**APPENDIX 7 of the TOR: UNICEF TECHNICAL REQUIREMENTS**

**NOTE: These technical requirements will guide the SERVICE PROVIDERS for providing technical proposals and later on for implementing the solar PV systems at UNICEF facilities.**

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# Nomenclature

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Description** | **Unit** |
| AC | Alternate Current | A |
| BIL | Basic Insulation Level | V |
| BOS | Balance of System |  |
| BOP | Balance of System |  |
| CCR | Central Control Room |  |
| CCTV | Closed Circuit Television |  |
| CE | European Conformity |  |
| CT | Current Transformer |  |
| DC | Direct Current | A |
| DCS | Digital Control System |  |
| DIN | Deutsche Industrie Norm |  |
| °C | Degree Celsius |  |
| DISCO | Distribution Power Company |  |
| Ed | Effect to structure |  |
| EMC | Electromagnetic Compatibility |  |
| EMPLOYER | UNICEF |  |
| EPC | Engineering Procurement and Construction |  |
| FMS | Fault Monitoring System |  |
| GLPAC | Guarantee Level provided by the Contractor/ Service Provider at PAC minimum value of 95% |  |
| GPOA, t | Total global solar irradiation on the plane of array [kWh/m²] within interval t | Wh/m2 |
| GPS | Global Positioning System |  |
| HMI | Human Machine Interface |  |
| HPOA | instantaneous irradiation on the plane of array of the tested PV module string, measured with a pyranometer with 2% measurement uncertainty | W/m2 |
| HSE | Health, Safety and Environmental |  |
| HSTC | Irradiance under standard test conditions and is equal to 1,000 W/m2 | W/m2 |
| HV | High Voltage | V |
| HVAC | Heating, Ventilation and Air-conditioning |  |
| Hz | Hertz |  |
| I | Current | A |
| I&C | Instrumentation and Control |  |
| Isc | Short circuit current | A |
| IEC | International Electrotechnical Commission |  |
| IEEE | Institute of Electrical and Electronics Engineers |  |
| IP | Ingress Protection |  |
| ISO | International Organization for Standardization |  |
| kV | Kilo-volt |  |
| kVAr | Kilo-volt-ampere-reactance |  |
| LAN | Local Area Network |  |
| LPS | Lightning Protection System |  |
| LRFD | Load and Resistance Factor Design |  |
| LV | Low Voltage | V |
| m.a.s.l. | Meters above Sea Level | m |
| µm | Micro-meter |  |
| MPPT | Maximum Power Point Tracking |  |
| MV | Medium Voltage | V |
| MVA | Mega-watt-ampere | V |
| MWp | Mega-watt-peak |  |
| n | Last interval of 1 hour at the end of the testing period |  |
| P | Power | W |
| PAC | Provisional Acceptance |  |
| PID | Potential Induced Degradation |  |
| Pmpp | Power at Maximum Power Point | W |
| POA | Planes of Array |  |
| PR | Performance Ratio | % |
| PTC | Photovoltaic United States of America Test Conditions |  |
| PV | Photovoltaic |  |
| Q | Reactive power |  |
| RAID | Redundant Arrays of Inexpensive Disks |  |
| Rd | Resistance of structure, material, soil or similar element |  |
| RTU | Remote Technical Unit |  |
| SCADA | Supervisory Control and Data Acquisition |  |
| EMPLOYER | Sustainable Energy and Economic Development |  |
| SF6 | Sulphur hexafluoride |  |
| SPD | Surge Protective Devices |  |
| STC | Standard Test Conditions |  |
| SWPPP | Storm Water Pollution Prevention Plan |  |
| SY | Specific Yield |  |
| t | Interval of 1 hour | h |
| T | Temperature | °C |
| THD | Total Harmonic Distortion | % |
| TÜV | Technischer Überwachungsverein |  |
| UL | Underwrite Laboratories |  |
| UNominal | Nominal Voltage | V |
| UPS | Uninterrupted Power Supply |  |
| V | Voltage | V |
| VDU | Visual Display Unit |  |
| Voc | Open-circuit voltage | V |
| VT | Voltage transformers |  |
| WAN | Wide Area Network |  |
| WPVS | World Photovoltaic Standard |  |
| XLPE | Cross linked polyethylene |  |
| Yadj | Adjusted PVsyst simulation with measured weather conditions & adjusted SY |  |
| YF | Safety factor for Effects |  |
| YM | Safety factor for Resistances |  |
| Ymeter | Energy meter Specific Yield |  |
| YPAC | SY at Provisional Acceptance Period compared with relevant energy meter |  |
| Yt | Electricity generation at the relevant meter within interval t | kWh |

# Supply of Solar PV Systems

The scope of supply of the solar PV System includes, but is not limited, to the following list of main elements, subsystems, and constructions:

* **PV Power System: PV generator; Balance of System (BOP), and System (BOS)**
* **All Connections between PV arrays, inverters and up to the transformer.**
* **Instrumentation, weather station, Data Acquisition, Control and Supervision.**
* **Site Security and Surveillance**
* **Civil, Mechanical, and Electrical Works**
* **Supply and Construction of Water and Fire Protection System**
* **Additional Works and Services**

## Supply of Works and Services

The full scope shall be performed according to the Good Industry Practice, which means, at a particular time, those practices, methods and acts as are in accordance with good standards of prudence applicable to the international electricity generation industry, which would have been expected to accomplish the desired result at lowest reasonable cost consistent with reliability, safety and expedition.

Those standards are based and defined in norms as i.e. IEC; CE; national Grid Code, including other regulations and other applicable. The scope includes also works not explicitly stated in UNICEFs Requirements or elsewhere in the Tender Documents but which are reasonably required for the installation and operation of the PV System according to Good Engineering Practices.

Reputable SERVICE PROVIDERS shall supply new equipment from one **Tier 1 Class A manufacturers**, which shall be subject to UNICEF’s review and approval. No used, reconditioned or salvaged equipment or material will be allowed in this tender.

All equipment used in connection with the Project shall be of proven design for the intended use of the equipment. As a general principle, the latest, commercially proven, most modern and up-to-date technologies will be selected with the objective of maximizing value to the UNICEF.

The PV System shall be designed, manufactured, erected and configured in such a way that it will achieve high life expectancy, high availability and reliability with minimum power generation costs.

All parts of the System shall be suitable in every respect for continuous operation at maximum efficiency as well as part loads and minimum load, under consideration of the climatic conditions particular to the site and environmental restrictions. Extreme weather conditions like cyclones are excluded from this requirement.

Each PV System element or component shall be designed to withstand local weather conditions.

All PV System equipment and systems shall be built according to internationally recognized standards and shall comply with all the applicable national codes.

The SERVICE PROVIDER shall apply a well-established component classification and identification system. The international SI system of units shall be used for design, drawings, diagrams, instruments, etc.

The System shall be designed to achieve a high level of reliability through component redundancy, quality construction implementation, quality equipment selection, and maintainability and operability. The facility shall be designed for safe continuous operation including the capability for unforeseen shutdowns.

The SERVICE PROVIDER shall provide first aid sets at all permanent working locations, such as offices, storages and workbenches and gatehouse.

## Engineering Design

The SERVICE PROVIDER shall develop the PV System´s engineering design in compliance with these specifications, and following best industry practices. The SERVICE PROVIDER shall prepare the project´s documentation that shall include, among others, the engineering, preparation and delivery program of the engineering, guaranteed data, essential diagrams, general arrangements, design criteria and main equipment specifications.

The design of the equipment and systems of the System shall be based on achieving the performance guarantees and its corresponding test procedures. The SERVICE PROVIDER shall apply for and be responsible for successfully passing all required approvals and certifications of the authorities, the government and the related authorized institutions and organizations.

## Preparatory Works

Prior to the start of construction and installation, preparatory works shall be performed in advance so that the erection of the PV System can be realized as planned.

**At its sole responsibility the SERVICE PROVIDER shall conduct and review (but not limited to) the following preparatory works on a case to case basis, and as necessary in each project site:**

* Collection of general meteorological data
* Review of existing structural/geotechnical studies
* Carrying out drainage evaluation; retention basins and discharge options
* Carrying out backfill studies including compaction
* Carrying out logistics and transportation studies for time of construction
* Carrying out a cartographic survey for the exact location of boundaries and the elevation in meters above sea level
* Carrying out own assessment for flooding risks
* Preparing and following up on an occupational health and safety plan for construction and operation of the PV System and related facilities
* Obtaining all required permits such as building permit, etc. on behalf of the UNICEF, including all certificates and acceptances of the authorities and related organizations
* Obtaining approval for all design works, including electromechanical, and civil works.
* Preparing the occupational health and safety plans, one for the site and construction purpose, and one for operations.
* Data collection for interface points
* Due diligence of all applicable aspects
* Site preparation, compaction of soil, filling of low areas with imported fill and grading of the entire area of the site to the required levels and slopes, as required, in accordance with the building plan
* Provision of temporary laydown areas, warehouses, workshops, vehicles, equipment etc. All as necessary for the construction phase
* Disposal of demolition materials according to local environmental guidelines
* Provision of temporary firefighting and alarm system
* Provision of temporary site drainage, storm water and sanitary drainage
* Disposal of sewage, as necessary
* Provision of temporary water and power supply
* Provision of temporary site fencing including gates
* Provision of first aid, site safety and security for the construction phase

# Specification

## Site Conditions

The SERVICE PROVIDER is responsible for its own investigations to establish sufficient and accurate information for the design of the Systems. The SERVICE PROVIDER shall visit the project site; ascertain the nature and location thereof, including all conditions which may affect design, layout, and costs of the PV System and project. The SERVICE PROVIDER shall make its own assessment of any and all of the information provided in this bidding document and collect own information.

Neither DISCO, nor any governmental institutions or other entity nor any representative or advisors to the government is responsible for the accuracy or completeness of any such information. It is 100% responsibility of SERVICE PROVIDERs to very all data.

## PV System Design Concept

The main characteristics of the grid connected PV System are defined below:

* The PV System shall consist of ground mounted or roof-top mount (depends on site) silicon (Monocrystalline/mono-silicon or Polycrystalline/poly-silicon) modules and string inverters.
* PV modules shall have appropriate spacing design between arrays to minimize shading and to optimize O&M.
* The PV module mounting frames and structures shall be built with fixed tilt angle set in appropriate azimuth and geographical orientation as per own design. Structure foundations shall be of the screw or micro pole type for ground mounting
* The PV System will connect to LV level according to local Grid Code and DISCO requirements.
* The power supply of auxiliary loads shall be considered.
* **Instrumentation & Control (I&C) system**: covering power circuits, meteorological stations, security; surveillance; and metering.
* Additional civil works and services as needed
* Internet connection for monitoring purposes.

## Assumptions

**Quality:** The PV Systems shall consist of Tier 1 class A PV modules and string inverters.

**Capacity:** The PV Systems capacities (composed either by 400 Wp or above; mono-silicon modules) are listed within the following scale:

Table 1: Ranges of Quantities of solar PV Modules

|  |  |
| --- | --- |
| **No.** | **Range Solar PV Capacity**  **[kWp]** |
| 1 | 0- 100 |
| 2 | 101- 200 |
| 3 | 201- 300 |
| 4 | 301- 400 |
| 5 | 401- 500 |
| 6 | 501- 600 |
| 7 | 601- 700 |
| 8 | 701- 800 |
| 9 | 801- 900 |
| 10 | 901- 1,000 |
| 11 | 1,001- 1,250 |
| 12 | 1,251- 1,500 |
| 13 | 1,501- 2,000 |
| 14 | 2,001- 2,500 |
| 15 | 2,501- 3,000 |

**Inverters:** Outdoor inverters. Indoor inverters shall be housed in a civil building-station, with controlled temperature. Proposed capacities:

1. Inverter Option 1: 25 kW
2. Inverter Option 2: 50 kW
3. Inverter Option 3: Other (SERVICE PROVIDER may suggest)

**LV-Line:** The PV System will be connected to LV. Location of the Transformer shall be gathered during SERVICE PROVIDER’s own field visit.

