

Technical Specifications for the supply of Pre-designed Power Solutions (PPS) defined as

- 1) Hybrid Renewable Energy Systems (HRES)**
- 2) Grid-tied Photovoltaic (GPV)**
- 3) Battery Energy Storage System (BESS)**

and

AFTER-SALES SERVICES (AS)

Annex B - Technical Specifications

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List of acronyms

°C	degree Celcius
A	Ampere
AC	Alternating Current
AS	After-Sales Services
BESS	Battery Energy Storage System
dBA	Decibel A-weighting
DC	Direct Current
DOD	Depth of Discharge
ECM	Electronic Control
FAT	Factory Acceptance Test
GPV	Grid-tied Photovoltaic
hr	Hour
HRES	Hybrid Renewable Energy System
Hz	Hertz
ISO	International Organization for Standardization
ITP	Installation Test Plan
kVA	Kilo Volt Ampere
kVAr	Kilo Volt Ampere reactive
kW	Kilowatt
kWe	Kilo Watt electric
kWh	Kilowatt hour
LED	Light-emitting diode
LFP	Lithium iron phosphate battery LiFePO4
LTA	Long-Term Agreement
m	Meter
MDB	Main Distribution Board
mA	milli-Ampere
mm	Millimeter
mm ²	square millimeter
PCC	Provisional Completion Certificate
PDF	Portable Document Format
pf	power factor
PO	Purchase Order
ppm	parts per million
PPS	Pre-designed Power Solutions
PV	Photo Voltaic
RMS	Root Mean Square
SAT	Site Acceptance Test
SoC	State of Charge
UN	United Nations
UNHCR	United Nations High Commissioner for Refugees
V	Volt
VA	Volt Ampere
VAr	Volt Ampere reactive
W	Watt
Ω	Ohm

Section 1. General Requirements

This section details the minimum technical and performance specifications that must be achieved by the required equipment and services. The specified requirements must be met in full, or exceeded, for the technical proposal to be found acceptable. More points will be allocated in the technical evaluation for requirements that are exceeded.

1.1 Environmental considerations

The supplied equipment must be appropriate for use in harsh environmental conditions and suitable for different climate zones (e.g. desert, tropical areas, mountain sites, etc.) in which there are several variations of the relative natural forces (e.g. temperature, humidity, wind, and other climatic conditions).

The applicable weather conditions are specified in the below table:

Ambient temperature range	50°C summer daytime maximum, -10°C winter night-time minimum. Rapid temperature drop (20°C in 20 minutes)
Humidity	Relative humidity ranging up to 95% with extended periods of high relative humidity
Air quality	Dusty with fine sand, polluted ambient air with areas of coastal salt spray and/or industrial pollution

1.2 Quality assurance

The Supplier shall have at his disposal a quality assurance system complying with ISO 9001 or higher standards. The Supplier 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 manufacturers' warranties.

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

1.3 Design life

The Supplier shall indicate with their offer the life of the mechanical and electrical equipment at rated efficiencies under preset operating conditions. The Bidder shall submit with its bid charts of life expectancy in hours and assumed efficiencies.

1.4 Applicable Codes, Rules and General Requirements

The supplied equipment must be designed and manufactured in accordance with the relevant current international or national codes. If equivalent codes are utilized *in lieu* of the referenced codes, then the Bidders must substantiate the differences between the codes.

A non-exhaustive list of relevant international standards is given in the following table for reference and as an example of what is required.

Reference	Title
IEC standards	
IEC 60068	Environmental testing - Part 2-68: Tests -Test L: Dust and sand and Part 2-78: Tests - Test Cab: Damp heat, steady state
IEC 60364	Electrical Installations for Buildings
IEC 60539	IP ratings
IEC 60664-1	Insulation coordination for equipment within low-voltage supply systems - Part 1: Principles, requirements and tests
IEC 60904-3:2016	Photovoltaic devices - Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data
IEC 60950	Battery cell safety
IEC 61000-6-2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments
IEC 61000-6-4	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
IEC 61140:2016	Protection against electric shock - Common aspects for installation and equipment
IEC/EN 61215	Terrestrial photovoltaic (PV) modules - Design qualification and type approval
IEC 61427	Secondary cells and batteries for renewable energy storage
IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems
IEC 61643-12:2020	Low-voltage surge protective devices - Part 12: Surge protective devices connected to low-voltage power systems - Selection and application principles
IEC 61701	Salt mist corrosion test
IEC/EN 61730	Photovoltaic (PV) module safety qualification
IEC 62109-1:2010 Part 1 & 2	Safety of power converters for use in photovoltaic power systems
IEC 62116:2014	Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures
IEC TS 62257	Recommendations for renewable energy and hybrid systems for rural electrification
IEC 62305	Protection against lightning

IEC 62446-2	Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance - Part 2: Grid connected systems - Maintenance of PV system
IEC 62548	Photovoltaic (PV) arrays - Design requirements
IEC 62619	Specifies requirements and tests for the safe operation of batteries used in industrial applications including stationary applications
IEC 62716	Photovoltaic (PV) modules - Ammonia corrosion testing
IEC 62721	Environment: dust, chemical/biological pollution, wind, precipitation, fire exposure
IEC 62804	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation (PID) protection
IEC TS 63019:2019	Photovoltaic power systems (PVPS) - Information model for availability
Other standards	
BS 7671:2018	Design, erection and verification of electrical installations
ASCE 7-10	Wind load provisions
EN 1999-1-1: Eurocode 9	Design of aluminium structures
EN 45554	General methods for the assessment of the ability to repair, reuse and upgrade energy-related products
EU 206/2012	Eco-design and energy labelling regulation
CE marking	European standards - technical specifications defining requirements for products, production process, services or test-methods
DIN VDE V 0126	Automatic disconnection device between a generator and the public low-voltage grid
ETL UL 2703	Grounding and Bonding Equipment
IBC (International Building Code) 1607	International Building Code Roof structures that provide support for photovoltaic panel systems
IBC (International Building Code) 2018	General criteria for minimum requirements for buildings systems
UL 50E/CSA 22.2	Standard for Safety Enclosures for Electrical Equipment Environmental Considerations
UL 790	Fire Tests of Roof Coverings
UL 1642	Standard for Lithium batteries
ULC/ORD STD C1703	Flat-plate photovoltaic modules and panels

The latest editions of the standards shall apply.

The above list must be considered as guidance to Bidders but it is not considered an exhaustive list. In the technical proposal, Bidders are required to indicate the list of standards with which their proposed equipment complies. Bidders must include in their proposal the certification that the proposed equipment and components meet, including their stated standards and any other datasheets, technical documents, reports and drawings deemed necessary to demonstrate that these standards are met.

1.5 Rationale of Specifications

- 1) **Specific requirements.** Expressed by a precise value (value to be achieved) or similar type statement (feature to be present/requirement to be met). These are to be met in full and no variation or deviation will be deemed acceptable.
Example: "DIN rail mounting: Required" means that a proposed non-DIN certified-mountable equipment would not be acceptable.
- 2) **Minimum requirements.** Expressed by a minimum value or a "not less than" or similar type statement (same or higher values are permitted).
Example: "Operating altitude minimum 2000 m" means that proposed operating altitudes lower than 2000 m are not acceptable.
- 3) **Maximum requirements.** Expressed by a maximum value or a "not more than" type statement (same or lower values are permitted).
Example: "Maximum consumption 4.3W" means that proposed power consumption values higher than 4.3W are not acceptable.
- 4) **Ranged requirements.** Expressed by a range of values from a minimum to a maximum. The relative range of the proposed equipment must completely include the required range in order to be found compliant.
Example: "Operating temperature -10 to +55°C" means that a proposed range of working temperature from -15 to +60°C is exceeding the requirement and acceptable; ranges from -15 to +50°C, or from 0 to +70°C, are not acceptable because they do not completely include the prescribed range.
- 5) **Indicated Standards.** Where international standards are indicated, e.g. European SEER of 6.10 (Class A++) for cooling and minimum European SCOP of 4.00 (Class A+) for heating, equivalent standards are acceptable as long as the Supplier demonstrates how the product supplied on the basis of equivalent standard do meet the requirements of the indicated standard.

1.6 Power Quality

The point of reference is at the supply terminals at the main distribution board.

1.6.1 Voltage

Standard of reference is IEC 60038 "IEC standard voltages" with a 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 the below table from the rated value is acceptable under nominal load conditions.

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

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

1.6.2 Frequency

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

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

1.7 Hybrid Renewable Energy System (HRES)

1.7.1 General System Configuration

The power systems must be complete integrated solutions, including PV panels, inverters, energy storage systems, cabling, supporting structures, electrical panels, necessary hardware, accessories and tools, and any special tools for trouble-free operation over serviceable life during the specified service conditions, with guaranteed performance.

The HRES shall make use of the existing UNHCR diesel generator on site whenever possible. Bidders will detail in their proposal what may be the technical limitations for doing so (only isochronous or droop-controlled diesel generator; maximum generator capacity, etc.). The architecture of the HRES shall be made in such a way that the loads can be powered by the HRES and the grid or the genset in parallel.

The power systems must be automatic with the most basic operational task being done by UNHCR local staff upon their training (cf. 3.3.3 Training).

UNHCR accepts the supply of complete HRES systems in two configurations:

1. **“Enclosed” systems**, i.e., complete packages with the necessary PV panels, inverters, batteries, cabling, junction boxes, electrical panels, etc. composing complete plug-and-play HRES to be used in conjunction with UNHCR supplied diesel generators.
2. **“Containerized” systems**, i.e., the same technical packages as per point 1, pre-installed in a modified ISO Sea container (wherever feasible, in 10', 20' or 40' containers, see 2.2 Containerization of power systems).

The Supplier will be requested to add a manual changeover switch to the HRES in order to power the loads directly from the mains and genset, similarly to the architecture prior to the installation of the HRES, and in order to anticipate for unplanned downtime from the HRES power system.

An ATS shall be included in the design if the inverter has only 1 AC input, and in order to allow both grid and genset AC inputs.

