Technical Specifications for a Photovoltaic Renewable Energy System for the UNHCR Pretoria Regional Bureau

Site information

|  |  |
| --- | --- |
| Site name of the system | WaterKloof House - Pretoria |
| Country of the system | South Africa |
| Site coordinates - Latitude | 25.7539100° S |
| Site coordinates - Longitude | 28.2104200° E |
| Name or function of the UNHCR compound | Pretoria Regional Bureau |

Table of contents

[Site information i](#_Toc136005076)

[Table of contents ii](#_Toc136005077)

[List of Tables iii](#_Toc136005078)

[List of Figures iii](#_Toc136005079)

[List of Acronyms and Definitions iv](#_Toc136005080)

[Disclaimer iv](#_Toc136005081)

[1 Key parameters required for the new photovoltaic renewable energy system for the Sub Office Pretoria 1](#_Toc136005082)

[1.1 Area available on the UNHCR compound 2](#_Toc136005083)

[2 Scope of Works 3](#_Toc136005084)

[3 System Overview and introduction 4](#_Toc136005085)

[3.1 PV power system layout 4](#_Toc136005086)

[3.2 Design requirements 5](#_Toc136005087)

[4 Quality assurance 6](#_Toc136005088)

[5 Reference standards 6](#_Toc136005089)

[6 Power quality 7](#_Toc136005090)

[6.1 Voltage 7](#_Toc136005091)

[6.2 Frequency 7](#_Toc136005092)

[7 Equipment component specification 7](#_Toc136005093)

[7.1 Switchgear 8](#_Toc136005094)

[7.2 PV modules 8](#_Toc136005095)

[7.3 PV support structure 9](#_Toc136005096)

[7.4 PV inverter 9](#_Toc136005097)

[7.5 Battery inverters 10](#_Toc136005098)

[7.6 Wiring standard 11](#_Toc136005099)

[7.7 Earthing, Equipotential Bonding, and Lightning Protection 12](#_Toc136005100)

[7.7.1 System type 12](#_Toc136005101)

[7.7.2 Earthing 12](#_Toc136005102)

[7.7.3 External lightning protection 13](#_Toc136005103)

[7.7.4 Surge protection 13](#_Toc136005104)

[7.8 Weather Station 13](#_Toc136005105)

[7.9 Battery Storage System 14](#_Toc136005106)

[7.10 Control and monitoring system 15](#_Toc136005107)

[7.11 Metering System 16](#_Toc136005108)

[8 Civil works and security 16](#_Toc136005109)

[8.1 Technical room 17](#_Toc136005110)

[9 Commissioning 17](#_Toc136005111)

[10 Spare parts and O&M materials 18](#_Toc136005112)

[11 O&M 19](#_Toc136005113)

[11.1 General description 19](#_Toc136005114)

[11.2 Allowed interruptions 20](#_Toc136005115)

[11.3 Liabilities and responsibilities 21](#_Toc136005116)

[11.4 O&M tasks 23](#_Toc136005117)

[11.5 O&M reporting 25](#_Toc136005118)

[12 Training 25](#_Toc136005119)

[13 Health and Safety Requirements 26](#_Toc136005120)

[14 Documentation 26](#_Toc136005121)

List of Tables

Table 1: System key parameters 1

Table 2: Environmental parameters for design. SOurce: Weatherspark. 2

Table 3. Voltage requirements 8

Table 4. Frequency requirements 9

Table 5. PV modules requirements 10

Table 6: Site-specific requirements for the PV support structure 10

Table 7. Requirements for PV inverters 11

Table 8. Battery inverter requirements 12

Table 9. Maximum voltage drop requirements 14

Table 10. Earthing resistance requirements 15

Table 11. Battery Storage System requirements 16

Table 12. Minimum Technical requirements of the data acquisition and monitoring system 17

Table 13. Minimum requirements for data measurement, recording and analysis 17

Table 14. Failure types 21

Table 15. Restoration times per O&M level and failure type 22

List of Figures

Figure 1: aerial view of UNHCR compound showing the available areas to install the different systems: i) PV generator on roof shown as yellow; ii) generators area in red. 2

Figure 2: Images showing general view on available rooftop space for PV generator (left) and the generators area showing two identical generators (right) 3

Figure 3: PV system SLD sample 6

Figure 4: Processes and restoration times for Type A failure 21

List of Acronyms and Definitions

ATS Automatic Transfer Switch

BMS Battery Management System

EPC Engineering, Procurement and Construction

DG Diesel Generator

GPS Global Positioning System

IEC International Electrotechnical Commission

kW kilo-watt

kWp kilo-watt peak

kWh kilo-watt-hour

LFP Lithium Ferro Phosphate

LV Low Voltage

MDB Main Distribution Board

MCB Miniature Circuit Breaker

MPPT Maximum Power Point Tracking

MV Medium Voltage

O&M Operations and maintenance

PV Photovoltaic

SIPS Structural Insulated Panel Systems

SLD Single Line Diagram

SOC State of Charge (of the battery)

SOW Scope of Works

SPD Surge Protective Device

STC Standard Test Conditions for PV modules (cell temperature of 25°C, irradiance of 1000 W/m² with an air mass 1.5 (AM1.5))

UNHCR United Nations High Commissioner for Refugees

UV Ultraviolet radiation

Disclaimer

This document describes the specifications for the design of a photovoltaic renewable energy system to meet the contractual requirements stipulated in this RFP. The specifications referring to the detailed system design must be considered as a technical orientation to develop the bidding documents. The bidder is responsible for carrying out a site visit to verify the site characteristics at their own responsibility before designing the system, as well as for calculating all related costs to install and operate the system. All standards referring to the quality of service, as outlined in this document, must be met in the system performance over the entire term of the contract.

2. Key parameters required for the new photovoltaic renewable energy system for the Pretoria Regional Bureau

The following key parameters define the minimum requirements that are specific to the above specified project. All references in this document relating to “key parameters”, this chapter name, or which refer to the parameter name in brackets must use the values defined below.

Table 1: System key parameters

|  |  |  |
| --- | --- | --- |
| **Key Parameters** | **unit** | **Requirement** |
| Continuous AC power rating available any time (Pnominal) | kW @ 0.8 PF @ 40ºC | 200 kW |
| Peak power for 15 minutes available any time (Ppeak. 15 minutes) | % of Pnominal | 120% of Pnominal |
| Peak power for 5 seconds available any time (Ppeak. 5 seconds) | % of Pnominal | 150% of Pnominal |
| Nominal voltage (Vnominal) | V | 230/400 V |
| Rated voltage at the supply terminals (Vsupply) | % (Vnominal) | ±5% (Vnominal) |
| Nominal frequency and tolerance (fnominal) | Hz (± 2 %) | 50 Hz |
| Available Rooftop space for PV panels installation | m2 | 1350 |
| PV Generator Capacity | kW @STC conditions | 176 |
| PV generator energy yield | MWh/year | 318 |
| Ratio PV inverter vs PV capacity | kW | n/a |
| Minimal usable storage capacity (Cminimum) | kWh | 200 |
| Mounting of the photovoltaic modules | - | Rooftop mounted |
| System type | - | Hybrid Photovoltaic Renewable Energy System |
| Number of existing diesel generators integrated to the system | - | 1 |
| Number of new diesel generators to be supplied and integrated to the system | - | 0 |
| Responsibility for the distribution of electricity inside the compound | - | UNHCR |
| Daily average demand (Edaily average) | kWh | 1,250[[1]](#footnote-2) |
| Annual Demand | kWh | 456 250[[2]](#footnote-3) |
| Minimum autonomy time to run at nominal power on the Battery if it was charged to 90 % before and not re-charged thereafter | hours | TBD by bidder |
| In case the system is on-grid, sales options of surplus PV generated electricity to the grid operator | - | not relevant |
| Minimum annual availability (Aannual, minimum) | % | 99.5% |
| Maximum monthly outage time (Tmonthly outage, maximum) | % | 0.5 |

The PV generator energy yield refers to the energy that the PV generator would generate during one year, ignoring any effects from the battery, the diesel generators, or possible grid blackouts; this must be demonstrated with a simulation using reputable PV software[[3]](#footnote-4), which does not need to include the batteries nor diesel generators.