**Civil Works:** The EPC contractor/ Service Provider shall be responsible for the PV System internal layout (including all civil works and services). A fire protection system shall cover the whole PV System, including security and surveillance system (permanent alarm routine).

**I&C system**: It shall incorporate the security and surveillance systems and signals from the PV System´s meteorological stations.

**Energy Meters:** One bi-directional energy meter shall be installed in the PV station. In case of two energy meters (depending on the local DISCO requirements in each CO):

1. First energy meter shall be located before the grid connection point and shall be used for counting energy evacuation to the grid (DISCO local regulation).
2. Second energy meter to be installed before the transformer. This meter is for the energy guarantee and performance evaluation.

**PV System Tentative Layout:** it is based on the capacity scale listed above. The PV module mounting frames and structures shall be built in line with the optimized tilt angle and selected orientation.

## General Specifications

### Permits, Licenses and Consents

It is the sole responsibility of the SERVICE PROVIDER to identify, obtain, complete, and maintain permits and other consents, licenses and approvals required for each PV System as per local applicable codes and standards.

The time line required to conduct all needed studies on site including checking of reinforcement, sufficient concrete covers, anchors and embedded parts must be included into each SERVICE PROVIDER’s work plan.

Quality Assurance and Control

During project execution, the successful SERVICE PROVIDER shall be required to develop, implement and maintain a project specific quality plan covering all aspects of the project. The SERVICE PROVIDER shall provide a quality assurance manual applicable to the design, procurement, construction, commissioning and testing of the System and evidence of accreditation to a national or international assurance standard equal to ISO 9001.

### Health, Safety and Environmental Requirements

The SERVICE PROVIDER is requested to provide a sound-working environment to all employees involved in the design, construction and operation of the System. This includes the consideration of but not limited to:

* All applicable national laws, guidelines and standards
* All applicable codes and standards to occupational HSE and environmental protection

The HSE Plan will govern SERVICE PROVIDER’s actions at all times during the design preparation and construction of the Project as well as during the operating phase of the System.

### Packing and Transport Identification

All parts of the PV System and equipment shall be well packed and protected against loss or damage during the transport by sea/air and over land and whilst in storage under adverse climatic conditions.

All packing shall be performed in such a way that overturning of the packages shall not damage the equipment. Dimensions of packages, crates, etc., shall be suitable for road transport. Instruction for handling shall be clearly marked on all parts, packages and crates.

All parts, packages and crates shall be adequately marked in order to enable identification. Each item contained in a package shall be clearly identified on the packing list by its description and part number and assembly drawing reference, and each item shall be marked or labelled to correspond with the packing list. The identification system to be used shall be as instructed by UNICEF.

The cost of all equipment needed for temporary fixing and supporting of various parts of the PV System and the various packages to crane hooks, etc., during handling, transport and storage and the cost of load distribution beams, etc., where they form part of the packing or crates, shall be included in the Price Proposal.

The SERVICE PROVIDER shall be entirely responsible for all packing and any loss or damage shall be replenished / fixed by the SERVICE PROVIDER and, except where otherwise provided, at the SERVICE PROVIDER's own expense.

During contract, all shipments are the SERVICE PROVIDER's responsibility. All cost(s) associated with shipment of materials and equipment shall be deemed to be included in the Contract Price. Identification, reinforcement or upgrading of roads/bridges for access to the site and transportation of equipment and materials shall be the responsibility of the SERVICE PROVIDER. Any costs associated with identification, reinforcement and upgrading of roads and bridges shall be deemed to be included in the offered Price.

### Material Properties

Materials selected by the SERVICE PROVIDER shall be proven adequate and sufficient for the complete term of the Project. The SERVICE PROVIDER shall carefully consider all corrosion and erosion possibilities subject to the environment of the Site and nearby facilities. All non-metallic materials in contact with water shall be proven, tested and certified as suitable for its purpose by an internationally recognized testing authority. Metallic and non-metallic materials shall be UV resistant and stand high temperature operation regimes over the whole System lifetime; and where materials are specified in any part of UNICEFs Requirements, those materials are to be considered as minimum requirement.

#### Corrosion Protection

The SERVICE PROVIDER shall be aware of and take into account the corrosion problems to be encountered on site due to the severe weather conditions, especially with equipment installed outdoors.

This shall include as well the correct choice including but not limited to any fasteners, bolts, dowels, anchors. Also contact corrosion and electrochemical corrosion shall be avoided by selecting only suitable materials and coatings or galvanization.

The SERVICE PROVIDER shall provide with their proposal the civil design criteria he intends to follow, in which details regarding their proposed methods of corrosion protection for reinforced concrete and steel structures are given and procedures described.

Furthermore, the SERVICE PROVIDER shall include in their proposal a description of their proposed concrete surface and metal surface protection systems. Detailed specifications are given in the following where required. On the site, the measures for corrosion protection shall be proven to be successful and as scheduled after construction.

#### **Water** Proofing

The SERVICE PROVIDER shall suitably take care for water proofing as per all applicable codes and standards. The same shall be true for damp proofing or vapor proofing where required.

Where necessary, the above mentioned shall be considered for underground structures or foundations. Where oil-proof coatings or coatings to preserve from contamination of the ground water are required, the SERVICE PROVIDER shall provide suitable coating systems.

### Environmental Management Requirements

It must be the understanding of the SERVICE PROVIDER to avoid any environmental damage and/or concerns to the environment during any phase of the project. Accordingly, the SERVICE PROVIDER shall provide, operate and maintain the System to meet all applicable national environmental regulations, environmental standards and stipulations. The SERVICE PROVIDER shall demonstrate during the design and construction phase and during the performance tests respectively operation phase that the System is able to comply with all applicable environmental regulations and standards. Applicable standards for environmental protection must be fulfilled without any restrictions. This applies in particular but not limited to:

* Air emission limit values and standards
* Water pollution limit values and standards
* Limit values for environmental noise
* Health and safety of construction workers and permanent staff.

### Redundancy Concept

The following requirements with regard to redundancy design are generally to be taken into account:

**Redundancy:** Any system that can cause a complete outage if one (1) component fails shall be designed as redundant equipment and/or for high reliability, ease of maintenance, and quick system backup support (n+1 redundancy).

**Failure:** If a failure in an instrument or in a control component can directly or indirectly cause the failure of the whole system, this component should have a redundancy factor; and

**Outage:** The trip or outage of any single equipment or any single piece of auxiliary equipment shall not affect the operation of the remaining, i.e. priority shall be given to stability of the electrical grid system.

The impact of the failure on System power output shall be minimal and shall not lead to the loss of the total System power output.

### Codes and Standards

The SERVICE PROVIDER shall ensure that engineering, design, construction, testing, etc. of all components, including all auxiliary facilities and systems, are according to internationally recognized standards. Tables 2 and 3 define basic applicable standards where applicable.

Table 2: International Standards

|  |  |
| --- | --- |
| **ANSI** | American National Standards Institute |
| **BSI** | British Standards Institution |
| **CE** | European Standards |
| **DIN** | Deutsches Institut für Normung |
| **ISO** | International Standardization Organization |
| **IEC** | International Electrotechnical Commission |

Table 3: National Standards

|  |  |
| --- | --- |
| **National** | National Codes |

Application of subsequent addenda and code cases published after the EPC Contract award is subject to agreement between UNICEF and the successful SERVICE PROVIDER. The SERVICE PROVIDER shall conform to all applicable requirements of national and local regulations, and meet all requirements of DISCO at the EPC Contract award date.

The SERVICE PROVIDER shall draw UNICEF's attention to any conflict between the requirements of this document and DISCO’s references. Should the requirements of this document conflict with the requirements of the codes and standards references herein or with the applicable law, standards, local regulations of DISCO’s and design specifications, then the more stringent requirements shall apply. Should there be any difference of opinion with regard to the interpretation of requirements, UNICEF shall instruct the SERVICE PROVIDER as to the requirements and the SERVICE PROVIDER shall, at its cost, comply with that instruction.

**For the design and construction of the buildings, structures or foundations the following codes and standards including the related national annexes may be considered in addition, and as applicable:**

* International Building Code (IBC)
* European Standards (EN and EC)
* American Concrete Institute (ACI)
* American Institute of Steel Construction, Inc. (AISC)
* American National Standards Institute, Inc. (ANSI)
* American Society for Testing and Materials (ASTM)
* American Society of Civil Engineers (ASCE)
* American Society of Mechanical Engineers (ASME)
* American Welding Society (AWS)

For all structures and structural components, buildings, basins, base plates and foundations an appropriate design according the above-mentioned specifications has to be elaborated and presented (case to case basis and as applicable).

**The design report shall include among other items the following minimum descriptions:**

* Introduction and structural description
* Drawings of structures and foundations
* Material properties
* Used normative and codes
* Load assumptions, safety factors and combination coefficients
* Analysis and design criteria
* Technical references
* Structural calculations
* Design results
* Information about the design software
* Connection design.

For the complete structure and structural components, buildings, basins, base plates and foundations the design method “Load and Resistance Factor Design (LRFD)” shall be used or the Design method in the local national code.

The drawings shall indicate material properties, sizes and dimensions of all elements, location of installation, constructing procedures, technical specifications, numbering system of elements, etc.

Each drawing shall be equipped with a general System overview indicating the location of the displayed element. Clear information shall be given by appropriate details.

All drawings shall be in scale, for overview drawings, the scale shall be 1:200, 1:100 or 1:50, for detailed drawings, the scale shall be 1:25, 1:20, 1:10 or 1:5.

Where construction and maintenance rules or guidelines of the manufacturers of the products or systems are available, the SERVICE PROVIDER shall follow these instructions as well.

If special trainings are required for executing the job, the SERVICE PROVIDER shall make sure their staff has successfully received the respective trainings including the documentation thereof.

### Interfaces

Interfaces” are the connections and physical tie-in points between:

* The PV System and the Low Voltage grid connection; and the I&C and communication facilities.
* The SERVICE PROVIDER shall provide with their proposal a complete and detailed description of the interfaces.

The SERVICE PROVIDER is obliged to coordinate the interfaces with other facilities / with other parties in cooperation with the respective counterpart.

#### **Grid** Connection

The grid connection point is at Low Voltage level, according to the local Grid Code, and requirements and regulations from DISCO.

#### **Instrumentation** and Control

The SERVICE PROVIDER shall be responsible for the coordination with DISCO for the proper consideration and realization of all instrumentation and control aspects being relevant for the exchange of required data.

#### **Communication** Facilities

The SERVICE PROVIDER shall be responsible for the connection of the communication facilities of the PV System to the available local communication systems. If no available communication systems are available, the SERVICE PROVIDER will supply and install a communication hardware and software to guarantee they can monitor the system performance remotely and from the main building of municipality.