1.7.2 Operation concept

The concept of the system's operation is as follows:

- In normal conditions, the hybrid inverter forms the grid (establishes the voltage and frequency for the entire AC network) and monitors the batteries' state of charge (SoC) ¹.
- The available power on the AC bus supplies the AC load connected to the system.
- In case the PV production is enough to power the loads:
 - The PV production powers the load and the hybrid inverter or specific dedicated charge regulators use the excess of PV production to charge the batteries.
 - When the batteries reach full charge, hybrid inverter or system controller is capable to modulate or even exclude the PV production in order to preserve the grid stability.
- In case the PV production is not enough to power the loads (or completely absent):
 - The hybrid inverter or inverter provides the AC bus with the necessary power integration (or full power supply) using the batteries' energy reserve.
 - In case the batteries discharge reaches a preset threshold, the hybrid inverter or inverter is capable of integrating the national grid if available, or start and modulate the backup diesel generator in order to supply the loads and recharge the batteries at the same time.
 - In case the energy demand reaches the hybrid inverter or system controller maximum AC output capacity, the device must be capable to start and modulate the backup diesel generator to supply a share of the energy demand.
- The system must be designed in order to satisfy the power demand during the daytime with the maximum available PV power generation, using the diesel generation only when required.
- The system must be able to manage up to two different AC power sources, grid and backup generators, prioritizing always in that order: PV, grid, battery and generators as last resource.
- The designed grid forming system must be able to supply the entire output capacity for each required system size. Systems with undersized grid forming devices capacity or other design issues acting as "bottlenecks or limitators" will not be considered technically compliant with the requirement.
- The HRES should come with a manual changeover switch to by-pass the whole HRES and connect the pre-existing backup diesel generators with the loads main distribution board (MDB).

1.7.3 HRES capacities

The HRES capacities are defined using the hybrid inverter output power capacities at an operating temperature of a minimum of 40 degrees Celsius. The set capacities are a minimum. Depending on the proposed equipment, Bidders will therefore be able to propose higher capacities for each of the required minimum capacities in the below Table 1 HRES capacities.

¹ The ESS State of Charge (SoC) can be measured by the hybrid inverter itself or via external measuring units (shunts) or as retrieved data from the Battery Management System (BMS), if any.

The PV capacities are suggested. Bidders can therefore propose different ones. The suggested PV capacities are calculated as 1.3 times the inverter capacities. The PV capacities are given as the sum of the peak capacity of each installed PV module.

Bidders may choose to propose a higher PV capacity but the financial evaluation will be done against the above suggested PV capacity.

The battery capacities are minimum ones, and are calculated as 3.8 times the inverter capacities in order to obtain 4 hours of autonomy at the average load.

Detail of the battery capacity calculation for 4 hours of autonomy:

Average load: “a” kW

Inverter capacity = $a \times 125\%$ (including 25% extra capacity) / 95% (assumed inverter efficiency) = 1.316a kW

Battery capacity = $a \times 4$ hours of autonomy / 80% (assumed DoD) = 5a kWh

Battery capacity / Inverter capacity = $5a / 1.316a = 3.8$

Bidders may choose to propose a higher battery capacity but the financial evaluation will be done against the above minimum battery capacity.

The PV and battery capacities will be fixed for each inverter capacity. They will remain the same for any project under this LTA in the future.

The HRES must come in eleven (11) different system capacities:

Table 1 HRES capacities

<u>Minimum</u> Hybrid inverter (Grid forming device) capacity [kW]	<u>Suggested</u> PV Capacity [kWp]	<u>Minimum</u> battery Capacity [kWh]	Number of phases	System configuration
5	7	19	1	Enclosure
15	20	57	1 & 3	Enclosure
30	39	114	1 & 3	Container & enclosure
45	59	171	3	Container & enclosure
60	78	228	3	Container & enclosure
75	98	285	3	Container & enclosure
90	117	342	3	Container & enclosure
105	137	399	3	Container & enclosure
120	156	456	3	Container & enclosure
135	176	513	3	Container & enclosure

150	195	570	3	Container & enclosure
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The HRES must be modular and expandable, i.e. must allow building of larger capacities in multiples of its own system capacities by interconnection of more than one system. One of the HRES must act as the ‘master’ of the entire installation, while the others must act as ‘slaves’ to provide the total multiple capacity. If the concept requires the inclusion of additional equipment, e.g. the totalizing electrical panels, the bidders must quote the additional equipment using the spare/miscellaneous parts list in the BOQ.

The distances between the hybrid inverters/charge controllers or charge regulators and the batteries must be the shortest possible in order to minimize the cables sizes and avoid power losses on cables.

Bidders are requested to provide the technical design documents for a 15, 60 and 150 kW HRES. The minimum documents to be provided are listed in **Annex I: List of Technical Returnables**.

1.8 Grid-tied Photovoltaics (GPV)

1.8.1 General System considerations

The GPV must be a complete solution, including PV panels, PV inverters, cabling, supporting structures, electrical boxes with its protection devices. The systems should come completely pre-designed, pre-tested and pre-assembled as much as possible (e.g. the string boxes should come pre-wired, with pre-sized cabling and protection devices, and ready to plug the different PV strings).

The GPV shall make use of existing UNHCR diesel generators at site whenever possible. Bidders will detail in their proposal what may be the technical limitations for doing so (only isochronous or droop-controlled diesel generator; maximum generator capacity, etc.). The architecture of the GPV shall be made in such a way that the loads can be powered by the GPV and the grid or the genset in parallel.

The power systems must be automatic with the most basic operational task being done by UNHCR local staff upon their training (cf. 3.3.3 Training).

UNHCR accepts the supply of complete GPV systems in one configuration:

1. **“Enclosed” systems**, i.e., complete packages with the necessary PV panels, inverters, batteries, cabling, junction boxes, electrical panels, etc. composing complete plug-and-play GPV to be used in conjunction with UNHCR AC supply (grid or genset).

1.8.2 Operation concept

The concept of the system’s operation is as follows:

- The system will work as a typical self-consumption system. The grid-tied string inverters will be connected to the office main distribution board (MDB) and will work in parallel with the existing electricity source, be it the national grid or a diesel backup generator.
- When the existing office grid (mains or diesel generator) is within the normal voltage and frequency parameters, the PV inverter should automatically connect to the grid and inject the maximum possible share of PV generation. When the grid voltage and frequency

parameters are not within the acceptance range, the PV inverter will automatically disconnect itself.

- In case the available solar energy output is higher than the energy demand (loads), the grid-tied string inverter should reduce its power output.

1.8.3 GPV capacities

The GPV capacities are defined using the PV inverter output power capacities at an operating temperature of minimum 40 degrees Celsius. The set capacities are a minimum. Depending on the proposed equipment, Bidders will therefore be able to propose higher capacities for each of the required minimum capacities in the below Table 2 GPV capacities.

The PV capacities are suggested. Bidders can therefore propose different ones. The suggested PV capacities are calculated as 1.5 times the inverter capacities. The PV capacities are given as the sum of the peak capacity of each installed PV module.

Bidders may choose to propose a higher PV capacity but the financial evaluation will be done against the above minimum PV capacity.

The GPV must come in eleven (11) different system capacities:

Table 2 GPV capacities

<u>Minimum</u> PV inverter (Grid-tied) capacity [kW]	<u>Suggested</u> PV Capacity [kWp]	Number of phases	System configuration
5	8	1 & 3	Enclosure
15	23	3	Enclosure
30	45	3	Enclosure
45	68	3	Enclosure
60	90	3	Enclosure
75	113	3	Enclosure
90	135	3	Enclosure
105	158	3	Enclosure
120	180	3	Enclosure
135	203	3	Enclosure
150	225	3	Enclosure

The GPV must be modular and expandable, i.e. must allow building of larger capacities in multiples of its own system capacities by interconnection of more than one system. If the concept requires the inclusion of additional equipment, e.g. the totalizing electrical panels, the bidders must quote the additional equipment using the spare/miscellaneous parts list in the BOQ.

Bidders are requested to provide the technical design documents for a 15, 60 and 150 kW GPV. The minimum documents to be provided are listed in ***Annex I: List of Technical Returnables***.

1.9 Battery Energy Storage Systems (BESS)

1.9.1 General System considerations

The power systems must be complete integrated solutions, hybrid inverters, energy storage systems, cabling, supporting structures, electrical panels, necessary hardware, accessories and tools, and any special tools for trouble-free operation over serviceable life during the specified service conditions, with guaranteed performance.

The BESS shall make use of the existing UNHCR diesel generator at site whenever possible. Bidders will detail in their proposal what may be the technical limitations for doing so (only isochronous or droop-controlled diesel generator; maximum generator capacity, etc.). The architecture of the BESS shall be made in such a way that the loads can be powered by the BESS and the grid or the genset in parallel.

The power systems must be automatic with the most basic operational task being done by UNHCR local staff upon their training (cf. 3.3.3 Training).

UNHCR accepts the supply of complete BESS systems in two configurations:

1. **“Enclosed” systems**, i.e., complete packages with the necessary hybrid inverters, Batteries, cabling, junction boxes, electrical panels, etc. composing complete plug-and-play power systems to be used in conjunction with existing electrical systems in UNHCR offices.
 2. **“Containerized” systems**, i.e., the same technical packages as per point 1, pre-installed in a modified ISO Sea container (wherever feasible, in 10', 20' or 40' containers, see 2.2 Containerization of power systems).
- The Supplier will be requested to add a manual inverter bypass in the system in order to power the loads directly from the mains and genset, similarly to the architecture prior to the installation of the BESS, and in order to anticipate for unplanned downtime from the BESS power system.
 - An ATS shall be included in the design if the inverter has only 1 AC input, and in order to allow both grid and genset AC inputs.

1.9.2 Operation concept

- The system will work as a typical power by-pass energy storage. In normal conditions, when there is grid availability, the hybrid inverter will monitor the grid and use its energy to charge or keep the batteries charged.
- When a grid power interruption happens, the hybrid inverter will change and work as a typical inverter using the energy from the batteries to provide electricity to the loads. This transition needs to happen without any power interruption on the load side.
- While the BESS is providing electricity, it should monitor at the same time the demand power; if this is above the BESS nominal power output, it should automatically start the backup generator.
- While the BESS is providing electricity it should constantly measure ESS's state of charge (SoC). If SoC reaches 20% (therefore depth of discharge 80%), it should automatically start the backup generator.
- When power sources are available (grid or backup generator), the BESS should recharge the batteries.

1.9.3 BESS capacities

The BESS capacities are defined using the BESS power inverter output capacities at an operating temperature of minimum 40 degrees Celsius. The set capacities are a minimum. Depending on the proposed equipment, Bidders will therefore be able to propose higher capacities for each of the required minimum capacities in the below Table 3 BESS capacities.

The battery capacities are minimum ones, and are calculated as 3.8 times the inverter capacities in order to obtain 4 hours of autonomy at the average load.