The following environmental parameters shall be considered for the design:

Table 2: Environmental parameters for design. Source5 Weatherspark

|  |  |
| --- | --- |
| Parameter | Value |
| Ambient temperature | Min: 2°C  Max: 28°C |
| Relative humidity | Max: 62% |
| Rain | 732 mm/year |
| Average Wind speed | 1.2 m/s |

* 1. Area available on the UNHCR compound

The area that can be used for the PV generator[[4]](#footnote-5) is:

1. The rooftop surface covering the main building area (1,360m2).

The generator to be integrated can remain in the existing generator area.



Figure 1: aerial view of Waterkloof House Pretoria compound showing the available area to install the system.

The predefined PV generator available spaces on the roof are tilted and not perfectly North oriented. Any roof orientation can be used as long as the bidder complies with the PV capacity (kWp) and the energy yield specified in Section 1. To prove this, the bid shall include energy yield simulations of the proposed layout with PV-specific software such as PVSYST or equivalent. The simulations shall include all roof-mounted PV arrays.

The technical room (hosting the battery storage system, inverters, and all the required control and switchgear equipment) shall be installed in an enclosed designated area inside the main building to be defined together with UNHCR Sub-Office Pretoria.

The bidders are required to inspect the site (mandatory site visit) to validate the most appropriate layouts at their own risk.

Please refer to ***Annex B, II. a) Pretoria Site Information Memo*** for more information on the space available for the proposed system.

1. Scope of Works

The Contractor is responsible for the following Scope of Works (SOW):

1. Initial site visit after contract award to collect all necessary information needed for the detailed engineering design.
2. Detailed Renewable Energy System Engineering Design.
3. Supply, construction, and commissioning of the renewable energy system described in Section 3, including any civil works required to make the system operational. The system must integrate two of the existing generators; the bidder is responsible for the election of which one(s).
4. Operation and Maintenance (O&M) obligations for a period of 5 years after commissioning (see Section 11).
5. Training to local UNHCR technical staff. This training will play an essential role for the envisioned O&M services and to guarantee that safety and environmental standards provided by the EMP are followed.
6. Supply of spare parts and any tools required for the O&M phase and handling of the waste generated during the O&M phase according to applicable legislation and UNHCR standards.

The list of required works specified in this document is by no means exhaustive. The Contractor is responsible for providing all materials and services necessary to accomplish the SOW mentioned above.

UNHCR reserves the right to modify the planned quantities at the time of the award of the contract and during its validity. The unit prices shown in the bidding offer will be applicable as long as the total quantities have not been reduced by more than 25% of the total quantities originally specified.

The Contractor is requested to coordinate with and involve UNHCR’s technical staff as much as possible throughout the installation and commissioning phases (see section 12 Training for further information). The Contractor is also encouraged to hire as many local personnel as possible. If qualified personnel cannot be found on-site, it is permitted to hire labour outside the work area.

The installations supplied shall be tested, commissioned, and handed over complete and in perfect operating condition in line with the dates agreed at contract signature.

The installations shall be covered under a defect liability (parts and labour) for a minimum period of 24 months from the date of commissioning.

1. System Overview and introduction

This technical specification provides the information for preparing the detailed technical offer. In addition to minimum requirements of the technical bidding documents, this technical specification document includes the operation, maintenance and reporting specifications for after the successful bidder is awarded as contracted service provider. The terms *bidder*, *contractor*, and *service provider* are used simultaneously depending on the stage of project.

The requirement is to install a renewable energy system following Section 1 requirements and composed of:

1. PV modules
2. PV support structure, including all necessary components needed for the installation.
3. Power conversion and modulation equipment, such as PV inverters and battery inverters.
4. Li-ion batteries, including a Battery Management System (BMS).
5. Electric boards, including switchgear and protections.
6. Cabling, conduits, and trenching.
7. Earthing system.
8. Control and monitoring system, including communications network, weather sensors, and energy/power meters.
9. Integrating two of the existing on-site generators
10. And external lightning protection system.
11. All other necessary equipment and materials to ensure the correct and safe operation of the system
    1. PV power system layout

The PV power system must make use of multiple MPPT PV string inverters to increase the availability in case of failure of a single inverter or a failure of a PV string. Each inverter must have at minimum one DC switch and a Surge Protective Device (SPD) per MPPT input. The DC switch and the SPD can be integrated within the PV inverter or installed in a separate string combiner box. String fuses must be installed inside the string combiner box if more than 2 PV strings are connected in parallel. Each inverter must be connected to a centralized on-line monitoring system to identify power output and potential failure of the inverter or individual strings. For details on the surge protection requirements, refer to Section 7.7.4.

Diagram, schematic

Description automatically generated

Figure 3: PV system SLD sample

* 1. Design requirements

The following general requirements shall be met:

1. The proposed system can support AC, DC or hybrid coupling options, in accordance with the design submitted.
2. The SOW includes a renewable energy system that needs to be connected to the LV side of the utility transformer and to the generators, besides integrating the PV generator as power sources. The AC output of the renewable energy system shall connect and feed directly to the ATSs by-passing the existing load management system (since the renewable energy system will manage the load itself) up to and including the connection to the LV side of the existing grid transformer. If needed, the supplier is responsible for the supply and installation of a new main distribution board.
3. The loads shall be fed from the PV generator and the grid during normal operation with grid availability. The system shall give priority to the energy from the PV generator, maximizing the PV energy use. Excess PV energy shall be used to charge the battery. If PV energy is not sufficient, the battery shall be charged from the grid. If the battery is full, excess PV energy shall be fed into the grid, according to the Tshwane SSEG regulations.
4. In the event of a grid blackout, the system shall automatically switch to off-grid mode and continue powering the loads while preventing any power from feeding into the grid. The battery inverter or a diesel generator shall automatically switch to grid-forming mode so that the grid-following PV inverters continue powering the loads. The system shall maximise the use of the PV energy and battery energy. The loads shall be powered by the PV inverters and battery inverter if the batteries are sufficiently charged. If the battery SOC is below the minimum threshold recommended by the manufacturer or if the power demand exceeds the available power from the battery inverter and PV inverters, the main diesel generator shall be automatically switched on. The system shall then maximise the PV energy use while ensuring a minimum genset load of 30%. Once the battery is charged from the diesel generator, the diesel generator shall switch off, and the loads shall be powered by the PV inverters and battery inverters.
5. The PV inverters shall be controlled (via frequency shifting, digital control, or similar) to prevent overcharging the battery and/or feeding power to the diesel generators.
6. The battery inverters shall act as charge controllers in the presence of an external AC source. They shall be able to work in dual mode (grid following + grid forming).
7. The bidder must submit a design with a high degree of automated control and redundancy. There must be a fallback with manual control and black-start capability of the system.
8. The system shall feature a manual bypass mode to bypass the renewable energy system itself and connect to the existing non-integrated back-up generators.