## Technical Specifications

### Electrical Requirements

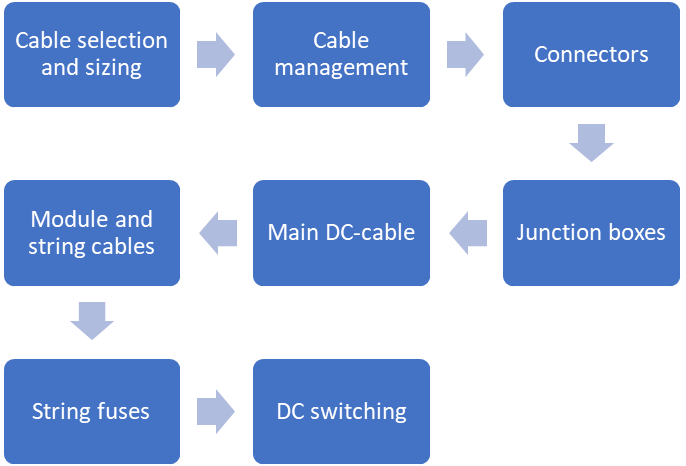
#### PV Power System

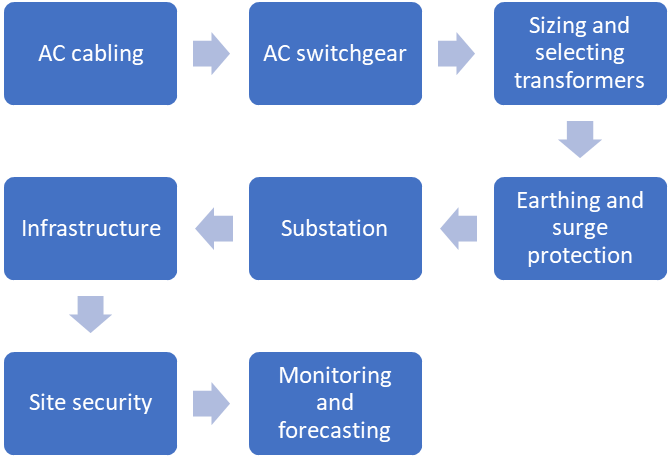
Mono or poly-silicon or Thin Film PV modules shall be installed on a metallic mounting structure on which they shall be placed in several rows upon each other depending of the module and mounting structure dimensions.

The string length of modules connected in series depends on the voltage of single modules in order to not surpass open circuit string voltages of 1,000 V under extreme environmental conditions (low temperatures and high irradiation).

Figure 1 shows the general baseline of the general electrical engineering concept of the solar PV System.

Figure 1: General Solar Electrical Engineering Concept





The PV module strings shall then be connected to first level string box. The string box shall be connected to the respective inverter. The incumbent inverter-block shall be connected to the PV transformer.

#### PV Inverter Station-Building

The building shall include enough space for: inverter-block; LV switchgear; and auxiliary service panel including UPS and charger if needed.

The dimension of PV inverter station shall be designed in accordance to the selected equipment size, operator room spacing, DISCO and HSE local guidelines.

**It is the SERVICE PROVIDER’s responsibility to supply and install all hardware to connect the PV station to the transformer according to the DISCO requirements.**

Table 4: PV Module Certificates (minimum requirement)

|  |  |  |
| --- | --- | --- |
| **No.** | **Feature** | **Parameter** |
| **1** | IEC 61215 | Crystalline silicon terrestrial photovoltaic (PV) modules –  Design qualification and type approval |
| **2** | IEC 61730 | Photovoltaic (PV) module safety qualification |
| **3** | IEC 61701 | Salt mist corrosion testing of photovoltaic (PV) modules |
| **4** | IEC 62716 | Ammonia Corrosion Testing for Solar photovoltaic (PV) modules |

Table 5: PV Modules Basic Technical Standards and Features

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Feature** | **Parameter** | |
| **1** | Product and workmanship warranty | ≥ 10 years **TIER 1** | |
| **2** | Power output warranty based on a linear degradation for 25 years of operation as follows: | 1st year degradation: **≤ 2.5%** | |
| **3** | From year 2 through 25, yearly degradation: ≤ 0.7% | |
| **4** | Ending in year 25th with ≤ 20% degradation after the start of power output warranty. | |
| **5** | Resistant to ambient conditions | As per Tables | |
| **6** | Minimum module efficiency | >20% | |
| **7** | PV module with positive tolerance | Positive tolerance only | |
| **8** | Modules grounding | According to manufacturer’s requirements. | |
| **9** | PV module model selected | Previously installed in other operating PV Systems within the last five years and with a substantial aggregate installed capacity. | |
| **10** | PV module model selected | Previously installed and successfully operated (reference) in other PV Systems under similar climatic conditions. | |
| **11** | Temperature coefficient rated power | -0.37%/ °C or lower (i.e. -0.36%/°C defined lower) | |
| **12** | Potential Induced Degradation (PID) resistance | Valid evidence/certificate independent 3rd parties. | |
| **13** | **Testing conditions for PID shall be the following:** | | |
|  | Chamber air temperature: 85 °C ± 2°C  Chamber relative humidity: 85 % ± 5 % r. H.  Test duration: 48 h  Voltage (bias): -1000 V | | Chamber air temperature: 60 °C ± 2°C  Chamber relative humidity: 85 % ± 5 %  Test duration: 96 h  Voltage (bias): -1000 V |

DC Cabling

The DC cables shall be selected and mounted in a way to withstand the external influences on site like temperature, UV irradiation, wind, sand and mechanical load.

All DC cables shall be single core cables and double insulated type PV1-F or equivalent shall be used, with a temperature range -40°C to +90°C. The circuit must be installed as close as possible in parallel to avoid induction loops

All string and main cables must be permanently labelled at both ends. The label shall inform at least about the corresponding inverter and string number. All cables shall be fixed and under no circumstances shall bear any mechanical load on their terminations (strain relief where required).

DC Connectors

PV DC connectors for string interconnection shall be of the same brand and type as used by the PV module manufacturer. In no case connectors of different brands are to be used in the same connection (male –female). Under no circumstances is it allowed to cut the PV module cables and to install other than the original connectors. All DC connectors shall be IP 65 or IP 67 as per manufacturer.

Inverters

The inverters shall be designed to be able to transmit the maximum output of the solar PV generator at all possible ambient temperatures and local conditions (e.g. soil, dust, atmosphere). The inverters shall be selected to be for grid tied applications, string type, three-phase configuration (separate PE and N conductors) and operate at 50 Hz or 60 Hz grid frequency (Based on local grid frequency).

Table 9 describes the basic features of inverters, subject to DISCO’s approval, including ENA-G59 standards (or updated).

Table 6: PV Inverters Basic Technical Standards and Features

|  |  |  |
| --- | --- | --- |
| **No.** | **Feature** | **Parameter** |
| **1** | Product and workmanship warranty | ≥ 10 years |
| **2** | Total harmonic distortion (THD) | < 3% |
| **3** | European efficiency | ≥ 98% |
| **4** | Input system voltage | ≤1,000 VDC |
| **5** | AC output voltage | As required by DISCO |
| **6** | Reactive and active power control | with power factor of 0.8 leading and lagging |
| **7** | Frequency-dependent | active power limitation and grid management service |
| **8** | Minimum frequency operation range | 47 Hz – 53Hz |
| **9** | Nominal AC power (SERVICE PROVIDER may propose alternatives) | 1. 25 **kWAC**; b) 50 **kWAC**; c) other **kWAC** |
| **10** | Protections | Shall follow the grid operation set points and conditions |
| **11** | Corrosion | Prevention due to marine, salty and tropical environment |
| **12** | Degree of protection: | Indoor installation |
| **13** | Selected inverters | Should have been installed in at least two other PV Systems with similar capacity in similar climatic conditions in the last two years. SERVICE PROVIDERs shall submit references. |
| **14** | **Warranty** | Product warranty at least 10 years. |
| **15** | **Certificates** | TÜV-tested for the required Certificates (or other recognized 3rd parties) |
|  |  | CE-marked |
| **16** | **Standards** | Compliance with the applicable standards:   * IEC 61000-6-2:2005 * IEC 61000-6-4:2006 * UL 1741 * IEEE 1547 * ENA-G59 (or updated) |

LV Switchgear

* Incoming feeders from junction boxes with load break switch and fuse/ earthing switch
* Outgoing/incoming feeders with circuit breaker
* Auxiliary transformer feeder with load break switch and fuse/ earthing switch.
* LV AC-auxiliary switchgear shall supply Inverter/Transformer Station for power, lighting/ emergency lighting, ventilation, SCADA, phones, UPS, etc.
* The LV auxiliary load switchgear shall be designed for a nominal voltage of 420/230 V (IEC 60038).
* The LV auxiliary load network shall be of TN-S type (five conductors including separate PE and N conductors).
* Surge arresters modular to be installed inside LV switchgear.

The LV switchgear shall be of the fixed mounted design. The LV switchgears shall be designed as indoor switchgear installations of metal-clad, bulk-headed type.

Each switchgear installation shall be equipped with a single copper bus bar system. The LV auxiliary load switchgears shall be designed for a nominal voltage of 400/230 V (according IEC 60038).

The incoming feeders to the main switchgears and outgoing feeders to sub-distributions are to be equipped with motor-driven circuit breakers larger than 630A.

All remaining outgoing feeders to the rectifiers and inverters etc. shall be equipped with load break switches and fuses. The LV switchgears shall be designed at least to protection class IP 41. Anti-condensation heaters shall be provided.

**The switchgear installations shall comprise at least:**

* Metal-clad switchgear cubicles, bulk-headed design, various components separated from each other.
* Bus bar earthing studs including earthing fittings
* Cable paralleling arrangements with auxiliary bus bar systems, connecting bars for all in- and outgoing feeds which require more than 2 parallel cables
* Fireproof enclosures to the base of the switchgear panels for sealing the outgoing power cables
* Auxiliary transformers for control voltage (where necessary)
* Heating systems within the switchgear panels.

DC and safe AC distributions may be of fixed installed type Form 2b according IEC 61439-1. Appropriate certificates must be supplied. The LV auxiliary load network shall be of TN-S (separate PE and N conductors).

Auxiliary Service

The auxiliary system in the Inverter station shall include, but not be limited to following components:

* Fault monitoring system (FMS) for transformers
* SCADA, and internet connections
* Power and control cables, cable supports
* Lighting and emergency lighting systems
* Required protection systems; earthing and lightning protection systems, including earthing connections to adjacent earthing grids
* Electrical workshop equipment
* UPS-Emergency Power Supply; security and fire alarm system.

Power and Control Cables

**LV AC and Control Cables:** LV AC power and control cables for the interconnection of the inverter and the LV/MV transformer (if ny), shall be provided with all accessories including the installations of the cable terminations into the related transformer and inverter and the required cable supporting systems including LV AC cable size calculation according to the IEC 60364-5-52.

