

## TERMS OF REFERENCE (TOR)

<b>Project</b>	Solar Installation at the County Service Centres
<b>Location</b>	Lofa (Voinjama), Gbarpolu, Bomi, County Service Centres
<b>Geographical coordinates</b>	7.061944°, -10.490000° (07°03'43", -10°29'24"), 6.886111°, -10.811667° (06°53'10", -10°48'42"), 8.421667°, -9.752500° (08°25'18", -09°45'09")
<b>Time zone</b>	UTC+00, Africa/Monrovia [GMT]
<b>Elevation</b>	14 m

This TOR sets the requirements for the supply, installation, commissioning, and after-sales services for Off-Grid Solar PV for Lofa (Voinjama), Gbarpolu (Bopolu) and Bomi (Tubman burg) Counties.

### The scope of the project includes:

1. Design, supply, installation, testing commissioning and user training of:
  - **Site 1 – One off-grid PV generator of 15 kWp with 30 kWh of total battery capacity. AC inverter 8.0 KVA.**
  - **Site 2 – One off-grid PV generator of 15 kWp with 30 kWh of total battery capacity. AC inverter 8.0 KVA.**
  - **Site 3 – One off-grid PV generator of 20 kWp with 85 kWh of total battery capacity. AC inverter 15.0 KVA.**
2. After-sales services of 1 year including maintenance (preventative and corrective) and technical support (on-site and/or remote), continued online system and performance monitoring.
3. Training on operations and maintenance (operator and end-user), including provision of operation and maintenance documentation.

### **Functionalities and general requirements:**

OFF Grid Photovoltaic power system with battery consists of **PV generator, module mounting structure, MPPT battery charger<sup>1</sup>, battery inverter, surge overvoltage protection, LiFePO4 battery bank with BMS battery Management system, data logger with its sensors, and system monitoring via GSM.**

Solar array will be roof mounted

The batteries, power electronics and ancillaries shall be in a technical cabinet and shall be pre-assembled and tested in a Factory/Lab environment before shipment.

OFF Grid Solar PV system will operate with batteries and must be designed with necessary features to supply directly the power generated by PV to the loads while simultaneously charging the batteries for later usage.

The battery banks of these systems have been sized to provide an autonomy ranging between 1.5 and 2.5 days of the rainy season

The equipment's manufacturer shall be a reputable entity and active in the solar sector for at least 5 years. It must have a quality (at least ISO 9001) and Environmental (at least ISO 14001) management system certification. All equipment installed shall be labelled with the equipment's brand name, model and other. The label should be highly discreet and unobtrusive, and readable only from very near distances of less than 1m.

The supplier shall carry out all civil and electrical works for solar solutions to be compatible electrical systems and distribution lines. They shall also ensure that each & every piece of electrical equipment & apparatus shall be connected to the main earth bus by means of branch main connection of earth continuity conductors. For the actual work to be carried out at the site bidder needs to execute the work in consultation with UNDP representative/Inspector.

The Supplier shall provide all necessary components except otherwise specified, and accessories as well as manpower, etc., at the Supplier's own expense to install complete operational units. The equipment shall conform in capability, strength, quality and workmanship to the accepted industry standards and relevant international quality standards. Any additional works not covered above, but necessary for the functioning of the system and required as per specification incorporated. The works of minor nature, which are not mentioned, shall be incorporated by the bidder.

The Supplier shall perform a detailed site assessment visit to the sites and confirm the suitability of the solution. The supplier will also inspect the solution and/or components prior to the installation and prepare an installation plan to collate the amount of work to be done.

Erection and commissioning of the supplied system on the specified site and do any other work urgently required as per site conditions.

The Supplier should remove the waste of works undertaken including the trash and dirt resulting from the works and attend to any snags caused by workmanship. The site should be returned to its initial state of cleanliness.

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<sup>1</sup> MPPT Charger can be a separate unit or built-in

## **Project Deliverables:**

### **Deliverable 1:**

- a) Detailed Planned Schedule of works.
- b) Detailed site survey report, including:
  - i. Identification for components' location(s),
  - ii. Identification of best available climatic data to be used in system sizing (at least monthly values of solar irradiance and temperature),
  - iii. Photo documentation and assessment of any shading objects,
  - iv. Review and calculation of consumption profile given by UNDP (appliances and daily use, including surge loads),
  - v. Selection of a suitable mounting system that does not compromise the integrity of the roof/ground.
- c) Design sizing and documentation, including (where applicable):
  - i. Site specific layout of the solar array.
  - ii. Appropriate sizing in piping lengths and sections for the entire installation.
  - iii. Bill of material (BoM) inclusive of technical specifications for the main components.
  - iv. Shop Drawings (*e.g. single line diagram, wiring layout including distances; protections; components etc.*);
- d) A Health, Safety and Environmental Management Plan.
- e) A description of the proposed performance and acceptance testing procedure that will be undertaken during commissioning phase.
- f) A letter certifying the compliance with requirements on warranties, spare parts and standards, etc.
- g) In case the PV modules are roof-mounted, supplier will take responsibility for structural integrity of the roof.

### **Deliverable 2:**

- a) Pre-assembling and wiring: mounting of inverters, controllers and the likes done as much as possible in a factory/lab environment.
- b) Supply and delivery of the equipment at supplier Monrovia warehouse with all components needed for project delivery and operation.