If required for compliance with these specifications, the Contractor is responsible for upgrading the existing transfer switches. The contractor must ensure safe local storage of the required most common spare parts, tools, and diesel to meet the requirements of the system operations.

1. Quality assurance

The Contractor shall have a Quality Assurance system at their disposal complying with ISO 9001 or higher standards. The Contractor shall ensure that all equipment proposed has already been proven to work reliably.

All systems and equipment must use a previously demonstrated technology deployed on a commercial scale. All equipment shall be new and in perfect condition, and it shall be installed according to the manufacturers’ specifications, complying with the manufacturer’s warranties.

All containers and packaging of separately shipped components shall be suitable for land or sea transport and offer suitable protection of the equipment inside against damage from weather, vibration, or shock from transportation.

1. Reference standards

The engineering, construction, and commissioning shall follow all relevant international and national regulations and standards. Particular attention shall be paid to the following standards or their national adaptations:

* Wiring and electrical regulations and codes adopted by South Africa
* **Decree No 6997 dated 29 /9/2020**, which establishes a compliance specifications sheet for PV panels, Solar collectors, batteries, and power converters
* **Circular No. 006/2021 issued on 19/10/2021** issued by the Lebanese Industrial Center, which sets the obligatory national measurement requirements regarding Solar energy and photovoltaic systems
* UNHCR Health and Safety Requirements for Contractors
* IEC 60364, specifically IEC 60364-7-712: Low voltage electrical installations - Part 7-712: Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems
* IEC TS 62257: Recommendations for renewable energy and hybrid systems for rural electrification
* IEC 62548: Photovoltaic (PV) arrays - Design requirements
* IEC 62305 - Protection against lightning
* IEC 62619 - Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries for use in industrial applications
* EN 45554 - General methods for the assessment of the ability to repair, reuse and upgrade energy-related products.

The latest editions of the standards shall apply.

1. Power quality

This chapter describes the minimum requirements of the power quality the bidder and service provider must guarantee. The supply terminals at the main distribution board are the point of reference for the power quality.

* 1. Voltage

Standard of reference is IEC 60038 “IEC standard voltages” with nominal value of voltage and frequency defined under “key parameters”.

Rated voltage at the supply terminals must be the nominal voltage. The tolerance specified in Table 3 from the rated value is acceptable under nominal load conditions.

Voltage lower than the one specified in Table 3 in any phase for a period longer than the time specified in Table 3 is considered as unavailability of the system.

Table 3. Voltage requirements

|  |  |
| --- | --- |
| Parameter | Requirement |
| Voltage tolerance at the supply terminals (deviation from nominal voltage) under nominal load conditions. | +-5% |
| Minimum voltage, under which is considered as unavailability of the system. | -10% of the nominal value at the supply terminals in any phase |
| Maximum time for undervoltage, above which is considered as unavailability of the system. | 1 second |

* 1. Frequency

Under nominal load, the frequency must remain within the range specified in Table 4. Deviation for more than the time specified in Table 4 outside the range is considered as unavailability of the system.

Table 4. Frequency requirements

|  |  |
| --- | --- |
| Parameter | Requirement |
| Frequency tolerance range under nominal load | +-2 Hz of the nominal frequency |
| Maximum time of frequency allowed to be out of tolerance, above which is considered as unavailability of the system. | 10 seconds |

1. Equipment component specification

The bidder must follow the minimum requirements for the system components offered and installed. Changes from the specification offered to the specification implemented require prior written approval by UNHCR. UNCHR will not accept a specification implemented with a lower performance and/or quality than the specification offered in the bid.

* 1. Switchgear

All electrical boards shall comply with IEC 61439 or equivalent.

Protection by extra-low voltage systems (SELV and PELV as defined by the IEC) shall be Class III or better. For all other systems, Class II protection or better is required.

Electrical boards installed outdoors shall have minimum IP protection of IP65 as per IEC 60529 and be UV resistant.

Switchgear in the DC side shall be rated for DC use and shall interrupt all poles. Positive and negative terminals shall be marked with their corresponding signs.

A circuit breaker shall protect each PV inverter AC output.

Electric boards that combine the AC output of the PV inverters can be installed either outdoors with minimum IP protection of IP65 or indoors with minimum IP protection of IP44. They shall have insulation Class II or equivalent and shall be flame-retardant.

The main distribution board that combines the diesel generator, the battery inverter, and the PV inverters shall be located indoors, shall have insulation Class II or equivalent and IP protection of at least IP44, and shall be flame retardant. All AC inputs (diesel generator, battery inverters, PV inverters) and output feeders shall be protected via circuit breakers. The board shall include an SPD Type I+II as per IEC 61643-12.

All switchgear shall be installed in a shaded place at all times of the day.

* 1. PV modules

Each module must be tested in the factory at STC conditions with individual serial numbers on the nameplate and factory test report. The factory test report must be attached to the commissioning report. Power tolerance must be positive only and within 0 … +5W.

The PV module manufacturer must have valid and internationally recognized ISO certification for the factory the PV modules are produced. Relevant minimum standards are ISO 9001 and ISO 14001. Certificates must be attached to the bid.

The modules must be certified by an internationally reputable organization according to the minimum scope of IEC 61215, IEC TS 62804, IEC 61730, IEC 61701 and IEC 62716 family of standards. Certificates must be valid for the time of production of the modules.

Modules must be of “Tier 1” quality.

Modules, connection boxes, and connectors must have an IP67 rating following IEC 60529. Third-party test reports must be provided stating compliance for the type of module offered.

Modules must have factory installed connecting cables of 4 mm² cross-section with pre-installed connectors. All connectors used must be fully compatible and from the same manufacturer.

Table 5. PV modules requirements

|  |  |
| --- | --- |
| Parameter | Requirement |
| Type | Crystalline silicon |
| Min. number of bypass diodes per module | >= 3 |
| Design wind loads | >= 2400 Pa |
| Linear decrease of the power output after 25 years | >= 80% of the nominal value |
| Warranty | Minimum 10 years product warranty |
| System voltage | Minimum 1000 V |
| Efficiency under STC conditions | >= 20% |

* 1. PV support structure

The PV support structure must be made of aluminium. Screws must be stainless steel only. Metals of different types shall be separated using suitable materials in order to avoid galvanic corrosion.

The design shall include relevant structural calculations following international and national standards considering the local soil conditions.

The support structure shall have a minimum product warranty of 10 years.