**Low Voltage, XLPE Insulated, PVC Inner Sheath, SWA, PVC Outer Sheathed Power and Control Cables for Above Ground Installation:**

* Rated voltage: 0.6 /1kV
* Conductors - Stranded annealed copper.
* Grade and quality of the copper used for the conductor shall have purity of the order of min. 99.5%.
* Circular or shaped section.
* Minimum size for power cables shall be four (4) mm² and for control cables 2.5 mm².
* Insulation - Cross linked polyethylene (XLPE)
* The cable shall be watertight.
* Conductor Lay - Cores laid up with extruded non-hygroscopic polypropylene filler for up to five (5) cores.
* For six (6) cores or more wrapping of polyester tape.
* Inner Sheath/Bedding - Extruded polyvinyl chloride.
* Armoring - Multi core cables shall have galvanized steel wire. Single core cables shall have aluminum wire armoring.
* Outer Sheath - The outer sheath of cable shall be an extruded layer of polyvinyl chloride having oxygen index not less than 30, colored black. The outer sheath shall be flame retardant to IEC 60332-3-22 and type tested for reduced propagation.
* The maximum voltage drop in the cables of any AC circuit from the inverter output to the MV switchgear shall be **< 1.50% at STC**.

Earthing and Lightning Protection

**The earthing system shall be designed according to the following standards:**

* IEC 60364 (4-41) Low-voltage electrical installations: Protection for safety - Protection against electric shock.
* IEC 60364(5-54) Low-voltage electrical installations: Selection and erection of electrical equipment – Earthing arrangements and protective conductors.
* IEC 61936-1 Power installations exceeding 1 kV A.C. - Common rules.
* EN 50522 Earthing of power installations exceeding 1 kV A.C.
* IEC 60364-7-717 Low-voltage electrical installations: Requirements for special installations or locations – Mobile or transportable units.

The resistance of the grounding system shall not exceed 1 ohm. After installation of the earthing and lightning protection system, but before connection to adjacent earthing grids, measurement of earth resistance and other safety features of the earthing design shall be carried out.

**Lightning and overvoltage concept as per international standards:** A lightning and overvoltage concept shall be designed according to the IEC 62305 (all parts). PV System shall be equipped with Lightning Protection System (LPS) type I according to the IEC 62305. If the result of risk assessment (according to the IEC 62305-2) proposes is different, LPS class than this is also acceptable. The components and systems belonging to the lightning protection systems are listed below:

* External lightning protection
* Internal lightning protection.

**External lightning protection includes:**

* Down conductors as connection to the earthing system
* External earthing system.

**Internal lightning protection includes:**

* Lightning protection equipotential bonding
* Earthing of cable trays, cabinets etc.
* Shielding of cables
* Surge protection devices.
* Connecting points of the external and internal lightning protection and metal parts of the building structure for equipotential bonding strips.
* The structure to be protected is the complete PV System including the service buildings, inverter/transformer station, delivery station and solar array.

**The criteria for design and installation of lightning protection measures shall be aimed to fulfil the following international standards:**

* Protection measures to reduce physical damage to structures and life hazard in a structure according to IEC 62305-3.
* Protection measures to reduce failures of electrical and electronic systems in a structure according to IEC 62305-4.
* Comply with all the applicable international standards (IEC 62305-1; IEC 62305-2).
* In order to protect the junction boxes from possible damages due to surge voltage in case of lightning stroke directly in or near the PV field, Surge Protective Devices (SPD) type I and SPD type II) shall be included.
* For communication and data lines, SPD type III devices shall be installed.
* Due to the expected distance between the combiner boxes and the inverters, both equipment shall be protected.
* SPDs type I and II according to EN 61643-11 shall be installed in the DC PV module circuit.
* On the inverter side the SPDs shall be installed on DC, AC and control sides.

Protection

**Note:** The present chapter represents a preliminary guideline only for the SERVICE PROVIDER on how to design the protection equipment. The Successful SERVICE PROVIDER shall discuss the protection coordination and relay settings with DISCO for their approval.

The protection devices for the 33kV and LV switchgear equipment shall be installed in the control building. All relays shall be digital type with event recording.

Auxiliary Service in Control Building

1. General

For main distribution of the auxiliary power supply refer to LV equipment.

The SERVICE PROVIDER shall supply all requested auxiliaries such as (but not limited to):

* UPS Battery Emergency Power Supply (DC and Safe AC)
* Internal/external lighting and emergency lighting systems in Control building
* Air conditioning in Control building
* Power supply of CCTV
* Fire alarm system

The SERVICE PROVIDER shall include the details of the proposed auxiliary supply system in their proposal.

Power supply systems may be categorized into essential and non-essential groups. Essential supplies should be continuously available without any interruption, whereas non-essential ones may be allowed to be subject to interruptions.

Low-voltage AC and DC systems shall be designed in accordance with the IEC 60364.

1. Fire alarm System and Fire Lighting

The detectors shall be stable against environmental influences (ambient temperature, humidity etc.) and shall be so positioned as to avoid the possibility of spurious operations due to air current from pressurization, ventilation or air-conditioning grills.

A manually operated alarm system shall be provided in each building with an alarm initiating point at each room exit. This system shall be fully integrated with the automatic fire detection and alarm system.

Alarms shall be signalled locally (audible and visible) and in the System control room and should also permit remote connection. The system should be integrated in the I&C concept.

Suitable firefighting equipment shall be provided in the control buildings, inverter/transformer station, and transformers compounds as required.

Surge Arresters

Surge arresters shall be of gapless zinc oxide type and shall be mounted on pole line. Their design shall comply with the IEC 60099-5 and relevant equivalent IEC standards.

#### Manage Non-Stormwater Discharges and Materials

**Practice good housekeeping:** The SERVICE PROVIDER shall perform activities in a manner to keep potential pollutants from coming into contact with storm water or being transported off site to eliminate or avoid exposure; and

**Construction materials and wastes:** The SERVICE PROVIDER shall store construction, building and waste materials in designated areas, protected from rainfall and contact with storm water runoff. They shall dispose of all construction waste in designated areas, and keep storm water from flowing onto or off of these areas. The SERVICE PROVIDER shall also prevent spills and make spilled materials cleaned up.

#### Temporary Site Installations

All temporary site installations shall be located either within the PV System site (e.g. PV System lay-down area) or in off-site areas to be arranged by the SERVICE PROVIDER within own responsibility.

For the avoidance of doubts UNICEF shall not be responsible for the provision of land for such off-site areas.

On completion of the construction phase, all temporary installations must be removed and demobilized leaving the occupied location clean and clear of debris or pollution.

#### Infrastructure and Outdoor Works

The following infrastructure and outdoor works are to be provided by the SERVICE PROVIDER:

* Modification, improvement and upgrading of the existing infrastructure as required to adequately service the requirements of the PV System, including civil works and services.
* Civil works for earthing and lightning protection system.
* Storm water drainage as necessary.
* Civil works for discharging rainwater, surface water and treated waste water including needed piping and pumping facilities.
* PV module cleaning system, according to the recommendations of the module manufacturer.
* Safety and fire-fighting works as necessary.
* Drainage and storm water collection system including additional facilities such as but not limited to retention basins, separators, as required.

#### PV Module Mounting Structure (Solar Arrays)

In order to get an optimized design for the PV System, the SERVICE PROVIDER is free to choose the type of mounting structures and final arrangement on the Site.

Regardless of the system selected, the SERVICE PROVIDER shall consider the following:

The mounting structure shall be designed, so that it withstands all of the combined unfavourable loads under consideration of safety factors.

The solar arrays shall be designed, manufactured and configured in accordance with a commercially proven design in such a way that the conversion of solar irradiation into electricity is based on high efficiency and achieves high availability and reliability.

To avoid and minimize effects of flooding the minimum height of the modules at any point shall be higher than 0.8 m above the recorded flood level as indicated in the general layout drawings.

**Corrosion protection:** Structure connection (Nuts, Bolts, Washers, Lock washers, etc.) shall be stainless steel or hot-dip galvanized steel. The SERVICE PROVIDER shall take appropriate measures, if necessary, to protect the structure and foundation against corrosion due to salty air, dust and chemical aggressiveness for the expected lifetime of the System.

The PV module substructure shall be designed to withstand the continuously repeated washing of the PV modules. The SERVICE PROVIDER shall demonstrate that their design of the substructure for the PV modules is able to withstand uplift and all weather-induced stress.

All works shall be planned and done in accordance with the environmental regulations, the impact to the environment during time of construction and the PV System use.

The mounting structure and the foundations shall be designed for a survivability / durability of at least 20 years. Deconstruction works at the end of lifetime of the PV System shall be minimized.

The structure shall be designed to resist all imposed loads in all possible working conditions. This includes wind load derived from reference wind speed and considering local terrain factors as well as wind gust variations, temperature loads and all other expected live loads.

**Fixed Mounting System:** The scope of the mounting system shall comprise at least the following:

* The fixed mounting system shall provide an equally tilted fixed surface of the structures, allowing for an optimized orientation of the PV modules towards the sun
* The mounting structure shall be adapted to the PV modules manufacturer’s requirements with respect to recommended PV module installation of portrait or landscape orientation or long-edge or short-edge respectively
* Good accessibility of all module rows to minimize cleaning and maintenance efforts
* Possibility for access of small vehicles between the module rows for mechanical cleaning or other necessary maintenance work for the ground mounted system.

### Instrumentation and Control (I&C) Requirements

#### I&C Scope of Work

The scope of supply shall include - but not be limited to - the following systems and components:

* PV System Control and Monitoring System (DCS – Digital Control System) done by inverter for the PV System, including all necessary software licenses - remote- PV Control System as Electrical Control and Monitoring System or as independently working system.
* Primary sensors, transmitters, actuators
* PV System monitoring and control system and PV System performance calculation
* Internal communication systems (cell-phone, LAN/ WAN system, internet)
* Meteorological station
* CCTV

Training for all I&C systems and equipment shall be provided to UNICEF’s management, operation and maintenance staff. The training shall cover hardware and software of PV System control and monitoring systems, meteorological stations, etc. SERVICE PROVIDER shall consider at least the following:

* Providing commissioning documentation
* Providing all as built drawings including set points, interfaces, etc.
* Complete hardware and software documentation (licenses and certificates).

#### PV System Control and Monitoring System and Performance Calculation

The PV System control and monitoring system shall consider measurements, evaluation of data, creation of models and performance calculations for at least:

* PV strings
* Inverters
* Meteorological stations;

The followings signals shall be considered as minimum:

* Inverters located in the solar field
* P, Q, temperature, Cos Phi.

**Meteorological Station**: A total of 1 (one) meteorological station shall be installed at representative locations throughout the PV System. Meteorological station shall contain as a minimum:

* Temperature; wind speed; irradiance.

#### Communication Equipment

* Internet Protocol based mobile system shall be provided.
* PV System internal LAN/ WAN system for O&M requirements shall be provided.
* Any other required hardware or software to remotely monitor the PV system.

#### Security and Surveillance Systems

The scope of supply shall include - but not be limited to - the following systems and components:

* CCTV surveillance system
* Fire detection system

The design and supply of the CCTV surveillance system shall include:

* Fixed outdoor cameras
* Fixed indoor cameras
* Work station; monitors; and led illuminators.

The number and type of cameras, their exact location must be fixed during the design phase.

The fire detection is to be made via smoke detectors located in the Service Building rooms, Delivery Station rooms and inverter/transformer stations.

### Inspection, Commissioning and Acceptance Testing

The requirements for inspection, commissioning and acceptance testing of the PV System as described below.

#### Inspection

The SERVICE PROVIDER shall provide a comprehensive description of such pre-shipment inspection procedure, subject to UNICEF’s approval, which shall then be signed by the Parties and bindingly applied to a sample of all modules to be shipped.

#### Commissioning and Acceptance Testing

UNICEF shall have the right to have their representatives present during all inspections and tests.