Detail of the battery capacity calculation for 4 hours of autonomy:

Average load: "a" kW

Inverter capacity = $a \times 125\%$ (including 25% extra capacity) / 95% (assumed inverter efficiency)
= 1.316a kW

Battery capacity = $a \times 4$ hours of autonomy / 80% (assumed DoD) = 5a kWh

Battery capacity / Inverter capacity = $5a / 1.316a = 3.8$

The BESS must come in eleven (11) different system capacities:

Table 3 BESS capacities

Minimum BESS power inverter (Grid forming device) capacity [kW]	Minimum battery Capacity [kWh]	Number of phases	System configuration
5	19	1	Enclosure
15	57	1 & 3	Enclosure
30	114	1 & 3	Container & enclosure
45	171	3	Container & enclosure
60	228	3	Container & enclosure
75	285	3	Container & enclosure
90	342	3	Container & enclosure
105	399	3	Container & enclosure
120	456	3	Container & enclosure
135	513	3	Container & enclosure
150	570	3	Container & enclosure

Bidders may choose to propose a higher battery capacity but the financial evaluation will be done against the above minimum battery capacity.

The BESS must be modular and expandable, i.e. must allow building of larger capacities in multiples of its own system capacities by interconnection of more than one system. One of the BESS must act as the 'master' of the entire installation, while the others must act as 'slaves' to provide the total multiple capacity. If the concept requires the inclusion of additional equipment, e.g. the totalizing electrical panels, the bidders must quote the additional equipment using the spare/miscellaneous parts list in the BOQ.

The distances between the hybrid inverters/charge controllers or charge regulators and the batteries must be the shortest possible to minimize the cables sizes and avoid power losses on cables.

Bidders are requested to provide the technical design documents for a 15, 60 and 150 kW BESS. The minimum documents to be provided are listed in the ***Annex I: List of Technical Returnables***.

Section 2. Product specifications – Main Components

2.1 System configuration

UNHCR wishes to offer Bidders the possibility to offer systems with different configurations, namely AC and DC-coupling. Bidders will choose one configuration or the other depending on the equipment they have and in order to achieve the highest PV penetration / lowest cost of energy possible. The chosen configuration shall allow for the PV generator and diesel generator to power the loads at the same time. This is deemed important for times when the PV production output will be lower than the loads connected at the office. In such situations, the diesel generator would complement the PV production. All-major components for the chosen configuration need to be included in the BOQ.

Performance specifications for each configuration are listed below and general specifications of major components within these architectures are also listed. This is done in order to ensure high quality equipment are selected in the design of PPS, while limiting unexpected problems, breakdowns and warranty claims.

2.1.1 AC coupling

This configuration will create a micro grid with batteries and a diesel generator for which other power supplies can synchronize to on the AC bus current flow is controlled by frequency shifting. The systems with this configuration must be interconnectable with other power systems and stackable. PPS under this configuration will have connection for two external power supplies: a diesel generator, and the grid. If only one connection is available, an automatic transfer switch must be included to allow for the correct external power source to be selected when needed/available. Power Supply inputs to system should be selectable for priority and start/stop conditions must be adjustable as needed. Unstable grid power will need to be used with the system; therefore, any stabilization needed to use unstable grid will need to be on offer in this situation.

All units needed to achieve this complete system in all its configurations should be on offer including any items for monitoring, battery charging direct from DC and system/units meeting the following general specifications:

- Battery bank with capability of charging 50Ah to 10000Ah (li-Ion LFP)
- System voltage options 110/220V 60hz and 230/400V 50hz
- Efficiency of over 95%
- Operating temperature of -10 to +50 degrees Celsius

- System must be able to be monitored online in a platform exclusively for UNHCR where data is stored and accessible. System may have a local SD card with event log to be shown to the manufacturer for fault finding/rectifying assistance, or similar.
- System must have battery temperature sensors and monitor batteries for state of charge.
- Systems must allow for a TN-S earthing system.
- Systems must have adequate Surge Protection Devices (SPD) and Residual Protection Devices (RCD).

2.1.2 DC coupling

This system will create a DC bus with batteries. All inputs will be connected to the DC bus and a battery inverter will be used to achieve the system output voltage required. These systems will be needed in sizes from micro systems through larger commercial sized building systems. All components needed to achieve this complete system in all its configurations should be on offer. General system and component specifications are below:

- Battery bank with capability of charging Li-Ion LFP.
- System voltage options 120/220V 60hz and 230/400V 50hz
- Efficiency of over 95%
- IP 21 and above for all units inside the enclosure or container. External units should be IP 65
- Systems must have an option for two external power sources to be connected (grid and generator)
- Systems must be able to control external power sources use
- Operating temperature of -10 to +50 degrees Celsius
- System must be able to be monitored online. Any local event log that can be downloaded is an advantage
- System must have battery temperature sensors and monitor batteries for state of charge
- System must allow for a TN-S earth system. Systems must have adequate Surge Protection Devices (SPD) and Residual Protection Devices (RCD)

2.2 Containerization of power systems

If Bidders are requested to provide a containerised PPS, then the following requirements will need to be met:

- The containerization of the main control and switching devices shall include the PV and battery inverters and the batteries. Upon request, the Supplier will propose an insulated, racked and weather-proofing container with all equipment pre-installed and wired.
- Depending on the size of the energy equipment (inverters, main switches, etc), the Supplier will devise and propose an appropriate standard shipping container: 10-foot, 20-foot or 40-foot.
- The container shall be designed and furnished with the following or as needed, so as to ensure that the energy equipment housed within the container is maintained within the ambient parameter ranges (temperature, humidity, etc) of the manufacturer(s), and any internal cabling is done tidily.

2.2.1 Arrangement prescriptions

- i. One or multiple standard 10', 20' or 40' ISO sea container (depending on the system capacity) must contain all main components in pre-assembled, pre-cabled configuration, with the only exception of PV panels and their supporting structures.

- ii. The container shall be painted white with a two meters long UNHCR logo painted in the middle of the two longest sides of the container. The logo template shall be provided by UNHCR.
- iii. The components inside the container(s) must be firmly secured (e.g. using metal rails to place the equipment on the container walls) in order to ensure proper and safe shipment of the systems. The resulting modified container(s) must be certified for regular shipping and no recertification must be needed for any redeployment of the systems.
- iv. The equipment inside the container(s) must be accessible through the standard double door on one of the short container sides. The internal arrangement must allow ease of commissioning, operation, maintenance and decommissioning for re-shipment.
- v. The container(s) must have internal walls and ceiling covered with insulating sandwich panels, or similar asbestos-free insulation means. The thermal transmittance of the insulation must be maximum 0.78 W/m²K.

2.2.2 Climatization

- i. One inverter split-type air conditioner capable to heat/cool must be installed in the container in order to keep the internal temperature and humidity at the internal equipment's standard test conditions. The minimum requirement is for 1x12,000 Btu/h for the 20' container and 1x18,000 Btu/hr or 2x12,000 Btu/hr unit(s) for the 40' container.
- ii. The air conditioner must be rated to meet the minimum European SEER of 8.50 (Class A+++) for cooling and minimum European SCOP of 4.00 (Class A+) for heating as per EU Eco-design Regulation 206/2012 and Energy Labelling Regulation 626/2011. The Bidders may adopt equipment compliant with other efficiency standards equivalent to the above indicated standards (e.g. AHRI 210/240). Bidders must prove the overall compliance with the above minimum values by means of technical calculation to be submitted with the technical offer.
- iii. The air conditioner must use a refrigerant with zero ozone depleting potential (ODP = 0), a global warming potential of maximum 750 (GWP ≤ 750), low-toxicity class A and maximum flammability class 2L as per ISO 817. As an example R32 refrigerant complies with the previous requirements, but the bidders are free to propose equivalent or better performing refrigerants.
- iv. The internal unit(s) must be installed on the wall of the container. The external unit(s) must be pre-installed and secured in a recessed compartment of the container, to be closed by metal plate fixed by nuts and bolts during transportation. Removable plates must also close the pre-cut openings in the container walls e.g. for the necessary refrigerant pipes, cables and vents during transportation.
- v. The cooling/heating of the container shall be designed to be as energy-efficient as possible; favouring passive ventilation before active ventilation where possible. Any opening vents of the container will be protected against the intrusion of rodents inside the container.
- vi. A suitable fan system must be installed in the container(s) for active ventilation. The system must be able to cool the internal equipment by fan whenever possible, and switch the air conditioner on only when the external temperature does not allow free cooling.
- vii. A High Temperature monitoring of the container including outdoor/external visual and audible alarms shall be included.

2.2.3 Electrical system

- i. The containers must be equipped with an internal LED lighting system capable to provide min. 400-lux, 3000K, the necessary wall switch and at least two (2) 1-phase,

- 16A rated electrical sockets, CEE 7 Type F (“Schuko”) for the 50Hz and NEMA 5-15 Type B for the 60Hz version. The entire internal electrical system must have a minimum protection rate of IP44. The internal cabling must run in proper ducting systems and cable trays in compliance with current safety installation standards and best practices.
- ii. Each container must be equipped with a red, ‘mushroom’ type switch button for quick disconnection of power supply in case of fire or emergency. The button must be recessed in a convenient and always accessible position on an external wall of the container. One (1) CO2 type extinguisher with a minimum capacity of 5 Kg must be included with each modified container, properly fixed to the internal walls near the exit.
 - iii. The manual override transfer switch should be installed inside the container.
 - iv. All the electric boxes, with its breakers, switches, fuses and all the electric distribution boards (AC and DC), and all the system components should be clearly identified and labeled.
 - v. Built-in cable entry boxes with waterproof gland plates and terminal blocks, near bottom corners of the container shall be included: it may contain but are not limited to the following
 1. Generator input connections (3-Ø + N + G)
 2. Generator stop/start control (1NO contact)
 3. Grid input connections (3-Ø + N + G)
 4. Load output connection (3-Ø + N + G)
 5. Main grounding connection input
 6. Data connection input
 7. Spare cable entrance inputs/outputs

The Bidders must include a layout of the designed internal arrangement of the containers with their proposals. That design shall be for a HRES system whose capacity is left open, i.e. bidders can choose for which HRES capacity they provide the layout of the designed internal arrangement of the container. The Bidders must allow a warranty on manufacturing defects on the assembly of the resulting containerized systems of **at least two (2) years** from the date of delivery.

2.3 Enclosure of power systems

All enclosure / 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 might have to be installed outdoors and therefore they shall have minimum IP protection of IP65 as per IEC 60529, be UV resistant and be flame-retardant.

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 inverter AC output where applicable.

The main distribution board that combines the diesel generator, the hybrid/grid-tied/battery backup inverters shall be located indoors, shall have insulation Class II or equivalent and IP protection of at least IP65, and 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.