Table 6: Site-specific requirements for the PV support structure

|  |  |
| --- | --- |
| Parameter | Value (roof-mounted structure) |
| Orientation | As per roof or North oriented |
| Tilt | 27-29º |
| Wind speed for design | Max: 30 m/s |

Specific requirements for roof-mounted structures:

* A minimum distance of 50 cm shall be left from the PV module to the roof’s edge.
* Structure: anchored slab rails, vertical and horizontal secondary rails, elevation poles etc.
* PV Module Fixation: middle clamps and end clamps
* Dimensions: per array size
* Material: aluminium
* Orientation: landscape or portrait
* Corrosion-resistant
* Available with grounding pins
* Manufacturer’s guarantee: ≥ 15 years for the structural integrity and corrosion; and ≥ 5 years for the leakages.
  1. PV inverter

The PV inverter must have multiple MPPT devices to optimise the output from possible shading in the morning and evening hours caused by the fencing, buildings, surrounding trees, vegetation, etc. A shadow analysis highlighting the different string connections must be provided by the Bidders to confirm that this aspect has been considered.

Table 7. Requirement

|  |  |
| --- | --- |
| Parameter | Requirement |
| Number of PV strings per MPPT | <=3 |

PV strings with different orientations and/or tilt cannot be connected to the same MPPT.

The following standards are required with the certificates of compliance:

* IEC 62109-1: Safety of power converters for use in photovoltaic power systems - Part 1: General requirements
* IEC 62109-2: Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters
* IEC 6100-6-4: Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
* IEC 6100-6-3: Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for equipment in residential environments
* IEC 62116:2014 Utility-interconnected photovoltaic inverters-Test procedure of islanding prevention measures

The PV inverters used shall be from the same manufacturer and model.

Table 8. Requirements for PV inverters

|  |  |
| --- | --- |
| Parameter | Requirement |
| Type | three-phase string inverters |
| Max. power per inverter | 25 kW |
| Min. number of inverters | 8 |
| Warranty | Minimum 5-year product warranty |
| Euro-efficiency | >=95% |
| Power factor | shall be adjustable at least between 0.85 and 1, leading and lagging |
| IP protection | at least IP20 for indoor and IP65 for outdoor installations |
| Surge Protection | a Type II Surge Protection Device (SPD) shall be included on the DC side, as per EN 50539-11. This can be internal or external to the PV inverter. |
| The ratio between the kWp of all PV modules connected to an inverter and the nominal AC output power of the inverter | 1.15 |
| Power limiting | The inverters shall provide means of controlling or limiting its power output if required by the power management system, either by measuring the line frequency or by an equivalent technique. |
| Location | The PV inverters can be installed outdoors, right on the rooftop next to the PV field, or indoors, inside a technical room |

* 1. Battery inverters

The battery inverters shall comply with the latest versions of the following standards:

* IEC 62109-1: Safety of power converters for use in photovoltaic power systems - Part 1: General requirements
* IEC 62109-2: Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters

The battery inverters used shall be from the same manufacturer and model.

Table 9. Battery inverter requirements

|  |  |
| --- | --- |
| Parameter | Requirement |
| Type | single-phase or three-phase, as long as the ensemble of all the battery inverters forms a three-phase AC grid with a nominal frequency and voltage as specified in Section 2, and the same nominal power is assigned to each phase. |
| Battery compatibility | battery inverters shall be compatible with the Li-ion battery and its BMS, and their compatibility shall be certified by both the BMS and the inverter manufacturer. The inverter shall control the battery according to the battery manufacturer specifications. |
| Warranty | Minimum 5-year product warranty |
| Efficiency | >=95 %. The manufacturer shall specify the efficiency at several power points, including at least 5%, 20%, 50%, and 100% of the nominal continuous power output at 25˚C. |
| Max. Total Harmonic Distortion (THD) | <= 4%. |
| Battery protection | the battery inverters shall provide means of protecting the battery. |
| Location | the battery inverters shall be installed indoors |
| IP protection | at least IP20 as per IEC 60529 |

* 1. Wiring standard

Wiring must follow the IEC 60364 family of standards or its national adaptation, especially IEC 60364-5-52.

All conductors must be copper and be able to connect to all equipment according to their characteristics.

All cables exposed to outdoor conditions shall be UV resistant or be protected from UV light by appropriate protection or be installed in a UV-resistant conduit or trunking.

All cables shall be flame retardant, as defined in IEC 60332-1-2 or equivalent.

Only PV connectors from the same manufacturer and model can be interconnected. PV connectors shall comply with IEC 62852 or equivalent. Under no circumstances is it allowed to cut the PV module cables and install other than the original connectors.

DC cables must follow “PV1-F” standard, and DC cables must be kept as short as possible, be single-core, and have a nominal temperature of 90oC. Cables from the PV strings to the string combiner box must be permanently protected against damage by attaching to the support structure using UV-resistant cable ties at no more than 0.5 m distance or being installed in UV-protected cable pipes. The loop area of the positive and negative cables of each PV string must be as small as possible to minimise induction loops. Cables from the string combiner box to the PV inverter must be as short as possible.

AC cables shall have XLPE insulation, a nominal voltage of 0.6/1 kV, and a nominal temperature of 90°C.

The cabling installation must be corrosion-resistant and physically strong to withstand impact and strain. All cabling should be carefully installed and secured with suitable fixings arranged at regular intervals. Cables shall not bear any mechanical load on their terminations. If plastic ties are used, they shall be UV resistant.

The cable installation shall minimise the area of induction loops.

All buried cables shall be contained within a PVC conduit of suitable diameter and buried at least 0.3m depth for protection against wildlife and physical damage. DC cables of positive polarity shall run in separate, underground conduits than those of negative polarity. PVC conduits or closed electrical trays shall protect any cable within reach of wildlife.

All load cable terminations shall be tagged and labelled correctly, specifying at least the load power and electrical voltage (DC or AC). Tags and labels shall be easily recognisable. Positive and negative terminals for DC power cables and busbars shall be clearly labelled with red colour for positive and black colour for negative.

The cables cross-sections shall ensure the following maximum voltage drops:

Table 10. Maximum voltage drop requirements

|  |  |
| --- | --- |
| Parameter | Requirement |
| From PV modules to the main distribution board | 5% |
| From the battery to the main distribution board | 3% |

The calculations shall consider the output of the PV modules at STC conditions and the maximum continuous power output of the battery inverter and PV inverter. The copper resistivity at a temperature of 90 °C must be taken into account. The bidder must justify these maximum voltage drops in their technical offer.

The supplier is responsible for all trenching works required to interconnect all components.

* 1. Earthing, Equipotential Bonding, and Lightning Protection
     1. System type

The earthing system shall comply with IEC 60364-7-712. Conductor colours to follow IEC with brown, black, grey, blue, green/yellow.

All the system shall be interconnected by a single equipotential bonding and connected to the existing earthing installation.

The earthing conductors shall always be as close as possible to the active conductors to minimise the induced loop areas.

* + 1. Earthing

The earthing must be a combination of a band strip with no more than 20 m mesh size and earth rods following all parts of IEC 60364 and country’s wiring regulations.

All the system (PV structure, PV module frames, metal cable trays, inverters, switchboard, etc) shall be interconnected by an equipotential bonding and connected to the existing earthing installation. The supplier shall ensure that the resistance of the whole earthing installation does not exceed the value specified in the table below, improving the existing earthing installation if necessary.