The presence of UNICEFs representatives during any inspection or test (or waiver by UNICEF of their right to witness any inspection or test) shall in no way relieve the SERVICE PROVIDER of its responsibility for supplying the equipment in accordance with the scheduled dates.

The SERVICE PROVIDER shall be responsible for providing all supplies required for carrying out such tests, except for supplies required to be provided for such tests by UNICEF.

All measurement uncertainties due to, for example, equipment inaccuracies etc. shall not be taken into account separately as they are already considered in the thresholds of provided formulas or guarantees.

The results of all tests can be certified by the manufacturer, the SERVICE PROVIDER, and/or an independent agency, the final approval certificate shall be issued by UNICEF’s Engineers.

Test Procedures

The SERVICE PROVIDER’s technical personnel, with the assistance and supervision of equipment manufacturer(s), will be responsible for complete Commissioning of the PV System.

The Commissioning of the PV System includes the following procedures:

Hot and Cold Commissioning testing outlined in SERVICE PROVIDER procedures. Tests and inspections required by codes, national standards, and equipment manufacturers. All measurements and testing procedures, such as string testing and I-V curve measurement results, will be provided completely in electronic form and as a hard copy.

Documentation from all procedures of Commissioning and testing tasks, measurements, and results will be submitted to UNICEF and UNICEF’s Engineer.

The overall testing program for the PV System shall consist of the following:

* Commissioning, including the Connection Infrastructure
* Provisional Acceptance Test

Cold Commissioning

The verification of the Commissioning tests will be based at least on the latest published testing procedure **IEC 62446: Grid-connected photovoltaic systems – Minimum requirements for system documentation, Commissioning tests, and inspection, for all electrical Commissioning**.

The verifications shall include, but not be limited to, the following equipment to be tested:

* PV modules
* PV modules support structure/tracking system; support structure foundations
* String cabling; LV DC cabling between combiner boxes; inverters LV AC cabling between inverters and transformers
* Combiner boxes
* Inverters
* Transformers
* Transformation, protection, distribution centres, and LV lines
* Piping, cable trays, inspection chambers, wiring, cabling, both for DC and AC
* Power, data transmission, and all other required transmission lines, including junction boxes, fuses, and all other required electrical equipment
* External interconnection cabinets
* Internal connections and connection infrastructure with external facilities as per IEC norms.
* Meteorological stations and monitoring system
* Civil works, including LV installations; and security system

Hot Commissioning

Once the PV System is energized (this may require a dump load during testing), the SERVICE PROVIDER shall demonstrate that the overall system and equipment operates in accordance with the equipment manufacturer specifications.

After successful completion of the items described above, the SERVICE PROVIDER shall be allowed to prepare the facilities for the Provisional Acceptance Test, which shall be carried out for the entire System, including related equipment and systems and by taking into account the conditions as specified in Section Tender Documents.

* **Provisional Acceptance Test Procedure**: The SERVICE PROVIDER shall submit to UNICEF a detailed test procedure for the Provisional Acceptance Test in writing one (1) month prior to the proposed commencement of the Provisional Acceptance Test in accordance with the provisions described above. The procedure must be approved by UNICEF’s Engineer. The Provisional Acceptance Test shall be performed for the entire PV System, evacuation infrastructure and grid connection. The test procedures shall include:
  + Provisional Acceptance Test detailed procedure
  + Description of instrumentation to be used, including accuracy
  + Method of data recording
  + Forms of test records and of test report.
* **Instrumentation:** The instrumentation for the Provisional Acceptance Test for the PV System will consist of at least one (1) meteorological station, consisting of:
  + One (1) calibrated pyranometer to measure the global inclined irradiance on the POA with a target measurement uncertainty of 2% and secondary standard according to ISO 9060 classification [W/m2].
  + One (1) calibrated pyranometer to measure the global horizontal irradiance (GHI) with a target measurement uncertainty of 2% and secondary standard according to ISO 9060 classification [W/m2].
  + A shielded, ventilated thermocouple to measure ambient temperature with a measurement accuracy of ± 1 °C
  + A resistance thermometer (e.g. Pt100, Pt1000) or equivalent to measure the temperature of modules (on the back of the PV modules) with a measurement accuracy of ± 1 °C
  + An anemometer mounted on a mast to measure the wind speed at the Site.

For the data collection and evaluation of the meteorological data from the stations:

* + Data will be collected by station, loggers, and instruments with a scan rate of one minute.
  + All collected data will be averaged into 15-minute records.
  + Records to be used for Provisional Acceptance Testing and for Annual Performance Review

The values of the pyranometers of different meteorological stations shall be averaged arithmetically. In case that the daily sum of the irradiation is more than 3% deviating between both pyranometers, the day shall be excluded and the test for that day repeated. The weather station shall be cleaned on regular basis.

The energy meter at the PV System Delivery Station (MV side) and calibrated and approved according to national standard are required.

* **Requirements for starting the Provisional Acceptance Testing:** The following requirements shall be fulfilled prior to starting the Provisional Acceptance Test:
  + The simulation model for PVsyst shall be re-done with irradiation and temperature logged during the testing period.
  + The **weather adjusted Specific Yield (SY) or Yadj** (in kWh) shall be determined for the entire testing period. This value is the SY that the PV System should have achieved during testing.
  + The **Yadj** shall then be compared with the relevant **energy meter Specific Yield (Ymeter)**, taking into account the guarantee level (GL) of the **Yadj** as contractually agreed.
* **Definition of Specific Yield at Provisional Acceptance Test:** Especially for PV systems the verification of Provisional Acceptance provides benefits when being assessed on the basis of a weather adjusted yield. The theoretically achievable **SY** of the PV System will be calculated with the simulation software based on the ambient conditions prevailing during the testing period. The actually achieved **SY** can be easily verified as it is recorded as the produced electricity at the relevant energy meter at the point of grid connection.

A shortfall of produced electricity can therefore be detected by a simple comparison after a rerun of the simulation. All kinds of losses and the individual performance of all components implemented are reflected in the actual electricity production measured at the energy meter.

If the Installed Capacity will be higher than the Nominal Peak Power, this will be reflected by means of adjusting the module quality losses of the original parameter setting of the PVsyst (or other approved software) simulation.

* **Requirements for Issuance of Provisional Acceptance Certificate:** The Provisional Acceptance Certificate will be issued by UNICEF once the following items are fulfilled:
  + Cold and Hot Commissioning Tests for the PV System is successfully executed
  + System Provisional Acceptance Test successfully passed.
  + The punch list has been prepared and delivered by the SERVICE PROVIDER and the UNICEF’s Engineer has approved the punch list items and determined the value thereof, which must be remedied within one month from the issuance of the Provisional Acceptance Certificate. The value of the punch list items shall not exceed 3% of the Contract Price.
  + The Final Documentation has been delivered by the SERVICE PROVIDER.
  + The O&M Manual has been delivered by the SERVICE PROVIDER.
  + Liquidated Damages have been paid if applicable.
  + The Initial Inventory has been delivered to the Site.

Annual Performance Ratio Review

* **Purpose:** The PV System’s annual **Performance Ratio (PR)** review shall **(i)** demonstrate the achievement of the Annual **PR** Guarantee during the Defects Notification Period of the PV System; and **(ii)** reliable, stable, and safe operation of the PV System. The Annual **PR** Review will be performed for the first year of System operation from the issuance of the Provisional Acceptance Certificate.

When the Annual **PR** Review is passed successfully the Annual Performance Review Certificate will be issued to the SERVICE PROVIDER by UNICEF.

If the Annual **PR** Review is not passed successfully, non-performance damages must be paid according to respective contractual clause.

* **Requirements for the Annual Performance Ratio Review:** The following requirements must be fulfilled prior to the start of the Annual **PR** Review:
  + The Provisional Acceptance Test has been successful and the Provisional Acceptance Certificate has been issued after six (6) months of provisional operation.
  + No punch list items are pending.

Final Acceptance Test

* **Purpose:** The Final Acceptance Test of the PV System shall be for the purpose of **(i)** demonstrating achievement of the PR Guarantee for the one (1) year of Defects Notification Period of the PV System, and **(ii)** reliable, stable, and safe operation of the PV System.

When the Final Acceptance Test is passed successfully the Final Acceptance Certificate will be issued to the SERVICE PROVIDER by UNICEF.

If the Final Acceptance Test is not passed successfully non-performance damages related to future losses must be paid according to correspondent contractual clause.

* **Requirements for the Final Acceptance Test:** 
  + The Annual Performance Review has been successful for the Defects Liability Period of one (1) year or relevant liquidated damages have been paid according to calculations above and relevant contractual clause.
  + The validity of the Provisional Acceptance Certificate is six (6) months.
  + The Initial Inventory has been replenished.
  + Thermographic analyses have been performed with IR camera for all randomly selected PV modules and electrical connections in order to detect possible hot spots.
  + PV modules with temperature anomalies have been replaced and electrical connections with temperature anomalies have been renewed, at the SERVICE PROVIDER’s sole expense

### Initial Inventory

The SERVICE PROVIDER shall be responsible for initial supplies of mechanical, electrical and I&C equipment as well as store and office equipment not specifically mentioned below, but necessary for the reliable operation and maintenance of the System, such as:

* Consumables for commissioning, testing and during the Defects Notification Period of the System
* Spare parts for at least the Defects Notification Period of the System
* Special tools and equipment for maintenance.

#### Spare Parts and Consumables

The SERVICE PROVIDER shall provide all spares necessary for discharging his responsibilities in carrying out the work, including commissioning and testing and during the warranty period. The SERVICE PROVIDER shall ensure that they have prompt access to the spares to avoid delay to completion, commissioning or loss of generation.

Spare parts are defined in Table 7.

Table 7: Initial Inventory of Spare Parts

|  |  |  |
| --- | --- | --- |
| **No.** | **Spare Parts** | **Amount** |
| **1** | **PV System** |  |
| 1.1 | PV modules | TBD \_\_\_\_\_ % of installed modules |
| 1.2 | PV module mounting assemblies | TBD |
| 1.3 | PV module cable connectors | TBD |
| 1.4 | DC string fuses | TBD |
| 1.5 | Combiner box-AC (complete) | TBD |
| 1.6 | Inverters | TBD\_\_\_\_ units |
| 1.7 | Electrical BOS | Other key components: cables, consumables, auxiliary transformer, LV terminations and connectors, protection, breakers, etc. |

AC= alternate current; BOS= balance of system; DC= direct current; LV= low voltage; TBD= to be determined

#### Special Tools and Equipment for Maintenance

All the special tools and other equipment that are necessary for the overhaul, maintenance and adjustment of the whole System facilities and equipment shall be included in the SERVICE PROVIDER’s scope of supply. The SERVICE PROVIDER shall provide two (2) sets of special tools.

### Performance Guarantee

The SERVICE PROVIDER is required to propose a PV System with PV capacity in kWp and **PR > 80%** as described in the technical design of the solar PY system at the time of commissioning regardless the month the PV System is commissioned. This is a Technical Mandatory Requirement subject of rejection if not compliant.

The PV System capacity in kWp and PR of the completed Facility will be measured in quantitative terms as specified above to verify the compliance with the System capacity and PR requirements specified.

The SERVICE PROVIDER shall provide the guaranteed values of the System operation as part of their proposal, by filling out the performance guarantee form listed below.

For the simulation of the expected yield of the PV System, which is the basis for the guaranteed performance, **i.e. the NASA Solar Data Base or other acceptable to UNICEF** shall be considered.