2.4 Photovoltaic Panels

2.4.1 Compliance with international standards

The PV panels must be compliant to IEC 61215 and IEC 61730 or equivalent international standards for crystalline silicon terrestrial cell type, with nominal operating temperature (NOCT) of $45^{\circ}\text{C} \pm 2^{\circ}\text{C}$. Their peak power output and efficiency must be determined in compliance with IEC 60904-3 or equivalent international standard. The panels may be CE marked and in possession of a certification for construction, safety and performance from any renowned international third-party certification body, such as TÜV-Rheinland or equivalent. The certification must include testing of salt mist corrosion with a salt concentration of 5% in weight as per IEC 61701 (or equivalent) and Potential-Induced Degradation (PID) resistance as per IEC 62804 (or equivalent). The bidders must provide the relevant test certificates along with their technical proposal.

2.4.2 Construction requirements

The panels must have an anodized aluminium alloy frame, must be vacuum-sealed and assembled with advanced encapsulation materials to prevent cell corrosion, weatherproof laminated and fitted with special solar tempered glass. The panels must be complete with bypass diodes, weatherproof junction box, inter-connection cables and MC4 or similar male/female quick connectors.

The panels must be capable to resist a static load of minimum 5,000 Pa (snow) on the front and 2,200 Pa (wind) on the backside, and a hailstone impact of minimum 25 mm diameter at 20 m/s velocity.

2.4.3 Technical requirements

The panels must fulfill the following technical requirements:

ITEM	REQUIREMENT
Power output *	To be defined by the bidder
Technology	Monocrystalline PERC recommended. Crystalline is a minimum requirement.
NOCT	$45^{\circ}\text{C} \pm 2^{\circ}\text{C}$
Power output tolerance ²	Only positive
Module efficiency ²	Minimum 20.0%
Minimum operating temperature range	-20°C to 80°C
Warranty on manufacturing defects	Minimum 10 years
Warranty on energy output	Minimum 90% after 10 years

² At Standard Test Conditions (STC) – 1000W/m² irradiance, 25°C cell temperature as per EN 60904

	Minimum 80% after 25 years
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2.5 Solar Panels Mounting Systems

The bidders selected to participate in the secondary bid will be required to provide a mounting structure design for the selected project(s).

The Supplier shall be able to supply three options of mounting structures for the PV arrays:

1. Ground mounting structure
2. Elevated mounting structure
3. Rooftop mounting structure

In order for Bidders to demonstrate they will be able to design, supply and install high quality support structures they are requested to provide the mounting structure design for the following power solutions:

- 150 kW HRES, ground-mounted as per 2.5.4 Ground mounting structure
- 150 kW HRES, elevated structure @ 2.6 meter high as per 2.5.5 Elevated mounting structure
- 150 kW, HRES, elevated structure @ 5 meter high as per 2.5.5 Elevated mounting structure
- 15 kW GPV, rooftop CGI sheet rooftop

The above design shall be made for the simplest, yet high quality support structure. It shall include the ground foundations. The design of the mounting structure shall come with a high level of detail and it is recommended Bidders validate their design with structural analysis using a dedicated software. The design shall comply with the panel manufacture mounting specifications

Awarded Bidders will be given the possibility during the secondary bidding process to adjust their design as per the future project site characteristics and requirements (e.g. to adjust the shape of the structure, add reinforcements for sandy soils, etc.). During the secondary bidding process, a site layout, photos of the site and photos of a 1 meter deep test pit will be provided. This information will be considered sufficient for bidders to finalize their support structure design. If deemed necessary UNHCR will be able to organize a site visit.

Because the technical requirements for rooftop mounting differs widely depending on the rooftop structure and conditions, the bidder awarded during the secondary bidding process will be expected to conduct a structural assessment and provide a technical and financial offer for a potential rooftop retrofitting and mounting structure prior to the issuance of a PO.

Bidders are required to detail the processes/tools/standards that will be used for the on-site structural assessment and preparation of a technical report for offices where a rooftop mounting is necessary.

2.5.1 General construction requirements

The design snow/wind resistance of the structures must take into consideration the requirements for the panels to resist a static load of minimum 5,000 Pa (snow) on the front and 2,200 Pa (wind) on the backside.

All necessary fixtures, fittings, joints, clamps and accessories (e.g. panel fittings, anchor bolts, threaded bolts and foundations base) are considered part of the structure requirement.

All the components of the supporting systems must be made of corrosion resistant steel or anodized aluminum alloy. It is required aluminum and steel to be the only materials used in the manufacturing of the structures, in order to minimize any risk of galvanic corrosion. The structures

must be 'universal', i.e. capable to accommodate any PV panel models from any manufacturer if the panels respect the same form factor and dimensions. The make of the structures must guarantee grounding continuity among all the PV panels and the components of the structures.

It will be the responsibility of the Supplier to ensure a proper design of the mounting structures' loading, and a simplification of the DC wiring management. It will also be the responsibility of the Supplier where heights of mounting systems are above 2.4 meters that designated attachment points are provided for maintenance staff to attach safety harnesses for working safely at heights. The structures will provide inter-row spacing with fast installation features, and will be tested under:

1. UL1703 for fire conditions
2. IEC 61215 for load testing

2.5.2 Compliance with international standards

The PV supporting structures manufacturing quality and dimensions must conform to the relevant provision of the American Society of Civil Engineers ASCE 7-10 or equivalent international standard. The structure must be designed to allow easy replacement of any module.

The mounting structures and all related clamps, joints and grounding equipment must comply with UL 2703 or equivalent international standard.

The structures designed for roof mounting must comply with UL 790 Class A fire resistance rating and with the relevant provisions of International Building Code IBC 2018, or equivalent international standards.

2.5.3 Rooftop Mounting Structure

The supporting structure design must be suitable for the most typical types of roofs currently in use in UNHCR operational scenarios, i.e. insulated sandwich panels of prefabricated buildings, Corrugated Galvanized Iron (CGI) sheet coverings, or flat concrete rooftop. All the necessary fittings that require piercing of the coverings must be equipped with proper gaskets or equivalent means to ensure a perfectly weatherproof installation.

The flat roof mounting structure will be built compliant to the following minimal characteristics:

- 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
- Wind load: ≥ 100 km/h
- Available with grounding pins
- Manufacturer's guarantee: ≥ 15 years for the structural integrity and corrosion; and ≥ 5 years for the leakages.

Bidders are requested to provide, with the design and architecture principles, details of components that will be used for future design, including CGI rooftop and flat concrete rooftop.

2.5.4 Ground mounting structure

Ground foundations are included in the solicitation. Bidders selected for the secondary bidding process will be provided with the photos of a 1 meter deep test pit in order to design the details of the required foundations necessary to guarantee the designed structural performance of the

ground mounting structures. (e.g. in case of concrete ballast foundations: dimensions, composition of concrete and drawings). If additional information will be required then a site visit can be organized.

The structures must be adjustable in tilt in the minimum range from 0° to 45°. For containerized solutions a fixed tilt angle is acceptable.

The grounding mounting structure will be built compliant to the following minimal characteristics:

- Dimensions: per array size
- PV Module Fixation: middle clamps and end clamps
- Orientation: landscape or portrait
- Material: galvanized steel
- Wind load: ≥ 100 km/h
- Available with grounding pins
- Manufacturer's guarantee: ≥ 15 years for the structural integrity and corrosion.

2.5.5 Elevated mounting structure

The structure will be built compliant to the following minimal characteristics:

- Structure: vertical and horizontal secondary rails.
- The structure shall remain on concrete foundations 60 cm tall to prevent potential collision from cars against the steel structure.
- PV Module Fixation: middle clamps and end clamps
- Pass height: 2.6 and 5 meters
- For areas including a parking space: single car park dimensions: 2.74 m x 6.10 m (US standard large); with a minimum of one accessible car park at 3.6 m x 6.10 m. The area below the structure should be a integer multiple of car space number.
- Dimensions: per array size
- Material: galvanized steel
- Wind load: ≥ 100 km/h
- No. of parking spots: per array size and work order specifications
- Available with grounding pins
- Manufacturer's guarantee: ≥ 15 years for the structural integrity and corrosion; and ≥ 5 years for the leakages.

2.5.6 Grounding and lighting protection

A common earth termination system (grounding network) must interconnect all the metallic parts of the installation. The bidders must design the grounding network taking into account the relevant prescriptions of IEC 62305. In the design, bidders must aim to achieve an earth resistance of less than 10 Ω (values to be confirmed in the testing and commissioning report), assuming a rectangular layout and an average soil resistivity of 250 $\Omega \cdot m$. Note that the metal supporting structures can be used as part of the mesh, if they have a minimum conductance according to IEC 62305. Alternatively, bidders may adopt UL 2703 or an equivalent international standard for the design of the grounding network.

To prevent direct lightning strikes, the equipment must be located in the protected volume of an air termination lightning protection system (LPS). The bidders must design the system to determine the necessary dimensions and number of air-termination rods. The LPS must be minimum Class III as per IEC 62305 or equivalent. It must be designed using the rolling sphere method as per IEC 62305, or according to the procedures described in the adopted equivalent standard.

Bidders must provide the earth termination and air termination systems as kits for each complete system capacity, including the necessary copper or stainless-steel earth rods, suitable length of ground conductors, air rods and all necessary clamps and connectors.

Earthing shall be made in a conventional manner. The use of chemicals such as bentonite to reduce resistance between the soil and the earth electrode(s) is not allowed.

2.6 Inverters

2.6.1 Hybrid inverters

The hybrid inverter may be adopted for each of the three types of PPS provided they can fulfill the required functions. The inverter will be used in single-phase voltage systems with an easy configuration upgrade to a three-phase system.

The inverter system will need to comply with the following minimal characteristics:

2.6.1.1 Inverter Inputs

1. 1 or 2 AC inputs (an ATS is required if only 1 AC input is available)
2. Battery DC input
3. Rated AC output power: per requirements
4. Nominal AC output voltage: single phase 220/240V and 100/127V,
5. (Optional three phase configuration on demand): 380/400V and 220/230V
6. Output AC Frequency: 50 or 60Hz on demand
7. AC Disconnect Breaker

2.6.1.2 Inverter output (standalone)

1. Operating temperature of -10 to +50 degrees Celsius
1. Rated power given at ambient operating temperature under continuous load
2. Total harmonic distortion at rated power: <5%
3. Nominal AC output voltage: single phase 220/230V and 110/120V,
4. (Optional three phase configuration on demand): 380/400V and 220/230V
5. Output AC Frequency: 50/60Hz
6. AC Disconnect Breaker
7. THD <3 %
8. Minimum transfer time: 8ms (seamless)

2.6.1.3 Charger DC output

1. The charge controller must be able to communicate with the battery BMS if any
2. Charge control: two stages, external BMS, custom
3. Compatible battery types: Li-Ion (LFP)

2.6.1.4 Efficiency

1. Minimum efficiency: 95%

2.6.1.5 Protective features

1. Ground fault monitoring / grid monitoring
2. DC reverse polarity protection / AC short circuit current capability

3. All-pole-sensitive residual-current monitoring unit.
4. Protection class (according to IEC 61140)
5. Overvoltage category (according to IEC 60664-1) grid/battery/PV
6. Surge Protection Device (SPD)

2.6.1.6 Inverter Unit

1. Communication Interface: WiFi, Ethernet, BAT-CAN, RSxxx
2. AC, DC, and Communication
3. Protection Rating IP20 (indoor use)
4. Manufacturer's warranty: ≥ 5 years

2.6.2 Grid-tie string Inverters

2.6.2.1 Compliance with international standards

The PV inverters, capable to synchronize the DC input of PV arrays with AC distribution grids, must be certified for safety to IEC 62109 parts 1 and 2 (or equivalent). In addition, the PV inverters must be protecting against 'islanding mode' according to IEC 62116, DIN VDE 0126 or international equivalents. Their make and installation must be compliant with IEC 60364 (or equivalent) and, in particular, part 7-712 which relates to solar photovoltaic power supply systems. The power conversion system must comply with IEC 61000-6-2 and IEC 61000-6-4 (or equivalent).