Table 11. Earthing resistance requirements

|  |  |
| --- | --- |
| Parameter | Requirement |
| Max. resistance of the whole earthing installation | 10 Ohm |

The earthing conductor of the ground-mounted PV arrays (if any) shall be buried if it is longer than 50 m. In such a case, the conductor shall be made of bare copper with a minimum cross-section of 25 mm2 to minimise corrosion.

The earthing conductors shall always be as close as possible to the active conductors to minimise the induced loop areas.

* + 1. External lightning protection

An external lightning protection system must protect the complete system following the IEC 62305 and IEC 60364-7-712 family of standards. Mesh size must be no more than preferably 15 m x 15 m or maximum 20 m x 20 m and 45 m radius for the sphere to validate the design. The external lightning protection must have its own earth termination system fully integrated into the earthing and equipotential bonding of the remaining system.

* + 1. Surge protection

The DC and AC sections for the system must be fully protected against overvoltage with type I, type II, type III, and type I+II surge protective devices following IEC standards to ensure high availability of the system.

At a minimum, the following SPDs shall be installed:

* Type II DC SPD at each MPPT input of the PV inverter, to be installed as close as possible to the inverter. It can be incorporated within the inverter itself.
* Type II AC SPD at the AC side of the PV inverter, to be installed next to the circuit breaker, as close as possible to the inverter.
* Type II AC SPD at the AC side of the battery inverter, to be installed as close as possible to the inverter. Only required if the distance between the battery inverter and the main distribution board is higher than 10 m.
* Type I+II AC SPD at the main distribution board (which combines the output of the PV inverters, battery inverters, and diesel generator(s)).
  1. Weather Station

The Contractor must install a meteorological station to measure the temperature-corrected global horizontal irradiation, PV module temperature, and ambient temperature and log the data in 10 minute or 15-minute intervals.

The meteo station shall follow the ISO 9060:2018 standard.

The recorded information should be easily accessible both on-site (via screens or laptop connection) and remotely (online).

* 1. Battery Storage System

Table 12. Battery Storage System requirements

| Parameter | Requirement |
| --- | --- |
| Technology | Lithium-ion |
| Uniformity | All batteries shall be from the same manufacturer and model. |
| Standards to comply with | Batteries shall comply with relevant standards, including IEC 61427-1 and IEC 61427-2 and other applicable IEC standards, UL, and transport standards such as UN38.3 |
| operating temperature range | At least between 0°C and 45°C |
| Number of cycles | At a Depth of Discharge (DoD) of 85%, the number of cycles shall be equal or higher than 3000 at a temperature of 25°C and a charging/discharging rate of C3 |
| BMS minimum functionalities | * Control and balance of each individual battery cell * Management of charge / discharge profile according to the type of battery * Protections: over-charging, under-charging, over-temperature, over-load, and a potential explosion * Setting of critical threshold levels * Alarm management system |
| The integration of the BMS into the renewable energy system’s control and monitoring system shall include at least the following parameters | * SOC * Battery voltage * Battery temperatures * Over or Under voltage (min, max, nominal) * Over or Under temperature (min, max, nominal) |
| DC overcurrent protection device | If applicable, each battery polarity shall be protected by an overcurrent protection device (DC circuit breaker or DC fuse) for paralleling the batteries on the common Main DC bus. |
| Product warranty | At least 5 years |
| Location | The batteries shall be installed inside the technical room power house, following the manufacturer’s installation requirements. |

The manufacturer of the system must have a minimum of 2 years of experience with the technology of the storage system offered and must be 10 years in business with similar storage solutions.

Before connecting the batteries, it shall be ensured that no overheating or uncontrolled ambient temperature is present. The batteries shall be isolated before working on them, ensuring that no current is flowing through the circuit. The installation shall prevent the risk of a potential short-circuit between the opposite polarities caused by a metallic object.

* 1. Control and monitoring system

The control devices shall allow the renewable energy system to operate correctly according to the Design Requirements described in Section 3.2, by managing the operation of the main components (PV inverters, battery inverters, battery, diesel generator, etc). They allow inter-communication between the various components to ensure optimal operation. They are used to measure and send information to monitoring devices.

Since the generator(s) will be from the existing ones, the supplier needs to consider a registering and communication device to be installed in the generator(s) in order to make possible the monitoring capacity as required below. As well, to make possible the generator(s) automatic switch-on and off based in Design Requirements in Section 3.2.

Each power system shall integrate a data acquisition and monitoring system performing the following functions:

Table 13. Minimum Technical requirements of the data acquisition and monitoring system

| Parameter | Requirement |
| --- | --- |
| Data acquisition | Measure all the operating parameters of the system with a minimum interval time of 5 minutes. The reporting rate shall be 15 min. |
| Data storage | Minimum capacity of 180 days. |
| Data processing | Data processing and editing for the maintenance staff. |
| Reporting | Generation and submission of daily operational reports to the system operators |
| Notification | Notification of any recorded system alarm to system operators |
| Interface | The recorded operational information should be easily accessible both on-site (via screens or laptop connection) and remotely (online). |
| Internet connection | All necessary materials for the connection to the internet to allow for remote monitoring shall be included. |
| Internet bursting | Data collected through the monitoring platform should be stored securely in a central database. An Application Programming Interface (API) should be built which supports retrieval of this data by other servers/platforms. |
| External communication | Configurable FTP push or HTTP put communication method to upload energy and alarming data on an external server. |

All necessary components for the measurement, recording, and analysis of at least the following data shall be included:

Table 14. Minimum requirements for data measurement, recording and analysis

| Parameter | Requirement |
| --- | --- |
| Battery inverters | Charge / discharge power, battery voltage, battery SOC and battery temperature. The battery voltage measurement shall be taken as close as possible to the battery to have an error measurement less than 0.5%. |
| PV inverters | Power, voltage, and current, both at the DC and AC sides. Maximum power during the day. |
| Diesel generators | Status, power, cumulated energy, voltage, current, frequency, cumulated working hours and fuel consumption. |
| Grid supply | Status, power, energy, voltage, current, frequency. |
| Irradiation and temperature | Global Horizontal Irradiance, ambient temperature, temperature in the battery room, and PV module's temperature. Appropriate sensors such as pyranometers and temperature probes shall be used. |
| Alarms | Operational alarms and faults from all different components. |
| Performance ratio | Performance ratio of the PV generator |

Information shall be provided in the form of tables, synoptics, and graphs by the monitoring platform. All information shall be retrievable in .csv format or equivalent (table).

In case of a failure of the remote monitoring platform or the data connection, a simple O&M process shall be ensured by showing at least the following parameters through simple on-site screens and displays in the Technical Room:

* Battery voltage or SOC.
* Total daily energy delivered by the batteries.
* Instantaneous power imported from the grid/diesel generator(s) (if applicable)
* Total daily energy imported from the grid/diesel generator(s) (if applicable)
* Maximum daily power delivered by the PV generator
* Total daily energy delivered by the PV generator

Wired communication bus between all components shall be included. Wireless communication networks are not allowed. Communication cables shall be properly protected against interferences.

* 1. Metering System

The meters shown in Annex C shall be provided and installed.