The SERVICE PROVIDER is required to perform the yield estimation by using PVsyst software (or other acceptable to UNICEF). The guaranteed PR shall be indicated in Table 8.

Table 8: Guaranteed PR

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **No.** | **Month** | **Year 0\***  **PR %** | **Year 1**  **PR %** | **Year 2**  **PR %** | **Year …**  **PR %** | **Year 20**  **PR %** |
| 1 | January |  |  |  |  |  |
| 2 | February |  |  |  |  |  |
| 3 | March |  |  |  |  |  |
| 4 | April |  |  |  |  |  |
| 5 | May |  |  |  |  |  |
| 6 | June |  |  |  |  |  |
| 7 | July |  |  |  |  |  |
| 8 | August |  |  |  |  |  |
| 9 | September |  |  |  |  |  |
| 10 | October |  |  |  |  |  |
| 11 | November |  |  |  |  |  |
| 12 | December |  |  |  |  |  |
| **Mean PR** | |  |  |  |  |  |

(\*) : At provisional acceptance [PAC]

#### Future Performance of the PV System

The SERVICE PROVIDER is also required to make yield estimations over a 20-year period considering PV module degradation according to Table 9.

Table 9: Future Performance of the PV System

|  |  |  |
| --- | --- | --- |
| **Year** | **Annual Degradation of PV Modules**  **[%]** | **Estimated Energy Production**  **[kWh]** |
| **1** |  |  |
| **2** |  |  |
| **3** |  |  |
| **4** |  |  |
| **….** |  |  |
| **20** |  |  |

### Training Program

The SERVICE PROVIDER is required to demonstrate the implementation of a Training Program for the personnel of UNICEF as well as for the PV System local staff of the SERVICE PROVIDER during construction and operation phase. UNICEF will select several employees for the PV power System. The training has to be carried out “on the job” during the operation guarantee and cover all aspects of O&M.

#### Program Description

The training shall comprise but not be limited to the following:

* Technical basics and components of a PV System
* Design and planning of PV System
* General function of a PV System
* Norms and standards
* Health and Safety
* Control room daily work:
  + Operation of the PV System
  + Monitoring of the PV System
  + Access to the monitoring system
  + Monitoring of grid connection signals
  + Fault detection
  + Action plan after fault detection
  + Preventive maintenance
  + Supervision and managing of corrective maintenance
  + Spare parts logistic and usage
  + System documentation
  + Monthly reporting
  + Communication with suppliers

## Requirements during O&M (Defect Liability period)

### General

The scope of work of the SERVICE PROVIDER shall include full operation as well as preventive and corrective operation and maintenance (O&M) services for the PV System for a period of **one year** starting from the System acceptance.

The SERVICE PROVIDER shall submit as part of its proposal the following:

* Description of the general O&M plan of the Project
* Detailed schedule of O&M activities

The initial inventory with spare parts and consumables will be full at the start of System operation, starting from PV System acceptance. The successful SERVICE PROVIDER is responsible for having in place all the necessary insurances for the performance of the services.

The successful SERVICE PROVIDER is responsible for having in place all tools and equipment necessary for the performance of the O&M services. These tools and equipment shall be handed over to UNICEF after the **one-year-period from the acceptance of the System without any additional cost**.

Cost for board and lodge of the successful SERVICE PROVIDER’s staff shall likewise be borne by the successful SERVICE PROVIDER and be covered in the lump-sum fee.

### O&M Requirements during Defect and Liability Period

#### System operation

The successful SERVICE PROVIDER shall be responsible for the daily operation of the System during 1st year of acceptance period. The operation and control system should not be limited to registration of data, but should comprise functions for assessment and interpretation of operating conditions in particular in order to allow for remote diagnosis of errors.

#### Preventive Maintenance Requirements

PV System specific scope of work of maintenance activities shall comprise inspection and testing according to IEC 62446. In particular, the inspection shall comprise the control and preventive maintenance of:

* Modules (cleaning; damages)
* Inverters
* Junctions boxes and cabling
* Mounting structure
* Annual IV-curve measurement and thermographic (IR) checks of a sample of at least 5% of the installed modules and electrical connections for identification of possible underperformance and/or hot spots
* Maintenance of the Project Site.
* Maintenance and cleaning of weather station.

#### Corrective Maintenance Requirements

During the period of guarantee of operation of the PV System, the successful SERVICE PROVIDER is required to provide full corrective maintenance at no extra cost for UNICEF. Corrective maintenance means the repair or replacement of defective material and components.

Corrective maintenance activities shall be initiated as soon as a failure is detected. It shall always be ensured that the staff of UNICEF is present and trained during each corrective maintenance activities.

The successful SERVICE PROVIDER shall be responsible for maintaining and refilling the spare parts stock at no additional cost for UNICEF. Furthermore, the successful SERVICE PROVIDER shall manage all warranty cases including the dismantling, packaging, shipping/ safe disposal of defective materials.

## Technical Documents and Information

### Documentation that has been submitted with the Technical Proposal

The SERVICE PROVIDERS must follow the instructions of **UNICEF’s TORs, and all its Appendixes for proposing and later on implementing** the solar PV Systems. The technical data sheets should be supplemented by additional descriptions, explanations, drawings and all other information necessary for a clear understanding of the technical and financial proposals to enable UNICEF to undertake the necessary assessment, evaluation and verification of the technical and performance features of the Proposal. UNICEF reserves the right to reject any Proposal as non-compliant at its sole discretion.

### Documentation to be submitted after Award of Contract

The following describes the minimum scope of information, documents, drawings, and other technical information to be submitted by the successful SERVICE PROVIDER to UNICEF. UNICEF reserves the right to request from the successful SERVICE PROVIDER such additional information, drawings, documents, etc. as may be reasonably required for proper understanding and definition of the design and engineering of the project.

#### Submission of Information

* Softcopies of all drawings and documentation.
* For as-built documentation a well-organized electronic file including excel based table of contents.

All information with respect to connection points and interfaces between the PV System and any other interface as well as for the entire System itself shall be included.

The number of copies or the final content may be amended as may otherwise be required by the provisions of the EPC Contract or as may otherwise be reasonably required by UNICEF.

### Documentation to be Submitted during Detail Design

The following documents shall be submitted as a minimum by the successful SERVICE PROVIDER to UNICEF within a maximum of one (1) month after the date of contract award (as applicable):

* Drawings, technical information and documentation required for DISCO to obtaining permitting, certifying and/or licensing of the System
* General arrangement and layout drawings; PVSYST/simulation files
* Project documents (data sheets, specifications, drawings) for major systems and components including system description of the main systems
* Operation and Maintenance plan
* Emergency response plan
* Health, safety and environmental (HSE) plan
* Cable size calculation according the IEC 60502-2 and IEC 60364-5-52
* Interface concept (concept and settings of protection equipment at the interface)
* Detailed layout drawings
* PV structures including foundations
* Information of codes and standards
* Specification of materials

### Documentation to be submitted prior to Site Construction

All documents and permits required for site construction shall be submitted prior to site construction.

#### Final Documentation

The successful SERVICE PROVIDER shall deliver to UNICEF the final documentation, both in digital and hard copies (as instructed above). The final documentation for the PV System shall be prepared in accordance with the IEC 62446 standard “Minimum requirements for documenting, commissioning and inspecting grid connected PV systems”.

The final documentation for the System shall comprise at least the following:

* All As-built drawings
* O&M Manual with safety guidelines
* Site safety procedures and HS procedure and plan
* Components data sheets
* Data sheets and manuals of all components and equipment
* Factory and site acceptance test reports
* Training program
* Legal documents including but not limited to:
  + Connection related documents, as far as relating to the successful SERVICE PROVIDER’s responsibility.
  + Permitting and authorization related documents, so far as relating to the successful SERVICE PROVIDER’s responsibility.

# Definitions

**“Adverse Weather Conditions”** mean instances of excessive climate and weather conditions measured by a weather station at the Site, or more than 15 mm of rain per day or storm conditions that impede the Commissioning and or Provisional Acceptance Test.

**“Annual Degradation”** is the constant annual factor of efficiency loss for the given PV module technology

**“Annual Performance Review Certificate”** means the certificate issued by UNICEF to the Contractor/ Service Provider to confirm the Annual Performance Review.

**“Annual Performance Review”** means the verification of the PV System performance.

**“Commissioning”** means all relevant tasks to be performed.

**“Completion Certificate”** means the certificate issued after all commissioning tasks have been performed successfully.

**“Completion Certificate”** means the certificate to be issued by UNICEF’s Engineer confirming the successful Commissioning of the System by the Contractor/ Service Provider pursuant to the provisions of the Contract.

**“Connection Infrastructure”** means all required components needed for grid connection in the scope of the Contractor/ Service Provider.

**“Counter Flash Tests”** means the measurement of the PV module peak power at the Independent Laboratory for a representative number of modules for the PV System.

**“Defects Liability** **Period”** will be one (1) year as contractually established.

**“Final Acceptance Certificate”** means the certificate issued by UNICEF to the Contractor/ Service Provider to confirm Final Acceptance as defined in Clause 1 of the Contract.

**“Final Acceptance Test”** means the tests to be performed.

**“Flash Peak Power”** means the peak power of all installed and connected PV modules of the PV System in kWp according to the manufacturer flash list.

**“Grid Code”** means the national regulations for the grid management, as guideline in order to allow for evacuation of electricity from the System into the grid.

**“Independent Laboratory”** means a first-class and IEC-accredited international testing laboratory such as Fraunhofer ISE in Freiburg, Germany, TÜV Rheinland in Cologne, Germany, or ASU (Arizona State University), to be determined by the Contractor/ Service Provider, subject to approval by UNICEF and UNICEF’s Engineer, for performance of the Counter Flash Tests.

**“Installed Capacity”** is the Nominal Peak Power of the aggregate PV modules in kWp verified through Counter Flash Tests. In the event that there is a deviation in

**“Interruption”** means, in the case of the Provisional Acceptance Test of the PV System, the shutdown of any facility forming part of the System preventing the System from delivering electrical energy.

**“Maximum Nominal Capacity Price Adjustment”** means an amount equal to 10% of the Contract Price.

**“Minimum Acceptance Criteria”** means the minimum acceptance criteria in respect of Performance Guarantees and Installed Capacity for Provisional Acceptance as contractually specified.

**“Nominal Peak Power”** means the nameplate capacity of the PV modules in Wp.

**“Nominal Capacity Price Adjustment”** means adjustment of the Contract Price pursuant to differences between Flash Peak Power and Installed Capacity.

**“Peak Power Certificate”** means the certificate to be issued by UNICEF’s Engineer confirming the verification of the Installed Capacity.

**“Provisional Acceptance Certificate”** means the certificate issued by UNICEF to the Contractor/ Service Provider to confirm Provisional Acceptance. The Provisional Acceptance Certificate is identical with the Operational Acceptance Certificate.

**“Provisional Acceptance Test”** means the test to be performed.

**“Provisional Acceptance Testing Period”** means the amount of days necessary for the testing.

# Technical Schedules of the Grid Connected Solar PV System

**INTRODUCTION:** the following sections describe the additional details needed in addition to the technical specifications required in Appendix 6, which are intended to deliver appropriate technical guidance to the Service Providers when preparing their proposals, and later on when implementing the solar PV systems. The specifications in Appendix 6 and Appendix 7 shall be followed when calculating the scenario-based price proposal requested in Appendix 10.