2.6.2.2 Technical requirements

The PV inverters must fulfill the following technical requirements:

ITEM	REQUIREMENT
Protection level	Minimum IP65, with a protective shade structure against strong rain for outdoor installation and IP10 for indoor installation
Output Frequency tolerance	± 5 Hz
DC side disconnection point	Required
Ground fault monitoring	Required
DC reverse polarity protection	Required
Topology	Transformerless
Minimum operating temperature range	-20°C to 60°C
Operating relative humidity	Up to 100%
Warranty on manufacturing defects	Minimum 5 years

Single-phase PV inverters

Peak efficiency	Minimum 97.0%
Noise emission	Maximum 25 dB(A)
Three-phase PV inverters	
Peak efficiency	Minimum 98.3%
Noise emission (below 50kW AC rating)	Maximum 51 dB(A)
Noise emission (from 50kW AC rating)	Maximum 65 dB(A)

The selected Supplier must supply the systems in both 230/400VAC-50Hz and 120/220VAC-60Hz versions. Due to its current operational scenarios, UNHCR envisages the 50Hz versions to be by far the most required configurations.

2.6.3 Battery backup Inverters

Battery inverters might be required in on-grid and off-grid applications where battery banks or BESS are AC connected onto the local grid. The battery inverters will be adopted in all sizes of HRES and BESS where required.

The unit is required to work in full compatibility mode with lithium-ion (LFP), providing intelligent battery management and control.

2.6.3.1 DC Battery Input

1. Battery-DC input
2. Reverse-Polarity Protection
3. PV 2-pole Disconnections
4. Battery types: Li-Ion (LFP)

2.6.3.2 Inverter Unit:

2. 1 or 2 AC inputs (an ATS is required if only 1 AC input is available)
3. Operating temperature of -10 to +50 degrees Celsius
5. Nominal rated grid frequency: 50/60 Hz
6. Nominal rated grid: 110/220V and 220/400V
7. Intelligent load and Energy management and Smart grid monitoring
8. Inverter Efficiency: $\geq 95\%$
9. Communication Interface: WiFi, Ethernet, RSxxx
10. Ground fault monitoring
11. THD $< 3\%$
12. AC short-circuit and AC overload protection
13. DC reverse polarity protection / DC fuse
14. Overtemperature / battery deep discharge protection
15. Overvoltage protection
16. Manufacturer's warranty: ≥ 5 years
17. Automatic full charge and equalization control
18. Battery temperature sensor

2.7 Batteries

The Batteries shall be designed to suit any storage requirement the power supply systems may require. The Batteries will provide the specified amount of effective energy capacity for 5-20 years with temperatures between -10°C and 50°C. The batteries may be used for the following:

- Self-consumption
- Back-up within battery inverters and controllers
- Back-up within a DC bus architecture (Energy sources blended as DC)
- Back-up within AC parallel architecture (Energy sources blended as AC)
- Spinning reserve
- Load shaving
- Generator efficiency

2.7.1 Batteries technical requirements

1. Recommended battery chemistry: Lithium Iron Phosphate (LFP).
2. Store the renewable energy in excess, for use at a different time of the day or night.
3. Guaranteed lifetime cycles (end of useful life) at 35°C and 80% DoD: > 4500
4. Remaining available capacity at end of useful life: ≥ 80%
5. Depth of discharge: ≥ 90%
6. Storage limitations: number of days batteries can be stored (e.g., during transport) without risk of permanent damage: > 100 days
7. Batteries and/or storage units must not be manufactured more than 2 years before assembling.
8. Can withstand high temperature fluctuations and provide energy storage for a long time (min 15. years) at temperatures of up to 50°C.
9. Provided with adequate mounting and mechanical fixing accessories (cabinet, racks etc.) and cables or connection bars for proper installation.
10. Equipped with any necessary or recommended ancillary equipment (i.e., temperature sensors, voltage sensors) which the manufacturer recommends for the optimal performance of the system for the long term.
11. Nominal storage capacity of each module: given in kWh and as per requirements.

The below table will need to be filled and signed for each energy storage system offered

Number of cycles	Effective capacity as % of initial effective capacity	Assumptions/conditions for the validity of the data provided (if any)
0	100%	Temperature:
1.000		Charge rate:
3.000		Discharge rate:
5.000		
8.000		
10.000		
15.000		

20.000		
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2.7.2 Battery Management System (BMS)

The battery modules might require specific monitoring and management; in such case the Supplier shall provide a compatible Battery Management System (BMS) if this function is not already provided by the inverter. The BMS, whether incorporated or not, will provide the management and control of the following parameters:

1. Temperature – string level
2. Temperature – cell level
3. Current/voltage – Charging
4. Current/voltage – Discharging
5. Current/voltage – Floating
6. Battery balancing at cell level

2.7.3 Monitoring system

The BMS shall provide local and remote detailed real time monitoring and historical performance reporting capabilities, to allow UNHCR to measure and monitor the performance and the health and status of the batteries as well as assist with the investigation and troubleshooting of any fault situations.

The batteries monitoring and reporting functionalities shall meet or exceed the following requirements:

1. Status monitoring: state, residual charge, health indicator, low voltage warning
2. Historical data for each storage string (average V, min V, max V, average I, min I, max I, hourly kWh for previous 7 days, daily kWh for last 30 days, weekly kWh for last 24 weeks, monthly kWh for last 60 months, alarms).
3. Manufacturer's remote (web-based) monitoring capability

2.8 Voltage and Frequency Stabilizers

Stabilizers or converters are an important aspect of power supply systems as they will allow the use of an unstable grid that could otherwise not be used meaning there may be more reliance on a dispatchable fossil fuel system. Stability in terms of voltage and frequency will be needed and as stabilization may be needed for systems that use renewable energy and that renewable energy may be able to be fed back into the grid, stabilizers and converters should be able to allow current flow in both directions. General specifications for stabilizers/converters are listed below:

1. All Stabilizers/converters on offer are to operate within -10 to +50 ambient temperature
2. Any stabilizer on offer must be able to stabilize plus and minus 25% voltage fluctuation to within a 1% accuracy in under 0.3 of second to specified voltage
3. Stabilizer must be capable of rectifying frequency of a 10% plus minus swing to within a 1% accuracy of specified system frequency
4. Single and 3 phase stabilizers will be needed at both 110/220V 60hz and 230/415V 50hz systems
5. All stabilizers must have the option of surge protection

All stabilizers must come with bypass switch.

2.9 Monitoring and Metering Systems

The Supplier will ensure energy production and consumption is measured where applicable and at all levels of the PPS. The type of power supply and the client's needs will determine the level of monitoring needed; however, three types of monitoring systems will be used as needed:

1. Technical monitoring system
2. Managerial monitoring system
3. Metering for charging purposes

2.9.1 Technical Monitoring System

This monitoring system is usually captured from a grid controller or generator control panel which is accessible on a web page or preferably an application. This system will monitor all technical aspects that can be used for fault finding/system diagnostics, alarms and will maintain historical data of energy and power inputs and outputs. This data can also be accessed on site by entering operating system of the power supply.

The technical aspects may be measured through means of the inverters or controllers and visualized through the equipment manufacturer's energy portal. The Supplier will offer additional energy meters for the electricity grid, the generators and any other power supplies which will need it.

The energy meters will display the following parameters:

- Instantaneous voltage (V)
- Instantaneous online current (A)
- Daily energy production and/or consumption
- Monthly energy production and/or consumption
- Annual cumulative Energy production and/or consumption
- Instantaneous peak-power demand
- Highest peak demand

The energy meters will be of the single and three-phase type, depending on the voltage of the electrical power distribution.

Bidders will also include weather sensors in their design in order to calculate the temperature-corrected Performance Ratio of the HRES and GPV from 15 kW of inverter capacity. The photovoltaic system performance shall be measured as per IEC 61724 or equivalent.

2.9.2 Managerial Monitoring System

This monitoring system will be used for public/managerial display purposes and will need to monitor all inputs and outputs of a system as well as environmental aspects if requested. The front end will be available on a webpage or app to display electrical, financial and environmental aspects of the system while also providing access to historical data. The below data points will be measured and displayed.

- Energy and power input to power supply system
 - Solar, Grid, Generator (kWh/kWp) fossil fuel burn (litres),
- Energy and power output from a system
 - Full load, critical load systems etc
- Energy storage system
 - State of charge
 - Temperature

- monitoring through communication ports and BMS
- Environmental Aspects
 - Solar irradiance, temperature, cell temperature

The online dashboard will need to be able to display a minimum of the following:

1. Live and historical charts/data for all electrical data points from all electrical inputs and outputs
2. Live and historical charts/data for all storage data points
3. Live and historical charts/data for all fossil fuel use
4. Live and historical charts/data for all environmental data points

As UNHCR is aiming to collect data from all sites and compile for an overall display, all measuring devices need generic pulse outputs. These outputs can be transferred by the Supplier into SCADA or similar generic control and data collection architecture where it can be used for display purposes by the Supplier or accessed by UNHCR to display in a worldwide system as needed. This will predominantly be a one-way system used as a live monitoring tool, however, a two-way Monitoring and Control system could be used where it presents no threat to UNHCR IT Security Systems or risks sending corrupted commands to power supplies due to poor internet connection. For all monitoring systems, the Supplier will provide UNHCR with a super-user or administrator account which may add and delete other users as needed.

2.9.3 Charging Metering and Monitoring systems

Listed below are two types of metering systems that may be used and may need to be monitored over the internet in certain projects.