All meters must be 0.5 % accuracy or better. Current transformers must be also 0.5 % accuracy or better. Energy meters for the generation are supply meters (1 way); for the energy storage, the meter must have separate supply and purchase (2 way) metering. Accurate clock must be provided from GPS or comparable time reference.

Meters must come with valid calibration certificate.

All metering shall be electronic.

1. Civil works and security

The Contractor shall follow the UNHCR “Health and Safety Requirements for Contractors”.

The Contractor is responsible for all trenching works required to interconnect all components.

* 1. Technical room

The technical room will be placed on an isolated space agreed with UNHCR Sub-office Pretoria. Should contain at least the batteries, the battery inverters, and any necessary switchboards.

The room should be the most insulated the possible, racked arranged and weather-proof ensured. The supplier should conduct any required adaptations on the designated technical room.

The bidder shall provide in the offer a drawing proposing the basic plan of the technical room.

Site specific requirements:

* The technical room shall be designed and furnished so as to ensure that the equipment and components housed within are maintained within the ambient parameters (temperature, humidity, dust, etc) of the manufacturer(s).
* The components insider the technical room must be firmly secured (e.g. using metal rails to place the equipment on the walls).
* The equipment inside the technical room must be accessible through a door with a reliable theft proof locking system. The internal arrangement must allow ease of commissioning, operation, maintenance and decommissioning.
* The technical room shall include an air conditioning system that shall keep the indoor temperature at a maximum of 25 0C, considering the ambient temperatures stated in Section 2. A redundant air conditioning system shall be installed, with low consumption and low starting current. The temperature inside the battery room shall be monitored to detect an abnormal temperature rise. An alarm system shall be included to warn the operator if the room temperature goes above the specified range.
* The technical room shall be permanently supplied with electricity by the renewable energy system and equipped with low-consumption LED lamps.
* Adequate signage shall prevent unauthorised personnel from entering the technical rooms and warn against any electrical or thermal risk.
* The technical room shall include a fire prevention system and a fire suppression system, both connected to an external audible and visual alarm that shall be triggered in case of immediate danger, including temperature and smoke sensors. The prevention system shall trigger the alarm in the event of early warnings, giving time to shut the system down before an event ensues. The fire suppression system shall include gaseous fire suppression agents, according to local regulations and battery manufacturer specifications.

1. Commissioning

After completion of the installation works, the commissioning phase will take place.

The supplier shall be responsible for preparing and submitting the commissioning procedures and their related checklists for UNHCR approval.

The commissioning phase shall include all the necessary tests to demonstrate that the system operates in accordance with the required technical and performance specifications, manufacturers' specifications, and quality standards. The supplier shall fix any malfunction identified during the tests and repeat the tests until they are passed satisfactorily.

The main aspects to be tested are:

* Inspection of all components and structural elements, including the roof retrofit, if needed.
* PV generator – testing of performance and compliance with standards. The commissioning shall follow IEC 62446. Detailed report following all requirements of IEC 62446-1 must be submitted.
* PV inverters – testing of all functionalities in all modes and power configuration settings.
* Battery and battery inverters – testing of all functionalities in all modes and power configuration settings.
* Functional tests of the whole renewable energy system, considering the interconnection between PV inverter, battery inverters, diesel generators, and grid.
* Safety tests and electrical measurement protocol for compliance according to the requirements in section 7 for the whole technical installation.

After successful commissioning and testing, a 7-day trial period will start. The supplier must demonstrate 168 hours of uninterrupted supply. In case of interruptions of the electric energy supply, the 168-hour period restarts. Commissioning is completed after 168 hours of uninterrupted electric power supply. After a successful 7-day trial period or 168 hours of uninterrupted supply, an acceptance certificate will be issued to the Contractor by UNHCR.

A representative appointed by UNHCR will supervise the complete testing and commissioning. The Contractor has to ensure the representative has access to all relevant documents and works.

1. Spare parts and O&M materials

The following spare parts shall be provided.

Table 15: Spare parts

|  |  |
| --- | --- |
| Parameter | Requirement |
| PV modules | at least 5% of the total number of modules. |
| PV connectors | at least 5% of the total number of connectors. |
| PV inverters | at least one or 10% of the total number of inverters. |
| Cables and conductors | at least 5 % of each different cable installed per site. |

The bidder is free to propose all recommended stock spare parts in the offer’s technical description to ensure 5 years of operation.

The supplier has an obligation to notify UNHCR six months prior to product obsolescence, product production halt, or end of service.

When replacing a part, the supplier is obligated to safely manage the end-of-life of the part that is swapped out. This has to be done to maximise recycling and in accordance with all applicable laws and regulations. The supplier is required to both arrange logistics and take financial responsibility for all end-of-life operations. This requirement applies for the duration of the O&M contract.

1. O&M
   1. General description

After the renewable energy power system testing and commissioning, the supplier will enter an O&M contract. During the O&M contract, the supplier will have to carry out a series of preventive and corrective maintenance tasks and activities as indicated in this section, along with remote monitoring. Additionally, the supplier will be responsible for ensuring the minimum service standards established in this section.

The O&M contract obligations are for the proposed photovoltaic renewable energy system but do not encompass the operational costs (fuel, oil, etc) and maintenance obligations and costs of the existing generator(s) to be incorporated, however, the supplier is responsible to ensure that the automatic control starts and synchronises the generator(s) when required.

Three major types of failures are categorised depending on the impact they will cause to UNHCR power infrastructure supply:

Table 16. Failure types

|  |  |
| --- | --- |
| Type A – Major failure | A.1) Power system blackout.  A.2) Failures that pose a safety risk at the battery storage system, such as a failure of the air-conditioning unit, of the fire prevention and protection systems, of the BMS, or any other component of the storage system.  A.3) Any failure that puts UNHCR personnel’s health and safety at risk.  A.4) Any other failures/malfunctions not mentioned here and considered to be of high priority by UNHCR. |
| Type B – Medium failure | B.1) Failures that lead to a decrease in the PV power system energy output of more than 20%.  B.2) Any other failures/malfunctions considered to be of medium priority by UNHCR. |
| Type C – Minor failure | C.1) Any other minor failures.  C.2) Any other failures/malfunctions considered to be of minor priority by UNHCR. |

For corrective maintenance, if any part of the generation power system fails or malfunctions for any reason within the responsibility of the service provider, two levels of intervention are defined:

**Level 1 - remote assistance and troubleshooting through local UNHCR staff.** The O&M service provider will establish communication with UNHCR staff as soon as a failure or energy output problem on the PV renewable energy system is identified. Through IT communications, the O&M service provider will work together with the UNHCR staff in understanding, troubleshooting, and restoring the correct operation of the power system. The service provider will have a maximum time to resolve the issue that is defined in Table 17. Restoration times . If, after the prescribed time, this first level of corrective remote O&M has not resulted in the issue being solved, the O&M service provider will be required to trigger level 2.

**Level 2 – on-site assistance and troubleshooting through the service provider’s own staff.** The O&M service provider will be required to deploy to site the necessary skilled labour to further investigate the issue, fix it and restore the service. The service provider will have a maximum time to resolve the issue that is defined in Table 17.

The time responses for three failure types shall be less than the values indicated in the table below.

