion equipment (PCE) are electric energy conversion devices such as d.c/a.c inverters and battery charge controllers. PCE in standalone solar PV systems optimize PV array performance and (for systems with batteries) provide optimal battery charging while protecting the batteries from overcharging.

2.6.1.1 General Requirements

- **All PCE shall comply with IEC 62109. PCE used as battery charge controllers shall comply with IEC 62509. PCEs shall also be qualified according to IEC 62093. Safety specifications of the PCE shall comply with UL 1741**.
- CE certification for low voltage directive (EN 50178: 1997) is recommended.
- Battery charge controllers shall be used to control the battery charging process from the PV array, which complies with the requirements of the battery manufacturer, to ensure the maximum life of the batteries.
- The charger controller shall be compatible with the PV array and batteries being used in terms of rated current and voltage respectively.

- Efficiency of the PV charger controller should not be less than 80%.
- The PV charger controller shall be rated for at least 125% of the full rated current.
- The PV charger controller shall also provide reverse polarity protection for both battery and PV connection, over voltage protection and under voltage cut off.
- PCE ingress protection rating shall comply with IEC 62093.
- The charger controller should have easy-to-read indicators illustrating the battery's state of charge, including a light indicator that shows when the battery is fully charged and a series of light indicators to indicate the level of charge.
- Temperature compensation should adjust the charging current to the battery against varying ambient conditions.
- The workmanship warranty of the solar charge controller shall be 5 years minimum.
- The charge controller must protect against:
  - Short circuits in the charge terminal
  - Transient waves of voltage induced by atmospheric discharges (lightning)
  - Polarity reversal in the module's terminal

2.7 Battery

2.7.1 General Requirements

- The batteries shall be solar photovoltaic batteries of the following types: deep-cycle lead-acid and made of hard rubber container or Lithium-ion batteries.
- Batteries shall comply with IEC 61427, IEC 60896 (BCIS-21 specification for non-spillable certification valve), and/or relevant BCI, DIN, BS and IEC standards.
- **Lead acid batteries shall be installed and maintained in accordance with IEEE Std. 937-2007.**
- The manufacturer's requirements for storage, shipping, installation, and safety shall be observed.
- The batteries shall use 2V cells and battery capacity is to be designed at C10/C20 rate with end cell cut off voltage of 1.75 V/cell.
- Battery terminal shall be provided with covers.
- Batteries shall be provided with micro porous vent plugs with floats.
- Charging instructions shall be provided along with the batteries.
- Suitable carrying handle shall be provided.
- A suitable battery rack with interconnections & end connector shall be provided to suitably house the batteries in the bank.

- The batteries shall be rated for operating in the environmental conditions in the State of Qatar.
- The self-discharge of batteries shall be less than 3% per month at 20 °C and less than 6% per month at 30 °C.
- The charge efficiency shall be more than 90%.
- The batteries shall have appropriate ventilation.

The battery technical specifications are given in Table 3.

Table 3 Technical specifications of the battery

No	Parameter	Requirement
1	Battery technology	Deep-cycle Lead-acid battery/Lithium-ion battery
2	Rate of discharge	C/10 or C/20
3	Battery efficiency	≥ 90%
4	Operation temperature	-5 °C to 55°C
5	Self-discharge	less than 3% per month
6	Batteries enclosure IP rating	IP65
7	Product warranty against manufacturing defects	≥ 5 years
8	Workmanship warranty	Minimum 5 years
9	Quality and safety certifications	BCIS-21 (specification for non-spillable certification valve) IEC 61427-1:2013 IEC 60896 Other applicable BCI, DIN, BS and IEC standards

2.8 Inverter

The solar inverter converts d.c. electrical energy generated by PV arrays (which may then be stored in a battery) into a.c. electrical energy.

2.8.1.1 General Requirements

- Inverters shall comply with IEC 62109, IEC 62093, and the safety specifications of UL 1741.