2.9.3.1 Net-Metering (Reversible Energy-Meters)

Most renewable energy projects implemented within UNHCR operations will take place in countries where the national energy policies do not provide for customers to feed-in excess energy into the electricity grid and get incentivized for it. However, there could be cases where UNHCR will request the Supplier to install reversible energy meters that can measure both energy from the electricity grid and the energy fed into the electricity grid. The reversible energy meters will have the capacity to measure the following parameters:

- Instantaneous voltage (V)
- Instantaneous online current (A)
- Instantaneous user peak-power demand
- Highest user peak demand within a 12 month span
- Daily user energy consumption from grid
- Daily feed-in grid energy (user into grid)
- Monthly user energy consumption from grid
- Monthly feed-in grid energy (user into grid)
- Annual cumulative user consumption from grid
- Annual cumulative feed-in energy (user into grid)

2.9.3.2 Multi-user Energy Metering

UNHCR may be providing energy power supplies in multi-user office buildings or compounds such as common UN premises. In such case, the Supplier will be requested to provide a multi-level energy metering system, which would accurately capture energy consumption separately for each user and help allocate energy costs within the premise. The multi-user energy metering will be

available for single-phase and/or three-phase users. The multi-user energy metering system will be equipped with the following features:

- Instantaneous voltage (V)
- Instantaneous online current (A)
- Integrated monthly energy allocation application
- Web-enabled access to user energy information
- User information configurable including energy cost USD/kWh
- Instantaneous user peak-power demand
- Highest user peak demand within a 12 month span
- Daily energy production and/or consumption
- Monthly energy consumption
- Annual cumulative energy consumption

2.10 Solar Panels Cleaning Kit

The cleaning of solar panels remains one of the biggest challenges in field implementation of solar PV projects. Very often the staff struggle to find adequate equipment locally for cleaning the installation. Therefore, the Supplier will be required to provide appropriate tools to enable the operation team to have the means for cleaning the solar panels. The cleaning kit will encompass but not be limited to the following items:

- Cleaning brush
- Water flow-through pole: $\geq 1.2\text{m}$
- Water flow-through extension pole: ≥ 3.8
- Microfiber wash sleeve
- Microfiber cleaning cloth
- Printed assembly instructions
- Storage bag

The cleaning kit will also include:

- Pressure washer: $\geq 2200\text{psi}$ (122-bar), 220V-50Hz
- Garden hose: $>50\text{m}$, (\varnothing -sized per pressure washer and brush)

Safe height accessibility is also an issue when it comes to cleaning solar panels. Therefore, UNHCR may request the supply of scaffolding systems along with safety harnesses for connection to designated attachment points as described in section 2.5.

2.11 Cabling

Cabling shall follow the BS 7671:2018 standard. Where superior or equivalent standard are applicable in countries where the BS 7671:2018 standard is not usually followed then the said standard can be followed instead. Bidders will inform in their proposal which cabling standard is being followed for each of the countries where they can supply PPS.

Cabling is expected to be laid underground, in a concrete trench wherever possible. Underground cables will have at least one layer of XLPE. Overhead cables shall be placed in cable trays. The core of cables shall be made of copper for better performance with regards to voltage drop.

Bidders are required to propose a structural drawing of a typical trench.

The PPS shall include drawings and specifications of a typical cabling work.

The distances between the various components of the future power systems are not known. Therefore, cabling has been broken down into the following categories:

- AC cable: 0-10m
- AC cable: 11-30m
- AC cable: 31-60m
- AC cable: >60m
- DC cable: 0-10m
- DC cable: 11-30m
- DC cable: 31-60m
- DC cable: >60m

The below table summarise the suggested maximum permissible cable voltage drops (Vdrop):

Battery to charge controller	<1%
Battery to inverter	<1%
Solar module to charge controller / string inverter	<3%
Inverter to MDB	<5%

Bidders will indicate what Vdrop values they intend to respect in the design of the various PPS.

Bidders will also provide calculations to confirm the above voltage drop values.

2.12 Tool Kits

Technicians may not always have the correct tools and consumables to install and maintain systems correctly and in a timely manner. Therefore, hand tool kits with toolboxes (including battery drill and bits if needed) and consumables must be available for the installation and maintenance of the units.

Section 3. Project Life Cycle

Section 3 **Error! Reference source not found.** is given as an overview of what will be requested during the secondary bidding process. Bidders are not requested to provide any technical or financial returnable related to this section. The requirements described in this section are nevertheless applicable to Section 7 Case scenarios.

For each project Bidders will be requested to provide detailed planning, from the receipt of a PO until testing and commissioning.

3.1 Phase 1 – Manufacturing and Assembling

When the design/tender phase is closed out, and on instruction from UNHCR, and if the PPS needs to be manufactured or assembled (in some cases it maybe selection from stock) the Supplier will initiate the manufacturing and assembling phase. If needed during this phase the Supplier will process all orders for the acquisition of third-party equipment manufacturers before executing the overall energy solution integration through the assembling of all the equipment. PPS involve prewiring, manufacturing, assembling, and/or preconfiguring equipment, then all works including any testing and pre-commissioning will be undertaken at the Supplier's factory, where UNHCR may decide to attend the process at any time. On completion, the Supplier shall submit

to UNHCR certification that the manufacturing and/or assembling of the PPS has been executed in accordance with third-party manufacturer requirements and the standards and designs approved in previous stages. The Supplier shall complete the phase before the deadlines identified in the contract document and will submit the following documents:

1. Drawings, specifications, and instructions/method statements for the installation phase.
2. A factory inspection and test plan, identifying all tests and inspections that have been carried out by the Supplier with emphasis on failures, defects and all potential problems.
3. Operation sequences and energy supply priority configuration, including installation requirements and instructions for proper installation.
4. Complete bill of materials and parts lists, identifying the quantity and type of all materials included in the assembling of the PPS.
5. A testing & commissioning plan, identifying all tests and inspections the Supplier will be required to carry out during the installation in UNHCR's premise.
6. The manuals as per 4.2 Manuals
7. Warranty terms and all remote support and emergency contacts.

Depending on the project, UNHCR might ask for a set of spare parts to be included in the shipment.

3.2 Phase 2 – Supply (shipping)

The Supplier will be required to ship the non-containerized PPS in Shipper Owned Containers (SOC) INCOTERM to avoid unnecessary demurrage/port charges costs.

3.3 Phase 3 – Installation, Testing and Commissioning & Training

3.3.1 Installation

The Supplier will be requested to execute necessary administrative procedures (permits and licencing) and the installation works of the procured PPS.

When the Supplier is in charge of Phase 3, he will formally agree a start date with UNHCR who will ensure availability of the site prior to commencement of the works. The Supplier will then mobilize the required technical expertise to execute the works on site.

The Supplier may subcontract a local company to execute installation works, however in such case he shall provide competent, trained and certified experts to supervise the works. The Supplier's technical expert shall inspect works carried out by the subcontracted company and make sure these are done in accordance with the requirements of the Supplier's documentation. Inspections shall be carried out in accordance with the submitted inspection and test plan. The Supplier's technical expert shall remain on site for the entire duration of the installation and commissioning phase. The Supplier shall be fully responsible for the following activities:

- Installation and supervision to ensure all relevant connections of the PPS are implemented in accordance with the approved design and Supplier's method statements
- Provide reports on progress and project issues to UNHCR
- Checking all additional electrical materials to be used on the project prior to their installation. When some elements, tools, components or parts of the PPS are missing and were not included in the supply (within the containers) or some of them are defective, the Supplier must inform immediately UNHCR
- The replacement of defective elements or the supply of missing elements; this shall be carried out at the Supplier's own expense (including manufacturing costs and transport/supply costs to the site). A detailed report detailing the event, the cause that

damaged the element and the proposed course of action to replace or repair the element shall be prepared by the Supplier's Technicians and submitted to UNHCR within 2 days from when the issue arises

- If during installation works it appears that an element or elements of the PPS requires replacement due to errors in design or fabrication, the replacement of incorrect elements and delay costs to the main works solely due to their omission/error shall be done by the Supplier, and costs shall be borne by the Supplier
- To execute test and commissioning after installation of the PPS. Results of the test will be included in the Testing and Commissioning report.

In the event that the installation works cannot proceed due to the delays arising from the Supplier, the Supplier shall be liable to repay these costs to UNHCR.

Delay penalty clauses are detailed *General Conditions of Contract for Civil Works*, in **Annex C Legal Documentation and Requirements**

The Supplier will provide an as-built design upon completion of the work.

3.3.2 Testing and Commissioning

Bidders shall provide Testing and Commissioning report templates that they intend to use for the various PPS.

Upon completion of the installation, and after the PPS has been tested and commissioned, the Supplier will deliver a commissioning certificate marking the closeout of all phases. UNHCR will accept completion when:

1. The installations have been completed fully in compliance with the requirements, and confirmed through a completion report, including the testing & commissioning results, by the supervisory expert;
2. The tests and commissioning have been successfully executed (with positive results) and have been certified by the Supplier; and
3. A Commissioning Certificate has been issued.

With the Commissioning Certificate the Supplier acknowledges that the PPS has been installed and completed in accordance with the agreed technical specifications and his method statements, and that the whole PPS is ready, properly configured, operable and reliable with all electrical safety precautions and it can be taken over and used by UNHCR. Beyond the signature of the completion certificate and the takeover of the PPS by UNHCR, the Supplier will still be considered responsible to complete any outstanding works or repair any damages that would have arisen during the installation works.

In case the power system capacity is increased at a later stage, a complete testing and re-commissioning of the whole power system shall be done, and re-commissioning certificate to be issued.

3.3.3 Training

Bidders shall describe a training plan for the UNHCR personnel in charge of operating the PPS to be conducted upon completion of construction works.

The objective of the training will be to (i) provide the appointed UNHCR staff with a basic understanding of the PPS and (ii) teach the appointed UNHCR staff to read the PPS signals (e.g. through the PV and battery inverters displays) and identify what part of the PPS is malfunctioning or failing at any time, (iii) act as focal points between UNHCR and the AS Supplier during Level 1 of the corrective AS, 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, safety, controlling, monitoring, proper use and care (cleaning).

The Supplier shall provide an AS 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.

The detailed training requirements will be provided during the secondary bidding process.

Section 4. Drawing and Documentation

Section 4Section 3 **Error! Reference source not found.**is given as an overview of what will be requested during the secondary bidding process. Bidders are not requested to provide any technical or financial returnable related to this section.

4.1 General

4.1.1 Documentation formats

All documentation shall be supplied by the Supplier as PDF and native formats as detailed below:

- Documents – MS Word.
- Specifications – MS Word.
- Schedules – MS Excel.
- Program – MS Project or MS Excel.
- Drawings – AutoCAD.

4.1.2 Units of Measurement

Metric units of measurement (System International) shall be used on all contract documentation. Angular measurement shall be in degrees with 90° degrees comprising one right angle.