Schedule 1: Technical Schedule for Solar PV Modules

|  |  |  |  |
| --- | --- | --- | --- |
| **PV MODULES TIER 1** | **Unit** | **Specifications** | **SERVICE PROVIDER to Complete** |
| Total Power PV System | **kWp DC** |  |  |
| Total PV System ground Area | **m²** |  |  |
| PV System module Area | **m²** |  |  |
| Number of Strings | **-** |  |  |
| Total Field ground area | **m²** |  |  |
| Type (Mono crystalline / poly crystalline) |  |  |  |
| Manufacturer |  |  |  |
| Temperature Operating Conditions Range | **°C** | **-5 °C to +65 °C** |  |
| Module Power @ STC | **Wp** | **As per manufacturer**  **Suggested: 400; 500; above** |  |
| @ STC: Impp | **A** |  |  |
| @ STC: Isc | **A** |  |  |
| @ STC Vmpp | **V** |  |  |
| @ STC Voc | **V** |  |  |
| Power Temp coefficient  (monocrystalline / polycrystalline) | **%/K** | **lower than -0.4** |  |
| Efficiency (Mono crystalline) @ STC | **%** | **%** |  |
| NOCT | **°C** |  |  |
| Efficiency (Mono crystalline) @ NOCT | **%** | **To include calculation** |  |
| Module Power @ NOCT | **Wp** | **To include calculation** |  |
| @ NOCT: Impp | **A** | **To include calculation** |  |
| @ NOCT: Isc | **A** | **To include calculation** |  |
| @ NOCT: Vmpp | **V** | **To include calculation** |  |
| @ NOCT: Voc | **V** | **To include calculation** |  |
| Warranties |  |  |  |
| Product Warranty Period | **-** | **10 years** |  |
| Power Warranty | **-** | **25 years linear** |  |
| Power Degradation | **-** | **\_\_\_\_% 25 years** |  |
| Certifications | **-** | **IEC 61215**  **IEC 61730**  **IEC 61701**  **Other** |  |
| PID resistant test | **-** | **Yes** |  |
| BIFACIAL | **-** | **Yes** |  |

Schedule 2: Technical Schedule for Solar Cabling, and PV Junction Boxes

|  |  |  |  |
| --- | --- | --- | --- |
| **SOLAR CABLING AND PV JUNCTION BOXES** | **Unit** | **Specifications** | **SERVICE PROVIDER to Complete** |
| Solar String Cable |  |  |  |
| Type PVF-1 | Yes/no | As per manufacturer |  |
| Maximum PV - System Voltage | DC V | 1,000 |  |
|  | kV | As per manufacturer |  |
| Max. permitted operation Voltage in DC | kV |  |  |
| Max. permitted ambient temperature | °C |  |  |
| Min. permitted ambient temperature | °C |  |  |
| Insulation |  | Double insulation |  |
| Warranty | Years | 25 |  |
| Certifications | - |  |  |
| LV AC Cable (Junction Box) |  |  |  |
| Manufacturer | Name |  |  |
| Nominal Voltage | kV | 1 |  |
| Maximum voltage level | kV | 6/10 as per DIN VDE 0276-603 |  |
| Current capacity in air at 30 ºC | A | As per manufacturer |  |
| Specific weight | kg/km | As per manufacturer |  |
| Cross section | mm² | As per manufacturer |  |
| Insulation type | - | As per manufacturer |  |
| Insulation class | - | As per manufacturer |  |
| Conductor material | - | Cu |  |
| Number of cables per phase | - | As per manufacturer |  |
| DC Cable (- 48VDC line |  |  |  |
| Nominal Voltage | kV | As per manufacturer |  |
| Maximum voltage level | kV | As per manufacturer |  |
| Current capacity in air at 30º | A | As per manufacturer |  |
| Specific weight | kg/km | As per manufacturer |  |
| Cross section | mm² | As per manufacturer |  |
| Insulation type | - | As per manufacturer |  |
| Insulation class | - | As per manufacturer |  |
| Material conductor | - | As per manufacturer |  |
| LV AC Cable (Inverter-junction box) |  |  |  |
| Nominal Voltage | kV | As per manufacturer |  |
| Maximum voltage level | kV | As per manufacturer |  |
| Current capacity in air at 30º | A | As per manufacturer |  |
| Specific weight | kg/km | As per manufacturer |  |
| Cross section | mm² | As per manufacturer |  |
| Insulation type | - | As per manufacturer |  |
| Insulation class | - | As per manufacturer |  |
| Material conductor | - | As per manufacturer |  |
| Junction Boxes |  |  |  |
| Number of PV string inputs | - |  |  |
| Input protection fuse for PV inputs | A |  |  |
| Permitted AC voltage | V | 1,000 |  |
| Protection level IP | - | IP 54 or IP55 |  |
| UV proof resistant and flame retardant | Yes/no | Yes |  |
| Surge protection | Yes/no | Yes |  |
| Input AC switch | Yes/no | Yes |  |
| Output AC switch | Yes/no | Yes |  |
| Surge protection on input side | Yes/no | Yes |  |
| Surge protection on output side | Yes/no | Yes |  |
| Maximum ambient temperature range | +90°C |  |  |
| Minimum ambient temperature | °C |  |  |
| Earthing | Yes/no | Yes |  |
| Warranties | - | 10 years |  |
| Certifications | UL -4703 | As per manufacturer |  |

Schedule 2a: Technical Schedule for DC Connectors

|  |  |  |
| --- | --- | --- |
| **No.** | **Usage Characteristics** | **Standard Reference** |
| 1 | Ozone resistance | EN 50396:2005 |
| 2 | Weather resistance | Excellent |
| 3 | Flame retardant | IEC 60332-1 |
| 4 | Fire retardant | C1, NF C 32-070 |
| 5 | Minimum Bend Radius- Installed | 17.7 mm |
| 6 | Corrosive or polluting substances | Condition AF 3 (intermittent accidental) according to HD 60364-5-52 |
| 7 | Outdoor use | Condition AN 3 (high solar radiation), permanent according to EN 50565-1:2014 |
| 8 | Thermal endurance | IEC 60216-1-2 |
| 9 | RoHS conform\* | RoHS 2011/65/EU |
| 10 | UV resistance | EN 50289-4-17 method A, for 720h. Nexans prestige test 4000h |
| 11 | Resistance to vibrations | Condition AH3 (sever industrial conditions) according to HD 60364-5-52 |
| 12 | Waterproof | Condition AD 8 according to EN 50525-2-1 annex D and E |
| 13 | Solar Direct Current (DC) connectors for string interconnection shall be of the same brand and type as used by the PV module manufacturer. In no case connectors of different brands shall be used in the same connection (male –female), neither can cut the PV module cables and to install other than the original connectors. | |

Schedule 3: Technical Schedule for Solar Module – Mounting Structure

|  |  |  |  |
| --- | --- | --- | --- |
| **SOLAR MODULE MOUNTING STRUCTURE** | **Unit** | **Specifications** | **SERVICE PROVIDER to Complete** |
| Model | **-** |  |  |
| Type: hot deep galvanized steel with a zinc coating thickness of 75 micro-meters (mk-m). As per industrial standards the corrosion at high aggressive environment is about 2 mk-m/ year, which gives a good 25-year corrosion warranty.  The structure design shall also cover the local requirements for wind load of about 180 km/h. To achieve the necessary structure stability, it is necessary to provide ground geotechnical study and practical tests on the site. The pulling force for the structure shall be at least 450 kg for stable metal supporting in lieu with local conditions. | - |  |  |
| Structure material | - | Steel/ Aluminium |  |
| Foundation solution (Table/ contour/ terraced) | - | As per manufacturer |  |
| Foundation material | - | As per manufacturer |  |
| Survival wind speed of design | m/s | As per manufacturer |  |
| Pull out test performed | Yes/No | If installed on ground As per manufacturer |  |
| Arrangement of PV modules (row/column) | - | \_\_\_per row/\_\_\_ rows  As per manufacturer |  |
| Position of PV modules landscape/portrait | - | As per manufacturer |  |
| Corrosion protection solution | - | Hoe Deep Galvanised  As per manufacturer |  |
| Type of PV module claws | - | Bolts and plates  As per manufacturer |  |
| Material of PV module claws and accessories | - | bolts and Alu plates  As per manufacturer |  |
| Antitheft protection bolts | Yes/No | Yes  As per manufacturer |  |
| Warranty | - | 20 years against corrosion  As per manufacturer |  |

Schedule 4: Technical Schedule for Solar Inverters

|  |  |  |  |
| --- | --- | --- | --- |
| **INVERTER TIER 1** | **Unit** | **Specifications** | **SERVICE PROVIDER to Complete** |
| **GENERAL:** The inverters shall be designed to be able to transmit the maximum output of the solar PV generator at all possible ambient temperatures and local conditions (e.g. soil, dust atmosphere, heat).  The inverters shall be selected for bi-directional grid tied applications, string or central type, three phase configuration (separate PE and N conductors) and operate at 50 Hz and/or 60 Hz grid frequency.  With adjustable Power factor according to the grid requirements; transformer-less with high voltage protection (surge arrestor), integrated fuses, DC switch, as well as protections; reverse current protection, input over voltage & over current via fuse.  The Inverter shall be provided with screen to provide instantaneous information about the system and the output; such as daily energy production, life time energy production, grid voltage, PV array voltage & PV array current.  Equipped with Bluetooth/IP connectivity, and able to be connected to web-based monitoring system through Ethernet port. | | | |
| **The inverters shall include the following general features:**  Total harmonic distortion less than 3% (standard)  European efficiency higher than 98%  Maximum humidity 0 – 95% without condensation.  Maximum input voltage of 1,000VDC or 1,500VDC  AC output voltage ≥ 380V (or customized to specific conditions)  Reactive and active power control with power factor of > 0.9 leading and lagging  Frequency-dependent active power limitation and grid management service  Minimum frequency operation range 48.5 Hz - 51Hz; 59 Hz – 60.5Hz  Protections shall follow the grid operation set points and conditions  Corrosion prevention due to marine, salty and desert environment | | | |
| **Inverters must be from Tier 1 supplier**  **Certificates:** The inverters should be TÜV-tested for the required Certificates, CE-marked and in compliance with the applicable standards also most comply with the IEC 61000-6-2:2005; IEC 61000-6-4:2006; UL 1741 and IEEE 1547  **Warranty:** Product warranty for inverters should be at least 5 years. In addition, it should be possible to buy an extended warranty for additional 5 years. | | | |
| System voltages:  Input DC voltage  Output AC voltage pure sine wave | V | As per manufacturer |  |
| Frequency and phases:  50 Hz / 3-phase; 60 Hz / 3-phase | Hz | YES |  |
| Ethernet connection, that enables Real Time Data Logging with all related hardware and software required.  GSM capability |  | YES |  |
| CAT6 data cable should be included in the installation with separated labelled conduit to nearest internet point. |  | YES |  |
| Rated Power AC | kW | As per manufacturer  Suggested: 20; 25; 30 |  |
| Protections |  | Over-voltage  Reverse-voltage  Over-current  Reverse current  Disturbances at input  Overload and short circuit at output |  |