- Inverters to be used shall be reliable inverters with a proven track record in performance and operation. The manufacturer shall be established in the market.
- The inverters specifications shall be selected with respect to the local climatic and environmental conditions, especially regarding temperature, dust and humidity.
- The output of the inverter shall be 240V (with standard tolerance level), 50 Hz single phase AC.
- The inverter shall incorporate suitable d.c./a.c. fuses/circuit breakers and a surge protective device. Fuses used in the d.c. circuit shall be d.c. rated.
- The inverter shall have internal protection against any sustained faults and/or lightening in d.c.
- The kVA ratings of inverters for the PV systems should be chosen as per the PV system wattage and should not be less than the total power rating of the loads.
- The Inverter enclosure shall be weatherproof (IP65) and capable of surviving climatic changes and should keep the Inverter intact under all conditions in the room where it will be housed. Moisture condensation and entry of rodents and insects shall be prevented in the inverter enclosure.

The minimum technical specifications of the inverter are given in Table 4.

Table 4 Technical specifications of the solar inverter

No	Parameter	Requirement
Inverter Characteristics		
1	Inverter type	Standalone inverter
2	Maximum conversion efficiency	≥ 97%
3	European efficiency	≥ 97%
4	Operating temperature range	-5 °C to 55°C
5	Maximum DC voltage	1,500 V
6	Connection phases	One/Tri-Phase
7	Frequency	50 Hz
8	Total harmonic distortion	≤ 3%
9	Maximal current ripple	3% PP
10	Power factor	0.95 inductive to 0.95 capacitive
11	Minimum IP rating for enclosure	IP65
12	String failure detection	Required
13	DC overvoltage protection	Required
14	Surge protection	Required
15	Product warranty	≥ 5 years

16	Workmanship/product replacement warranty	Minimum 5 years
17	Service warranty	Minimum 25 years
18	Quality and safety certifications	IEC 62109 IEC 62093 UL 1741

2.9 Balance of Systems (BoS)

All BoS equipment shall be qualified according to IEC 62093.

2.9.1 Junction Boxes and Array Combiner Junction Box

- The junction boxes shall be provided in the PV yard for termination of connecting cables. The junction boxes shall be made of fibre-reinforced plastic (FRP)/cast aluminium/copper with full dust, water & vermin proof arrangement. All wires/cables shall be terminated through cable lugs. The junction boxes shall be such that input & output termination can be made through suitable cable glands.
- Copper bus bars/terminal blocks shall be housed in the junction box with suitable termination threads.
- Junction boxes should be at IP65 rated and comply with IEC 62208. Hinged door with EPDM rubber gasket shall be used to prevent water entry.
- Junction box shall use single compression cable glands, have proper earthing and should be placed at a suitable height for accessibility.
- Each junction box shall have high quality suitable capacity metal oxide varistors (MOVs)/surge arrestors, and suitable reverse blocking diodes. The junction boxes shall have suitable arrangement monitoring and disconnection for each of the groups.
- String/array combiner boxes shall incorporate d.c. string circuit breakers, d.c. array disconnect switch, lightening and over voltage protectors, screw type terminal strips, strain-relief cable glands, any other required protection equipment.
- String/array combiner boxes shall be secured onto walls or metal structures erected separately on the terrace.

2.9.2 d.c. Distribution Box

- The d.c. distribution box shall receive the d.c. output from the array field with a measurement meter for voltage, current and power from different combiner boxes so as to check any failure in the array field.

- The d.c. distribution box shall be dust & vermin proof. The bus bars should be made of copper of desired size. Suitable capacity circuit breaker to be provided for controlling the d.c. power cable feeding the inverter along with necessary surge arrestors.
- The d.c. distribution box shall incorporate d.c. disconnect switch, lightening surge protectors, any other protection equipment, screw type terminal strips and strain-relief cable glands.
- The d.c. distribution box shall be wall mounted inside the control room.

2.9.3 a.c. Distribution Box

- The a.c. distribution box shall control the a.c. power from the inverter and should have necessary surge arrestors. The interconnection from the a.c. distribution box to the mains at the LV bus bar shall be carried out. All equipment, sensors, and measurement devices shall be installed in the a.c. distribution box. An a.c. distribution box shall be provided at the cable terminating point emanating from the inverter for interconnection control of the dedicated electrical loads.
- The a.c. distribution box shall incorporate a.c. circuit breakers, surge protective devices, any other protection equipment, plant energy meter, screw type terminal strips and strain-relief cable glands.
- The a.c. distribution box shall be wall mounted inside the control room.