4.1.3 Language

All manuals and drawings shall be available in **English, French and Arabic**. (only the English versions should be submitted with the offer). These languages shall be used on all drawings and in all documents and wherever anything is required by the Contract, to be written, marked, printed or engraved.

4.2 Manuals

The selected Supplier shall provide the following manuals:

1. Quality Assurance Manual.
2. Safety Manual.
3. Operations Manual.

4.2.1 Quality Assurance Manual

The Supplier shall operate and maintain a quality management system conforming to ISO 9001 or approved equivalent. The Supplier shall take and keep records of quality inspections and tests as evidence that the requirements of the Contract have been met. The Quality Assurance Manual shall include but not be limited to the following:

1. Project management and organization chart
2. Design and as-built plan
3. Quality plan
4. Qualification and experience of key personnel
5. Sub-supplier quality assurance plan
6. Inspection and test plans
7. Field installation check lists
8. Instrument test certificates
9. Statutory certificates
10. Reports on non-conforming work and corrective action
11. Results of all inspections and tests undertaken prior to delivery.

During the course of the Contract the Supplier shall register and maintain all quality documentation in an up-to-date centralized file and make this available for inspection by the Engineer or his representative at all reasonable times.

4.2.2 Safety Manual

The Supplier shall provide a safety manual that will include the necessary information, instructions and procedures intended to ensure the safe operation of the power system.

The Safety manual shall be produced in good quality A4 size paper and placed in a suitable A4, D Type, 3-hole ring-binder. No ring-binder shall have rings greater than 50mm. The Bidders shall provide the compiled PDF copies with the technical offer.

4.2.3 Operations Manual

The Supplier shall provide an Operations Manual for the PPS as a whole, and it shall include manuals for all equipment supplied. The information required from the Supplier shall conform to the standard requirements detailed below:

4.2.3.1 General

The format of the Operations Manual or information contained therein, shall be provided in electronic and paper format and comprise instructions, detailed diagrams (including the earthing system) and drawings which shall be sufficiently comprehensive to facilitate the training of the staff and to enable the operation of the PPS to be performed in a safe and efficient manner. Two (2) hard copies and two (2) compiled PDF copies on USB memory sticks shall be supplied. They shall contain full documentation of the goods and shall be in a form agreed prior to binding. The Operations Manual shall be produced in good quality A4 size paper and placed in a suitable A4, D Type, 3-hole ring-binder. No ring-binder shall have rings greater than 50mm. The Bidders shall provide the compiled PDF copies with the technical offer.

All drawings shall be of A3 size paper and placed in a suitable A3 (landscape), D Type, 3 hole ring-binder. No ring-binder shall have rings greater than 50 mm. The sections of manuals shall contain the following as a minimum requirement:

4.2.3.2 Index

An index which conveniently and logically sets out the format of the Operations Manual. Part of this index shall be a contents tick sheet. All items shall be listed regardless of actual document contents. Items already included shall have a tick in the appropriate box.

4.2.3.3 Design

A design and technical section which shall include but not be limited to;

1. Physical and electrical layout of the designed internal arrangement
2. Detailed descriptions of equipment components and systems including detailed drawings and block diagram.
3. Technical data for the PPS as installed.
4. Design and material limits for loadings such as pressure, temperatures, voltage,
5. current, operating limits, settings, etc.
6. Test and performance data.
7. Details of electrical circuits, accompanied by schematic and logic diagrams, indicating
8. the physical location of the equipment parts.
9. A list of alarms detailing alarm initiator location and setting for alarm operation and reset.
10. A comprehensive list of parts for each item of installed PPS.

4.2.3.4 Installation

A general description of the installation in regard to location and function. The description should include all process parameters associated with the installation and should be supported by general arrangement drawings.

4.2.3.5 Procedures

The operating procedures shall be set out in step-by-step instructions with each step numbered in correct logical sequence. Reference to the labels used for the PPS shall be included. It shall include;

1. Pre-start check lists covering all the individual PPS.
2. Starting procedures.
3. In service checks and limits including routine test procedures.
4. Shutting down procedures.

4.2.3.6 Operation

Operating instructions are required for all items of equipment for start-up, normal operation, shutdown, standby, emergency action, and on load and off load testing procedures, and shall contain the operating procedures of the systems, in addition to the emergency and abnormal conditions procedures.

1. Operating limits, normal, abnormal and hazards.
2. Procedures detailed under the heading of "Emergency Action" shall include:
 - a. Actions upon receipt of alarm/alarm condition/appropriate action.
 - b. Emergency procedures for each major fault situation.
 - c. Fault conditions.
 - d. Diagnostic procedures.
 - e. Initial actions.
 - f. Follow up action and operation.
 - g. Loss of electrical supplies associated with important auxiliaries, controls and

h. instrumentation

4.2.3.7 Test Documentation

The Operations manual shall include an Appendix for insertion of;

1. Factory Acceptance Testing (FAT).
2. All commissioning reports, site calibration documents, data recorder logs / scope traces and test sheets to be included in this section.

4.2.3.8 Certificates and Warrantees

1. Manufacturers' written warranties and guarantees.
2. Product type test certificates.
3. Electrical Certificates of Compliance

Section 5. After-Sales Services (AS)

This section is given as an overview of what will be requested during the secondary bidding process. Bidders are not requested to provide any technical or financial returnable related to this section.

5.1 General description

After the testing and commissioning, the Supplier will perform an After-Sales Service (AS) contract. During the AS 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 AS does not include operational tasks, and regular cleaning of the solar panel. The three types of power systems must be automatic, with the most basic operational task being done by the UNHCR local staff upon their training.

HRES and BESS are especially sensible since the power availability in the offices depends on the system itself, therefore the AS needs to respond to system failures based in levels of importance. Three major types of failures are categorised depending on the impact they will cause to UNHCR power supply:

Type A – Major failure	<p>A.1) PPS blackout.</p> <p>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.</p> <p>A.3) Any failure that puts UNHCR personnel's health and safety at risk.</p> <p>A.4) Any other failures/malfunctions not mentioned here and considered to be of high priority by UNHCR.</p>
Type B – Medium failure	<p>B.1) Failures that lead to a decrease in the PV energy output of more than 20% (GPV and HRES).</p> <p>B.2) Any other failures/malfunctions considered to be of medium priority by UNHCR.</p>

Type C – Minor failure	<p>C.1) Any other minor failures.</p> <p>C.2) Any other failures/malfunctions considered to be of minor priority by UNHCR.</p>
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For corrective maintenance, shall any part of the PPS fail or malfunction for any reason within the responsibility of the Supplier, two levels of intervention are defined:

1. Level 1 – remote assistance and troubleshooting through local UNHCR staff. The AS Supplier will establish communication with UNHCR staff as soon as a failure or energy output problem on the PPS is identified. Through IT communications, once the energy service is secured/restored, the AS Supplier will work together with the UNHCR staff in understanding, troubleshooting, and restoring the correct operation of the PPS. The Supplier will have a maximum time to resolve the issue that is defined in the table above. Restoration times. If, after the prescribed time this first level of corrective remote AS has not resulted in the issue being solved, the AS Supplier will be required to trigger the level 2.
2. Level 2 – on-site assistance and troubleshooting through the Supplier's own staff. The AS Supplier will be required to deploy to site the necessary skilled labour to further investigate the issue, fix it and restore the service. The Supplier will have a maximum time to resolve the issue that shall be given during the secondary bidding process.

5.2 Liabilities and responsibilities

The AS Supplier will be responsible and liable for the following within the AS contract period:

- Perform all the AS tasks as specified in this section
- Replace any equipment that breaks down or malfunctions within the warranty period at its own cost
- Full compliance with the health and safety requirements as per the UNHCR Health and Safety Requirements for Contractors.
- The Supplier has an obligation to notify UNHCR Employer when upgradable software and hardware will be available.

The AS Supplier 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 is not capable of delivering fuel to the site
- UNHCR staff or third parties damage or destroy part of the PPS assets
- UNHCR staff or a third party damages or destroys part of the distribution network assets that affects the correct energy delivery of the PPS

5.3 AS tasks

Preventive Maintenance Service Description		
PV Arrays		
Item	Activity	Frequency
1	PV module cleaning according to manufacturer recommendations.	Annual ³
2	PV module visual inspection and infrared inspection.	Annual

³ Water will be provided by UNHCR

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, maximum 10 years
10	Replace surge protection devices.	As per manufacturer
Lithium Iron Phosphate batteries and BMS (if applicable)		
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
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
Diesel generator (if applicable)		
Item	Activity	Frequency
1	Inspect the lubricating system (oil leakage, level of engine oil) and correct or provide any replacements.	As per the manufacturer's instructions
2	Inspect the cooling system (oil leakage, radiator block, cooling fluid, antifreeze, belt status), and correct or provide any replacements.	As per the manufacturer's instructions
3	Inspect the air inflow system (Oil gas, resistance of air cleaner, pipe fittings, and joints) and correct or provide any replacements	As per the manufacturer's instructions
4	Inspect the fuel system (leakage, quantity of fuel, pump nozzle, fuel pipe and joints, oil pump) and correct or provide any replacements.	As per the manufacturer's instructions
5	Inspect the exhaust system (air leakages, resistance of exhaust) and correct or provide any replacements.	As per the manufacturer's instructions

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

The duration of the AS is requested for five years. An option to extend it shall be proposed by Bidders.

5.4 AS reporting

The Supplier shall perform remote monitoring during the AS period. An annual AS 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 (if any), and the utility grid (if any).
- Temperature-corrected Performance Ratio of the PV generator for systems equal or above 15 kW, and as per IEC TS 61724-2 or IEC TS 61724-3
- Plant availability of the PV generator as per IEC TS 63019:2019.
- Number of grid outages and their duration (if applicable).
- Unscheduled down-times and their duration.
- List of faults and alarms.
- List of AS tasks undertaken.

Together with the annual AS 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 (if any), 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 the weather sensors (in W/m2).

Bidders will provide templates that will be used as part of the AS reporting task. The templates proposed shall cover the above parameters.

5.5 Spare parts and AS materials

The following spare parts shall be provided.

Parameter	Requirement
PV modules	at least 5% of the total number of modules.
PV connectors	at least 5% of the total number of connectors.
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 25 years of operation. Spare parts must be available on site for the following 1 year of operation.

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

The Supplier should provide a safe storage enclosure for spare parts, which explains how safe storage will be ensured in the storage place available at the compound.

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 AS contract.