Table 17. Restoration[[5]](#footnote-6) times per O&M level and failure type

|  |  |  |
| --- | --- | --- |
|  | **Level 1**  **Restoration time** | **Level 2**  **Restoration time** |
| Type A | 24 hours | 24 hours |
| Type B | 2 days | 4 days |
| Type C | 4 days | 5 days |

The following flowchart summarises the process and levels of corrective O&M:

Diagram

Description automatically generated

Figure 4: Processes and restoration times for Type A failure

If the O&M contract is not renewed after the O&M contract duration, UNHCR plans to take over the operation of this infrastructure; therefore, handover forms and all relevant documentation will have to be submitted and agreed between the Contractor and UNHCR.

* 1. Allowed interruptions

As allowed interruption is understood when the renewable energy system is not performing, therefore the back -up generators (the ones that are not integrated into the renewable energy system) will have to work since facility total blackout is not allowed. The manual bypass switch will be used to allow existing non-integrated generators to operate in an emergency back-up mode.

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| **Unscheduled interruptions in the PV renewable energy system** | |
| Maximum backup generator start-ups[[6]](#footnote-7) | 2 per month |
| Maximum back-up generator run-time[[7]](#footnote-8) | 2.2% |
| **Scheduled interruptions in the PV renewable energy system** | |
| Scheduled maintenance works | Maximum twice a year for a maximum of 4 hours each  Time and date to be agreed at least 14-days in advanced |

* 1. Liabilities and responsibilities

The O&M service provider will be responsible and liable for the following within the O&M contract period:

* Perform all the O&M tasks as specified in this section
* Do at least two site visits per year
* Replace any equipment that breaks down or malfunctions within the warranty period at its own cost.
* Replace any equipment that breaks down as a direct result of the improper/inadequate operation by the supplier during the O&M period, even if that equipment is out of the warranty period.
* Provide at its own cost collection, reverse logistics, storage, and recycling of the non-working parts encountered during the provision of O&M services, in accordance to all applicable laws and regulations.
* Provide O&M reports to UNHCR as specified in this section
* Handover the O&M operations to the appointed UNHCR staff after the O&M period, including end-of-life management procedures.
* Full compliance with the health and safety requirements as per the UNHCR Health and Safety Requirements for Contractors.
* The Contractor has an obligation to notify UNHCR Employer when upgradable software and hardware will be available.

The O&M Contractor will not be responsible and liable to fix or restore the service (unless agreed with UNHCR on a separate agreement) in the following cases:

* UNHCR existing generators, including the one(s) that will be connected to the renewable energy system.
* UNHCR is not capable of delivering fuel to the site.
* UNHCR staff or third parties damage or destroy part of the renewable energy system generation assets.
* UNHCR staff or a third party damages or destroys part of the distribution network assets that affects the correct energy delivery of the power system.
  1. O&M tasks

|  |  |  |
| --- | --- | --- |
| **Preventive Maintenance Service Description** | | |
| **PV Arrays** | | |
| **Item** | **Activity** | **Frequency** |
| 1 | PV module cleaning according to manufacturer recommendations | Every 3 months[[8]](#footnote-9) |
| 2 | PV module visual inspection and infrared inspection. | Annual |
| 3 | General cleaning and vegetation removal. Determine if any new objects, such as vegetation growth, are causing shading of the array and move them if possible; remove any debris from behind collectors and from gutters. | Annual |
| 4 | Measure the I-V curve characteristics of each PV strings (Voc, Isc, Vmp, Imp, and Pmp). | Annual |
| 5 | Calibrate weather senSOrs and meters | As per manufacturer |
| 6 | Test earthing resistance. | Annual |
| 7 | Inspect DC cabling and MC4 connectors for signs of defects. Replace damaged MC4 connectors. | Annual |
| 8 | Inspect the PV combiner boxes (if any) - fuse check and replacement, electrical connection tightness and retorquing, water intrusion, corrosion damage, intrusion by pests. | Annual |
| 9 | Check all hardware for signs of corrosion and remove rust and re-paint if necessary. | Annual |
| 10 | Inspect ballasted mounting system (if any) for abnormal movement | Annual |
| 11 | Torque inspection of PV structure and PV modules. | Every 2 years |
| 12 | In roof-mounted generators, inspect the roof penetrations to ensure the proper waterproofness. | Annual |
| **Inverters** | | |
| **Item** | **Activity** | **Frequency** |
| 1 | Perform a remote performance test on the PV generator, considering the measurements of the PV inverter output power, irradiance, as well as ambient and PV module temperature. | Monthly |
| 2 | Remotely collect and inspect inverter logs (alarms and faults logs) | Monthly |
| 3 | Remotely check inverter’s well behaviour with safe fallback setting | Monthly |
| 4 | Inspect housing and/or shelter for physical damage. | Annual |
| 5 | Clean dust from heat rejection fins. | Annual |
| 6 | Turn off and on logging and communications to ensure they are communicating and ensure battery backups are working. | Annual |
| 7 | Check output AC cable connection tightness. | Annual |
| 8 | Clean and replace air filters. | As needed |
| 9 | Install any recent software upgrades. | As upgrades become available. |
| 10 | Replace surge protection devices. | As per manufacturer |
| **Li-ion batteries and BMS** | | |
| **Item** | **Activity** | **Frequency** |
| 1 | This might include charging up to a certain SOC level on a monthly basis. | As per manufacturer |
| 2 | Visual inspection of the batteries to check for defects, cracks, leaks, the integrity of the enclosure, and support structure. | Every 6 months |
| 3 | Inspect electrical protections and cables. | Every 6 months |
| 4 | Visual inspection of the communication cables. | Every 6 months |
| 5 | Check all terminals for corrosion and proper torque. | Every 6 months |
| 6 | Inspect Air Conditioning system. Replace air filters as needed. | Every 6 months |
| 7 | Inspect Fire Detection and Suppression system. | Every 6 months |
| 8 | Check the registered minimum voltage of the battery modules. | Every 6 months |
| 9 | Check the battery SOH and assess its lifetime. | Every 6 months |
| 10 | Check the battery number of cycles completed on the BMS. | Every 6 months |
| 11 | Check the electrical resistance of each battery module. | Every 6 months |
| 12 | Inspection of the communication system - all battery modules shall be communicating with the BMS. | Every 6 months |
| 13 | Collect data for events and alarms, analyse them, and correct if necessary. | Every 6 months |
| 14 | Thermographic measurement of the battery for potential hotspot detection. | Every 6 months |
| 15 | Check with UNHCR if any new loads have been added and report. This will affect the system’s autonomy. | Every 6 months |
| **Wiring Systems** | | |
| **Item** | **Activity** | **Frequency** |
| 1 | Inspect all switchboards: tightness of the electrical connections, corrosion, intrusion of water or insects, sealing. | Annual |
| 2 | Check proper position of DC disconnect switches and fuses and replace failed fuses. | Annual |
| 3 | Check proper position of AC disconnect switches and breakers. | Annual |
| 4 | Inspect cabling for signs of cracks, defects, pulling out of connections, overheating, short or open circuits, and ground faults. | Annual |
| 5 | Test the disconnect switches to ensure they are not jammed. | Annual |
| 6 | Test system grounding. | Annual |
| 7 | Insulation resistance RiSO (resistance in ohms of wires, cables to guard against electric shocks and avoid equipment damage from accidental discharges). | Annual |
| 8 | Check the SPDs, replace when needed. | Every 6 months or after a lightning storm event. |
| 9 | Thermographic measurements on the electrical connections. | Every 6 months |
| 10 | Check grounding hardware | Annual |
| **Monitoring System, and Data logging** | | |
| **Item** | **Activity** | **Frequency** |
| 1 | Test monitoring system hardware and its communication. | Annual |
| 2 | Ensure all documentation is in place. | Every 6 months |
| 3 | Document the preventive maintenance that has been carried out: observations, work performed, replacements, meter readings, and system testing results. Include non-conformance reports to identify potential short-term and long-term power production issues | Every 6 months |
| 4 | Update as-built drawings if necessary | As needed |

Apart from these O&M tasks, the Contractor shall conduct any other necessary task to comply with the warranty of the manufacturers.