2.9.4 Cables & Wires

- Cable Marking: All cable/wires shall be marked in a proper manner by good quality ferule or by other means so that the cable can be easily identified. All cable schedules/layout drawings shall be approved from the purchaser prior to installation. All cable tests and measurement methods should confirm to IEC 60189-3.
- All d.c. and a.c. cables shall be terminated using suitable crimped cable lugs/sockets and screw type terminal strips. No soldered cable termination shall be accepted.
- Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted.
- Conduits/concealed cable trays shall be provided for all d.c. cabling on the ground/roof. Conduits/concealed cable trays shall be adequately secured onto the ground/roof.
- The d.c. and a.c. cables of adequate electrical voltage and current ratings shall be also rated for in conduit wet and outdoor use.
- The d.c. and a.c. cable size shall be selected to maintain losses within specified limits over the entire lengths of the cables. The maximum voltage drop should be limited to 1%.

- d.c. cables from array combiner box to d.c. distribution box shall be laid inside a cable duct where available or secured with conduits/concealed cable trays where duct is not available.
- d.c. and a.c. cabling between inverter and distribution boxes shall be secured with conduits/concealed cable trays.
- All cable conduits shall be GI/ high density Polyethylene type or rigid PVC.
- All cable trays shall be powder coated steel or GI or equivalent.
- Multi strand, annealed high conductivity copper conductor should be used.
- PVC type 'A' pressure extruded insulation should be used.
- Overall PVC insulation for UV protection should be implemented.
- Armoured cable for underground laying should be used.
- All cables shall conform to Kahramaa Wiring Code 2016 and the relevant international standards.
- All electrical cables/wires inside the building to be fixed in accordance with specifications for electrical works.
- Proper laying of cables shall be ensured in appropriate cable trays, pipes / trenches as per site requirement.
- a.c. supply cables shall be terminated at the distribution boxes.
- For laying/termination of cables, latest international codes & standards shall followed.

Table 5 Technical specifications for BoS components

	Component	Specification
1	String/array junction boxes	IP65, Protection Class II
2	Surge protective devices	Type 2, d.c. 1000V rated
3	Enclosures for inverters and charge controllers	IP65
4	PV module/string/string combiner box interconnects	MC4 compatible, d.c. 1000V rated
5	The central Inverter shall be rated for	IP65
6	The d.c./a.c. distribution boxes shall be rated	IP65
7	The data acquisition systems shall be rated for	IP65
8	All d.c. and a.c. cables, conduits, cable trays, hardware	Relevant International Standards
9	Earthing System	TN-S earthing system in accordance with IEC 60364

10	PV array support structure	Relevant International Standards
11	Parts and Workmanship warranty	Minimum 10 years
12	Service warranty	Minimum 10 years

2.10 Auxiliary Systems

2.10.1 Fire Extinguishers

- A firefighting system for the proposed PV system shall consist of:
  - Portable fire extinguishers in the control room for fire caused by electrical short circuits
- The installation of fire extinguishers shall confirm to Qatar's Civil Defense regulations and international standards. Fire extinguishers shall be provided in the control room as well as on the site where the PV arrays have been installed.

2.10.2 Lightning Protection

- Where required, a lightning protection system shall be installed, wherever applicable and available to be connected.

2.10.3 Earthing Protection

- PV array structures, d.c. equipment, inverter, a.c. equipment and distribution wiring shall be earthed as required.
- All metal casing/shielding of the plant shall be thoroughly grounded. In addition, the lightning arrester/masts should also be provided inside the array field
- Equipment grounding (Earthing) shall connect all non-current carrying metal receptacles, electrical boxes, and PV panel mounting structures in one long run. The grounding wire should not be switched, fused or interrupted.
- The complete earthing system shall be electrically connected to provide return to earth from all equipment independent of mechanical connection.
- Earthing system design should be as per the standard practices.
- Earth resistance should be tested in presence of the representative of Kahramaa after earthing by a calibrated earth tester.