Section 6. Warranty Condition

For every PPS procured and installed the Supplier will provide Basic Warranty for minimum **two (2)** years and for the complete integrated PPS if delivered in enclosures. During these two years, the Supplier will ensure that defects, breakdowns and faults are mitigated with the relevant workaround whether it is troubleshooting, repair or equipment replacement. The Supplier will be responsible for any replacement of damaged equipment and their shipment to UNHCR's country of operation and premise. During the two-year warranty period the Supplier will be responsible for, at least:

- Tasks detailed in Section 5 After-Sales Services (AS)
- Remote detection and troubleshooting of faults on the system
- Delegation of an expert onsite for critical defects which cannot be resolved by the local staff and would put the system out of operation.
- Online 24hrs support via email
- Regular communication support via email
- Replacement and shipping of defect equipment to UNHCR's premise
- A onetime annual onsite maintenance and re-commissioning of the full PPS.

Outside of the two-year warranty for the full integrated PPS, the Supplier will ensure as well that manufacturer extended warranty is provided to UNHCR for each individual equipment comprised in the PPS. The extended manufacturer warranty will be for a minimum of **five (5) years** for each equipment unless specified otherwise in the specifications of the equipment in this Annex B. The minimum warranty for the PV modules is set to **ten (10) years**.

The Supplier shall include the Warranty Terms for the full integrated systems and the manufacturer's warranty information for the individual energy equipment.

The Supplier is also encouraged to make available paid warranty extensions that UNHCR may wish to purchase, these extensions will adhere to all previous points.

The PV mounting structure shall be under warranty for 15 years (structural and corrosion); and 5 years for the leakages.

Section 7. Case scenarios

In Section 7, Bidders are requested to provide three fully designed power solutions and the complete project package, as per Section 3 Project Life Cycle, and Section 5 After-Sales Services for three hypothetical offices hypothetically situated in Kakuma, Kenya.

The required technical propositions for each of these three case scenarios shall be used to evaluate each Bidder's ability to comply with the specifications detailed in the above sections. Bidders shall complete the BOQ for each case scenario as this will also be part of the financial evaluation.

These three case scenarios are representative of some of the projects that could be required of the awarded Bidders in the near future.

The necessary parameters to use the pre-design power solutions as defined in Section 1 General Requirements Section 2 Product specifications – Main Components and provide the final design of power solutions are provided for each case scenario.

It is accepted that Bidders shall make assumptions where technical information is missing. Awarded Bidders will be provided with more detailed technical and site-specific information for each project. The assumptions taken by Bidders in these three case-scenarios shall be detailed in the proposals.

7.1 Case scenario 1 - BESS - 30 kW - containerized

7.1.1 Technical requirements

This hypothetical registration office hosts 10 staff and is connected to the national grid. This grid is mostly powered by renewable energy but it is unreliable. The staff are present during the day. The only loads during the night consist of security lights and the security guard office. In order to reduce the diesel consumption from the backup generator (16 kVA, three-phase) and after analysis of the office load profile and the national grid's characteristics it was decided that a **30 kW BESS** is required for this office. The below image shows the compound where the office buildings are situated. There is ample space to install the container right by the main distribution board (within 10 meters).



Bidders are hereby requested to provide a finalized design for the chosen PPS and as per the specifications given in Section 1 General Requirements and Section 2 Product specifications – Main Components.

Any other information that may be required by Bidders in order to finalize the design of the power solution for this particular project shall be assumed and assumptions shall be clearly detailed in the technical proposal. The proposed finalized design shall be ready for implementation.

7.1.2 Project Life Cycle applied to one case scenario

Bidders are requested to provide the documentation relevant to Section 3 Project Life Cycle. In particular, Bidders will provide:

- A detailed planning starting with the reception of a PO and ending with the testing and Commissioning
- A description of the installation methodology
- A detailed description on the training component (planning, content, etc.)
- A testing and commissioning report template

7.1.3 Drawing and Documentations applied to one case scenario

Bidders are requested to provide the documentation relevant to Section 4 Drawing and Documentation. These documents can be relatively standard and not fully tailor-made for this particular case scenario. In particular, Bidders will provide the digital copies only of the of the following manuals:

- Quality insurance manual
- Safety manual
- Operations manual

7.1.4 After-Sales services requirements

Bidders are requested to provide a detailed AS plan including templates and detailed methodology. The documents provided will detail how Bidders intend to comply with the requirements detailed in **Error! Reference source not found. Error! Reference source not found. and Error! Reference source not found. Error! Reference source not found..**

The required restoration times for this particular project are defined in the below table:

	Level 1 Restoration time	Level 2 Restoration time
Type A	24 hours	48 hours
Type B	2 days	5 days
Type C	5 days	10 days

7.2 Case scenario 2 - 60 kW hybrid – enclosure

7.2.1 Technical requirements

This hypothetical office consists of about 400 m2 office space in concrete buildings inside a 2700 m2 fenced premise. 57 staff are working there. The national grid serving this office is very unreliable, as illustrated by the running time of the diesel generator: 19.5 hours per day on average. It is also a grid that is mostly powered by fossil fuels, thus the need for a PV system to reduce the carbon footprint of the office.

The generator (model: WPS150BS: Prime Running Power: 150 kVA; three-phase) is situated in the north-west side of the compound, 10 meters away from the main distribution board.

After analysing the energy profile of the office and the national grid's characteristics it was concluded that a **60 kW HRES** is required.

The below images highlight the location of the compound and office buildings, and the potential usable area for the installation of a rooftop installation of the PV modules:



The system is required in enclosures. A room of 5x10 meters next to the main distribution board can be used to install the various enclosures.

In this case scenario, it is assumed that the concrete rooftops are clear from any obstacles and can be safely used to mount the solar modules.

The design of the mounting structure shall come with a high level of detail and it is recommended Bidders validate their design with structural analysis using a dedicated software.

Bidders are hereby requested to provide a finalized design for the chosen PPS and as per the specifications given in Section 1 General Requirements and Section 2 Product specifications – Main Components.

Bidders are also requested to provide the documentation described under Section 3 Project Life Cycle.

Any other information that may be required by Bidders in order to finalize the design of the power solution for this particular project shall be assumed and assumptions shall be clearly detailed in the technical proposal. The proposed finalized design shall be ready for implementation.

7.2.2 Project Life Cycle applied to one case scenario

Bidders are requested to provide the documentation relevant to Section 3 Project Life Cycle. In particular, Bidders will provide:

- A detailed planning starting with the reception of a PO and ending with the testing and Commissioning
- A description of the installation methodology
- A detailed description on the training component (planning, content, etc.)
- A testing and commissioning report template

7.2.3 Drawing and Documentations applied to one case scenario

Bidders are requested to provide the documentation relevant to Section 4 Drawing and Documentation. These documents can be relatively standard and not fully tailor-made for this particular case scenario. In particular, Bidders will provide the digital copies only of the of the following manuals:

- Quality insurance manual
- Safety manual
- Operations manual

7.2.4 After-Sales services requirements

Bidders are requested provide a detailed AS plan including templates and detailed methodology. the documents provided will detail how Bidders intend to comply with the requirements detailed in **Error! Reference source not found. Error! Reference source not found.** and **Error! Reference source not found. Error! Reference source not found.**

The required restoration times for this particular project are defined in the below table:

	Level 1 Restoration time	Level 2 Restoration time
Type A	24 hours	48 hours
Type B	2 days	5 days
Type C	5 days	10 days

7.3 Case scenario 3 - 150 kW Grid tied

7.3.1 Technical requirements

This hypothetical office hosts 105 staff and is connected to a reliable but “dirty” grid (i.e., mostly powered by fossil fuels).

After analysing the energy profile of the office and the national grid’s characteristics it was concluded that a **150 kW GPV** is required.

The below images highlight the compound perimeter and the area that has been identified to install the PV modules:



The main distribution board is situated in the north-west side corner of the compound, 50 meters away from the north side of the area highlighted in yellow. The structure shall be an elevated mounting structure with a height of 5 meters.

The design of the mounting structure shall come with a high level of detail and it is recommended Bidders validate their design with structural analysis using a dedicated software.

Bidders are hereby requested to provide a finalized design for the chosen PPS and as per the specifications given in Section 1 General Requirements and Section 2 Product specifications – Main Components.

Bidders are also requested to provide the documentation described under Section 3 Project Life Cycle.

Any other information that may be required by Bidders in order to finalize the design of the power solution for this particular project shall be assumed and assumptions shall be clearly detailed in the technical proposal. The proposed finalized design shall be ready for implementation.

7.3.2 Project Life Cycle applied to one case scenario

Bidders are requested to provide the documentation relevant to Section 3 Project Life Cycle. In particular, Bidders will provide:

- A detailed planning starting with the reception of a PO and ending with the testing and Commissioning
- A description of the installation methodology
- A detailed description on the training component (planning, content, etc.)
- A testing and commissioning report template

7.3.3 Drawing and Documentations applied to one case scenario

Bidders are requested to provide the documentation relevant to Section 4 Drawing and Documentation. These documents can be relatively standard and not fully tailor-made for this particular case scenario. In particular, Bidders will provide the digital copies only of the of the following manuals:

- Quality insurance manual
- Safety manual
- Operations manual

7.3.4 After-Sales services requirements

Bidders are requested provide a detailed AS plan including templates and detailed methodology. the documents provided will detail how Bidders intend to comply with the requirements detailed in **Error! Reference source not found. Error! Reference source not found. and Error! Reference source not found. Error! Reference source not found.**

The required restoration times for this particular project are defined in the below table:

	Level 1 Restoration time	Level 2 Restoration time
Type A	24 hours	48 hours
Type B	2 days	5 days
Type C	5 days	10 days

Section 8. Bill of Quantities

8.1.1 BOQ in Technical returnable

The Supplier shall prepare a complete Bill of Quantities (BoQ) for the project as per the template in **Annex E VI. BOQ _ Pre-designed power solutions.**

Depending on the Bidder's equipment particularity additional items may need to be added in the BOQ. This can be done under the section "Spare/miscellaneous parts".

PLEASE NOTE: NO INFORMATION REGARDING PRICING SHALL BE INCLUDED IN THE TECHNICAL OFFER OTHERWISE THIS WILL INVALIDATE YOUR BID

8.1.2 BOQ in Financial returnable

The Supplier shall prepare a complete Bill of Quantities (BoQ) for the project as per the template in **Annex F_BOQ _ Pre-designed power solutions**.

Depending on the Bidder's equipment particularity additional items may need to be added in the BOQ. This can be done under the section "Spare/miscellaneous parts".

Prices in the financial offer shall be given **ex-works**.

The installation and AS for three cases scenarios need to be quoted for in the BOQ. Bidders will detail all individual items necessary to carry out each installation including all labour. The list shall be prepared adding new or removing not required items from the proposed generic BoQ as deemed relevant. The Supplier shall provide full details of the insurance and any other expenses necessary to carry out the installation of the PPS.