* 1. O&M reporting

The Contractor shall perform remote monitoring during the O&M period. A quarterly O&M report shall be prepared, including at least:

* Average, maximum, and minimum voltage at the supply terminals recorded over the last 3 months.
* Average, maximum, and minimum frequency at the supply terminals recorded over the last 3 months.
* Monthly energy demand.
* Monthly energy provided by the PV generator, the diesel generators, and the utility grid (if any).
* Monthly fuel consumption
* Temperature-corrected Performance Ratio of the PV generator.
* Number of grid outages and their duration.
* Unscheduled down-times and their duration.
* List of faults and alarms.
* List of O&M tasks undertaken.

Together with the quarterly O&M report, hourly values of the following parameters shall be provided in a separate file (Excel, CSV, or similar):

* Power of the loads, the PV inverters, the battery inverters, the diesel generators (if any), and the grid (if any) in kW.
* SOC (in %), voltage (in V), and temperature (in oC) of the battery.
* Global Horizontal Irradiance as measured by a pyranometer (in W/m2).

Each visit shall end with a Monitoring and O&M Report, which summarises all the measurements taken to demonstrate that the system is working up to the specifications laid out in this document. The report shall also include all the O&M tasks undertaken.

During each of these visits, the supplier shall provide a 6-hour training to the UNHCR personnel. The trainings shall revisit the O&M requirements of the system. Any necessary documentation shall be provided along the trainings.

Apart from these two visits, the Contractor shall conduct any necessary site visits for corrective O&M during the defects liability period in case of system failure.

1. Training

Bidders shall describe a training plan for UNHCR personnel to be conducted upon completion of construction works. The training shall last a total of 32h and shall be offered to 2 staff to be appointed by UNHCR. Bidders are also encouraged to involve the appointed UNHCR staff during the project installation, in particular during the testing and commissioning.

The objective of the training will be to (i) provide the appointed UNHCR staff with a basic understanding of the Solar PV hybrid power system and (ii) empower the appointed UNHCR staff with the necessary information SO that they can read the power system signals (through the PV and battery inverters displays) and identify what part of the power system is malfunctioning or failing at any time, (iii) act as focal points between UNHCR and the O&M Contractor during Level 1 of the corrective O&M as described above, and (iv) empower the appointed staff to ensure the proper use of the system and end-of-use of its specific parts, in order to enable the continuity of operation and longevity of the system and minimise its negative environmental impacts.

Training shall cover design fundamentals of the hybrid system installed, technical characteristics including functionalities, operations & maintenance, safety, controlling, monitoring, proper use and care (cleaning), end of life management, and reporting.

The Contractor shall provide an O&M plan following IEC 62446-2 for UNHCR approval, including preventing and corrective maintenance, tasks, responsible people, and a list of materials and tools needed for each task.

Training is to be provided at the site.

All associated costs shall be borne by the Contractor, including at least transport to site, accommodation, meals, and training materials.

1. Health and Safety Requirements

The Contractor shall follow all applicable health and safety codes as per national regulations and the UNHCR Health and Safety Requirements for Contractors.

The Contractor shall at all times take all reasonable precautions to maintain the health and safety of the Contractor’s personnel, and that suitable arrangements are made for all necessary welfare and hygiene requirements.

The Contractor shall appoint an accident prevention officer at the Site, responsible for maintaining safety and protection against accidents. This person shall be qualified for this responsibility and shall have the authority to issue instructions and take protective measures to prevent accidents. Throughout the performance of the contract, the Contractor shall provide whatever is required by this person to exercise this responsibility and authority.

The Contractor shall notify the details of any accident as soon as practicable after its occurrence. The Contractor shall maintain records and make reports concerning health, safety, and welfare of persons, and damage to property, as the Employer may reasonably require.

Only certified electricians are allowed to do electrical works at voltage levels above the Extra Low Voltage as defined by IEC 60364. If the nominal voltage of the battery is higher than 120 Vdc and the positive and negative poles can be inadvertently touched at the same time, (1) insulating rubber gloves and an insulating mat shall be used, and (2) workers shall be accompanied by a third person.

Only personnel trained and certified to work at heights are allowed to do SO.

The installation team must include at least one person trained in First Aid.

1. Documentation

After the initial site visit, the Contractor shall provide a complete Engineering Design Report, including at least the following set of drawings:

* Layout drawings specifying the physical location and positioning of all components.
* Civil engineering drawings, including at least:
  + PV support structure (different views)
* Functional drawings and Single Line Diagrams.
* Installation drawings
  + Details of the installation of all equipment inside the technical room, including at least the power conversion equipment, battery, switchboards, cable trays, and internal electrical distribution.
* Detailed electrical drawings, including at least:
  + General Single Line Diagram
  + Earthing diagrams
  + Communication and control diagram
  + Physical diagram of the PV strings
  + Detailed diagrams of the connections between all main components

After commissioning, the supplier shall provide a new “as-built” Engineering Design, updating those items that could have been modified during the previous installation and commissioning phases. In addition, the Contractor shall also provide:

* O&M manuals to be used by the local technical team for the proper handling of the facilities.
* Detailed O&M plan shall clearly indicate and describe the tasks to be carried out (daily, weekly, monthly, quarterly, yearly) and the personnel involved.

1. The Daily average demand is an estimated non-binding value only for information purposes only [↑](#footnote-ref-2)
2. The Annual demand is an estimated non-binding value only for information purposes only [↑](#footnote-ref-3)
3. Such as PVSyst, Helioscope or similar Software [↑](#footnote-ref-4)
4. PV generator as per IC 61836: power supply unit using the photovoltaic effect to convert Solar irradiation into direct current electricity. The main component of a photovoltaic generator is the photovoltaic array. A photovoltaic generator does not include energy storage devices or power conditioners. [↑](#footnote-ref-5)
5. IEC: time interval, from the instant of failure, until restoration [↑](#footnote-ref-6)
6. From that point on it is understood that back-up generators are the ones not integrated in the renewable energy system. Therefore, if the back-up generators (= non system integrated) are working, this means that the hybrid system is not working [↑](#footnote-ref-7)
7. If fuel is supplied by UNCHR and available on site [↑](#footnote-ref-8)
8. Water provided by UNHCR [↑](#footnote-ref-9)