3. System Documentation

A system manual shall be submitted with each standalone solar PV system that includes the following:

- A complete equipment list for the system alongside the technical specifications and datasheets for each component in accordance with Table 6 in Annex 1.
- Product quality certificates, from a certified testing laboratory, and manufacturer warranty certificates, for: PV panels, inverters, charge controllers, batteries, and any other devices used in the system.
- A summary of the system specifications (including electrical protection equipment), load characteristics, and monthly system performance.
- Electrical line diagrams for the system.
- System operation procedures.
- Emergency procedures.
- Maintenance procedures.
- Copies of engineering calculations and drawings.
- Installation and O&M manuals.

Annex 1

The bidder shall submit the system specification in accordance with Table 6 below. The following documents shall also be attached: datasheets for each component, quality and safety compliance certificates, warranty certificates, and system electrical wire diagrams.

Table 6 Standalone solar PV system specifications

Parameters	Specification	Comments
PV Module		
Module manufacturer		
Solar cell manufacturer		
Model name/No		
PV Module area (m^2)		
Dimensions (L × W × H) (m)		
Weight (kg)		
Max. power (W), P_{mp} @ STC		
Max. power tolerance (0 -+ %)		
Tolerance at V_{mp} (+/-%)		
Tolerance at I_{mp} (+/-%)		
Tolerance at P_{mp} (+/-%)		
Max. power point voltage (V), V_{mp} @ STC		
Max. power point current (A), I_{mp} @ STC		
Open circuit voltage (V), V_{oc} @ STC		
Short circuit current (A), I_{sc} @ STC		
Max. system voltage (V)		
Temp. coefficient of V_{oc} (%/^oC)		
Temp. coefficient of P_{mp} (%/^oC)		
Efficiency @ STC (%)		
NOCT (^oC)		
Max. power (W), P_{mp} @ NOCT		
No. of bypass diodes		
Total number of PV modules		
Total plant's foot print area (m^2)		
Energy performance ratio (%)		
Quality and safety certifications		
PV Array Structure		
Material and finish		
Types of Sections used		
Installation method		
Other		
Charger Controller		
Type (PWM or MPPT)		
Nominal battery voltage (V)		

Max. battery voltage (V)		
Max. charge current (A)		
Max. load current (A)		
Power consumption (nighttime) (W)		
Regulated battery charging voltage (V)		
Voltage across terminal (PV to battery) (V)		
Voltage across terminal (battery to load) (V)		
Supported battery types		
PV reverse polarity protection		
Battery overcharge protection		
DC load discharge protection		
Battery charger stages		
Recommended wire size		
Operating temp (°C)		
Quality and safety certifications		
Battery		
Manufacturer		
Battery type		
Dimensions (L × W × H) (m)		
Battery capacity (Ah)		
Depth of discharge (%)		
Battery efficiency (%)		
Operating temperature (°C)		
Self-discharge (% per month)		
Battery voltage (V)		
Battery design life cycle (years)		
Protection type IP for batteries enclosure		
No. of batteries		
Quality and safety certifications		
Inverter		
Manufacturer		
Model name/No.		
Dimensions (L × W × H) (m)		
Weight (kg)		
IP rating		
Operating temp (°C)		
No. of installed Inverters		
Max. DC input voltage (V)		
Max. DC input current (A)		
MPPT DC input voltage range (V)		
No. of DC input ports		
Nominal AC power (W)		
AC power frequency (Hz)		

Nominal AC voltage (V)		
Nominal AC current (A)		
Power Factor		
Max. Efficiency (%)		
Communication interface		
Quality and safety certifications		
Balance of System		
String Combiner Box		
Array Combiner Box		
Module DC cable		
String DC cable		
Array DC cable		
DC string circuit breaker		
DC disconnect switch		
Lightening/over voltage surge protective devices		
DC distribution box		
AC distribution box		
AC cable		
AC circuit breaker		
Energy meters		
Other		