Schedule 4: Technical Schedule for Solar Inverters (continuation)

|  |  |  |  |
| --- | --- | --- | --- |
| **INVERTER TIER 1** | **Unit** | **Specifications** | **SERVICE PROVIDER to Complete** |
| Integrated fuses |  | YES |  |
| Protection switches |  | YES |  |
| Power factor adjustability |  | YES |  |
| Power factor cos ȹ |  | 1 |  |
| European Efficiency | % | ≥ 98 |  |
| Number Maximum Power Points (MPP) |  |  |  |
| LCD display |  | YES |  |
| Operating temperature | ºC | -5- 65 |  |
| Harmonic distortion less than 3% |  |  |  |
| Protection rating indoor |  | IP54 or IP55 |  |
| Protection rating outdoor |  | IP65 or IP66 |  |
| Cooling type |  | Fan/ natural |  |
| Warranty | Years | 5 + 5 |  |

Schedule 5: Technical Schedule for Energy Meters, Control and Monitoring Power Distribution Units, Weather Station

|  |  |  |  |
| --- | --- | --- | --- |
| **ENERGY METERS**  **CONTROL & MONITORING POWER DISTRIBUTION UNITS (PDUs)**  **FULLY CERTIFIED** | **Unit** | **Specifications** | **SERVICE PROVIDER to Complete** |
| Energy Meters: Programmable Energy Meter having accuracy Class 0.2 and Time of Day (TOD) feature.  GSM data logging availability | Unit | YES  As per manufacturer |  |
| Remote Monitoring PV Generator and Grid:  To record features via internet  GSM data logging availability | Unit | YES  As per manufacturer |  |
| Weather station with global radiation, ambient temperature, relative humidity  GSM data logging availability | Unit | YES  Measuring range:  0- 1500 W/m2  Sensor: Thermo element/ photo cell  Solar-spectrum:  250 – 2800 nm  Non-linearity:  < 0.2% @ 0 -1,000W/m² |  |
| Web portal for real-time technical data access | Unit | YES  As per manufacturer |  |
| Mobile phone app for real-time technical data access | Unit | YES  As per manufacturer |  |
| Standards |  | As per manufacturer |  |
| GSM data logging availability |  | YES |  |
| Power Distribution Unit (PDU):  System components and load will be connected to a PDU able to connect and disconnect from the power distribution grid. | Unit | Yes  As per manufacturer |  |
| Switches: Automatic connection/ disconnection from utility grid and system when commanded by automatic control or in case of fault detection. |  | Yes  As per manufacturer |  |
| Electrical features |  | As per manufacturer |  |
| Degree of protection | IEC 60529 | IP 20 |  |
| STANDARD CERTIFICATIONS | IEC  OTHER |  |  |

Schedule 6: Technical Schedule for Civil and Electromechanical Works and Services

|  |  |  |  |
| --- | --- | --- | --- |
| **CIVIL AND ELECTRO-MECHANICAL WORKS AND SERVICES** | **Unit** | **Specifications** | **SERVICE PROVIDER to Complete** |
| **General:**  All power electronics, switch boxes and control/monitoring systems shall include all necessary protections/ ventilations/ cooling, and other to ensure a safe operating temperature. | | | |
| Civil works and services  As needed for anchoring PV generator; BOP; and BOS | Lot | Yes  As per manufacturer | Separate sheets as necessary |
| Electro-mechanical works and services  AC/DC cabling  Grounding/lighting/protection/monitoring/control/measurement  LV/MV power distribution cabinets. | Lot | Yes  As per manufacturer |

Schedule 7: Technical Schedule for Warranty of Components of Solar PV System

|  | **MANDATORY WARRANTED COMPONENTS** | **Description** |
| --- | --- | --- |
| 1 | PV system | Product Guarantee of ten (10) years for modules, the factory-assembled DC connectors and cables.  Performance Guarantee: linear warranty, starting with 100 % of the peak power from the date of issuance of the Operational Acceptance Certificate  Certificate by an Independent Laboratory, stating that the modules are free from PID.  The mentioned warranties and certificates shall be clearly defined and part of the module purchase agreement between the Contractor/ Service Provider and the module supplier.  Product Guarantee of \_\_\_\_ years for mounting system |

Schedule 8: Technical Schedule for LV Switchgear

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No.** | **Parameter** | | | **Unit** | **Value** |
| **Low Voltage switchgear**  LV switchgear will be placed in the adequate place, consisting of:  Incoming feeders from junction boxes with load break switch and fuse and earthing switch  Feeders with load break switch and fuse and earthing switch and with circuit breaker/ load break switch/ fuse/earthing switch.  Outgoing/ incoming feeders with circuit breaker  Auxiliary transformer feeder with load break switch and fuse and earthing switch.  An LV-AC auxiliary switchgear shall supply inverter/ power transformer station for power, lighting, emergency lighting, ventilation, SCADA, telephones, UPS, etc.  The LV-AC auxiliary load switchgear shall be designed for a nominal voltage of 420/230 V (according to IEC 60038).  The LV switchgear shall be designed at least to protection class IP 41.  The LV auxiliary load network shall be of TN-S type (five conductors including separate PE and N conductors).  Surge arresters come in the form of modules to be installed inside LV switchgear.  Auxiliaries: cables, connectors, switches, earthing and lighting protection and mounting frames | | | | | |
| **1** | Rated Uninterrupted Capacity | | | A | SERVICE PROVIDER |
| **2** | Rated Ultimate Breaking Capacity under short circuit @ 440V AC, | | | kA |  |
| **3** | Rated Service Breaking capacity under short circuit @ 440V AC | | | kA | 100% of Isc |
| **4** | Rated Short time withstand current (1 second) | | | kA | 100% of Isc |
| **5** | Rated making capacity under short circuit (Peak) @ 440V AC | | |  |  |
| **6** | Rated Service Voltage | | | kV | 0.7 |
| **7** | Rated Insulation Voltage | | | kV | 1 |
| **8** | One-minute dry withstand test voltage | | | V | 2,500 |
| **9** | Rated Impulse withstand Voltage | | | kV | 8 |
| **10** | No. of Poles | | |  | 3 |
|  | **Operating Time** | | |  |  |
| **11** | Closing Time (max) | | |  | 80 mS |
| **12** | Breaking time (max) | | |  | 70 mS |
| **13** | Rated Operating Temperature | | |  | 5°C to 70°C |
| **14** | Module Type | | | With-draw-able | |
| **14** | Type of tripping mechanism | | | Direct/Shunt trip (Electrical) Manual (Mechanical) | |
| **15** | Method of closing | | | Electrically operated spring charged (normal) Mechanical (Emergency). | |
| **16** | Nominal voltage of Closing/Tripping coil | | |  | 110 V DC +10 % -20% |
| **17** | Voltage for spring charging motor (for stored energy mechanism) | | |  | 230 V AC +10 % -20% |
| **18** | Breaker operations | | | Electrically operated with Draw-out type. | |
| **19** | Features of circuit breaker | In-built trip free and anti pumping feature for both Electrical & mechanical (in case of unavailability separate anti-pumping relay shall be provided) | | | |
| **20** | Breaker tripping mechanism | In-built trip unit for breaker tripping, parameter measurement, event marking & communication feature | | | |
|  | **Switchgear Cubicles** | | 690V/1000V (Uo/U) | | |
| **21** | Design voltage of switchgear bus | | |  | IP 54 |
| **22** | Type of enclosure (indoor) | | |  |  |
| **23** | Power frequency withstand voltage for complete cubicle | | | kV | 2.5 |
| **24** | Bus Bars | | | kA | SERVICE PROVIDER |
| **25** | One-minute power frequency withstand voltage | | | kV | 2.5 |
| **26** | **Operational Features LV Switchgear** | | |  |  |
|  | **Circuit Breaker Specifications**  The circuit breaker shall confirm to the latest amendments of IS: 13947 / IEC-60947-1 &2- 2003, and shall comply EC directives “Electromagnetic Compatibility Directive” (EMC) N.89/336 EEC.  i. All Circuit Breaker shall be suitable for operation, at 50 Hz +/- 5%, and 415V +/- 10% AC voltage with adequate thermal capacity for continuous operation.  ii. The Circuit breaker shall be air break type, 3 Pole (4-Pole type for panel-II, Incomer), electrically operated, draw out type (EOD)  iii. Main contacts shall have ample area and contacts pressure for carrying the rated current and the short time rated tripping current of the breakers without excessive temperature rise which may cause pitting or welding.  iv. Contacts shall have a minimum of moveable parts. It shall be designed such that no maintenance shall be required under normal condition of use. The contacts shall be replaceable.  v. The temperature rise and maximum temperature on any part of the circuit breaker, while in service under continuous full load conditions shall not exceed the permissible limits of temperature rise as specified in the IEC- 694:1996 publication for alternating current circuit breakers  The controller shall have inbuilt feature to measure and record the following parameters:  a. Current-Phase, neutral  b. Voltage, Ph-Ph, Ph-Neutral  c. Power (Active, reactive & Apparent)  d. Power factor  e. Frequency  f. Fault wave form capture feature  **Protection LV switchgear**   * The LV switchgear shall be of the fixed mounted design according IEC 61439-2 / SI 1419. The LV switchgears shall be designed as indoor switchgear installations of metal-clad, bulk-headed type. * Each switchgear installation shall be equipped with a single copper bus bar system. * The LV auxiliary load switchgears shall be designed for a nominal voltage of 400/230 V (according IEC 60038). * The LV switchgears shall be designed at least to protection class IP 41. Anti-condensation heaters shall be provided. | | |  |  |

Schedule 9: Check-List Scope of Supply of Grid Connected Solar PV System

|  | **TECHNICAL REQUIREMENTS FOR BATTERY ENERGY STORAGE SYSTEM** | **COMPLIANCE** |
| --- | --- | --- |
| 1 | **Lithium Ion** |  |
| 2 | **Usable Deep of Discharge (DOD) 90%** |  |
| 3 | **Capacity of pack 5kWh** |  |
| 4 | **Capacity of each unit (specify)** |  |
| 5 | **Self-discharge < 2% per month**  **(battery off)** |  |
| 6 | **IP 55** |  |
| 7 | **Standards:**  • IEC 62133  • UL 2271  • UL 1973  • UN 38.3 |  |

|  | **TECHNICAL REQUIREMENTS FOR GRID CONNECTED SOLAR PV SYSTEM** | **COMPLIANCE** |
| --- | --- | --- |
| 1 | **The scope of supply of the full PV System will include, but is not limited, to the following main elements, subsystems, and construction:**  Full engineering and permitting  Solar PV generator;  inverters/ power electronics (balance of system- BOS)  Balance of System (BOP): PV mounting structures, including trackers; cabling; all related connections between PV System, and connection point to the power distribution grid.  Instrumentation, data acquisition, control, monitoring, and supervision  Civil, mechanical, and electrical works  Site security and surveillance; supply and construction of a fire protection system  Additional works and services. |  |
| 2 | **Solar PV system benchmarks:** the engineering design and simulation must guarantee for the grid connected solar PV system. |  |
|  | **(a) maximum Performance Ratio (PR); and (b) Specific Yield (SY)** for the full duration of the expected PPA Agreement to be signed with the utility.  The proposed LTSA for O&M shall be for a tenor of \_\_\_\_ years. |  |

Schedule 10: Implementation and Resource Schedule of Grid Connected Solar PV System

**Sample Schedule**

|  |  |  |
| --- | --- | --- |
| **Activity** | | **Timeline** |
| **Milestones** |
| **Step 1** | |  |
|  |  |  |
| Resources: | |  |
| **Step 2** | |  |
|  |  |  |
| Resources: | |  |
| **Step\_\_\_** | |  |
|  |  |  |
| Resources: | |  |