### **Deliverable 3:**

- a) Installation of complete Solar PV Plant with all components required for operation, and implementation of all related performance testing.
- b) Formal signed User Acceptance Test (UAT) and Commissioning of the Solar PV Plant, etc. Report shall be approved by the Project representatives beforehand.
- c) Submission of final Technical Report, inclusive of:
  - i. As-built drawings,
  - ii. Technical description of the final solution
  - iii. Testing/Commissioning report (inclusive of final testing and values),
  - iv. Datasheets,
  - v. Complete bill of materials (BOM),
  - vi. Static verification of mounting structure (if applicable),

- vii. Warranty certification/documentation for the main components.
- d) Submission of photos, videos and visual material of the final system installed.
- e) Training on Operation and Maintenance (O&M) of the installed equipment for the beneficiaries' representatives (end users and beneficiaries' staff maintenance crews) and provision of training materials and O&M manuals. Inclusive of:
  - i. Basics on the Solar PV system commissioned (components and operation)
  - ii. Basic shutting-down procedures (in case it is necessary)
  - iii. Operation and Maintenance of the solar PV system (for future hand-over after maintenance period)
  - iv. Integration with gensets (where applicable)
  - v. All basic issues that might occur and the relevant troubleshooting.
  - vi. A special focus should be on using the online monitoring system and troubleshooting of basic errors and problems that occur frequently.
- f) Signaling labelling:
  - i. All components shall be labelled in English.
  - ii. Signs or labelling warning about safety hazards, e.g. smoking, water contact, etc.
  - iii. Emergency shutdown procedures (visual information) shall be provided.
  - iv. Panel with up keeping and operating instructions for the beneficiary shall be installed.
- g) Visual Material.

#### **Deliverable 4:**

- a) System monitoring inclusive of reporting as part of the maintenance service.
- b) After-sales services of 1 year: including maintenance (preventative and corrective) and technical support (on-site and/or remote) including continued online monitoring. This is inclusive of appropriate escalation or system modification procedures.
- c) The awarded LTA vendor must remain at the disposal of the beneficiary for at least two months (stabilization period) after handover/commissioning to assist in answering any technical or other related questions.
- d) Warranty and O&M for 12 months:
  - i. System Warranty: Required warranty period for all PV systems is 1 year from commissioning date. It should include monitoring, technical support and maintenance. This should be provided in the form of a warranty certificate/statement. During the referred warranty period, Bidder's shall further bear the cost of transporting equipment from its operating site to workshop appointed for provision of warranty services
  - ii. Warranty certification/documentation for the PV System Main Components including summary overview of warranty arrangements (technical and logistical).
  - iii. Overview of available warranty extension options for main components.
  - iv. Cost associated with warranty replacements during the warranty period will be borne by the supplier.
  - v. Cost associated with the maintenance and technical support for the PV system during maintenance subscription will be borne by the supplier.

#### **Deliverable 5:**

## **1. Cables, Wiring and Electrical Connectors**

All external wiring, cabling, insulation material and junction boxes must be UV-resistant, and terminals protected against dust and moisture. The wiring installation shall be both physically robust against bumping and tugging, and electrically robust. All wiring and connectors should have a design lifetime of 20 years.

### *1.1 Junction Boxes and External Enclosures*

All junction boxes shall be rated as specified. Any junction boxes used externally shall have bottom entry glands, and with drip loop installed externally. They shall be located to facilitate inspections with sufficiently long wiring loops internally.

### *1.2 Electrical Connectors and Cable-Ends*

All wiring must be neatly done and secured by means of appropriate fasteners at regular intervals. Wiring lengths shall be sufficiently looped to allow ease of connection and disconnection in the case of component replacement, and for maintenance. Any wiring connections whether internal, external, high voltage or low voltage shall be inside accessible junction boxes. No visible connections. Conductor lugs should be used to terminate all DC wiring. Lugs and connectors should be crimped or soldered, and mechanically and electrically sound. All DC electrical connections shall be treated with corrosion inhibiting paste.

### *1.3 External wiring*

All external wiring and cabling shall be straight and aligned vertically or horizontally, and cables firmly attached to the walls or cable trays at least every 500mm. Cable entries into buildings shall be made good, and with drip loops as necessary.

### *1.4 Certification*

All AC wiring shall be as per the requirements of the electricity standards of IEC

## **2. Earthing**

The bonding of equipment should prevent dangerous voltage differentials arising between metallic equipment during fault conditions and provide alternative conduction paths to power cables should ground surges from nearby lightning strikes arise. The main earth point for the system shall be a systems earth electrode, as specified in Section 6.1. It shall be located directly below each array structure.

The earth electrode shall be the common point for the casings of all balance of system components, and the array structure. The risk of lightning strikes varies according to location. However, for this site location the basic guidelines shall apply, as the electrical distribution is contained within one building.

### *2.1 Earth Electrode*

Bare copper or bare galvanized steel, in stranded, strip or rod form earth rods should be used. The down conductors shall be connected to copper or galvanized/stainless earth spikes of minimum length 1200mm. The spikes shall be driven vertically into the ground till buried to a depth of 300mm. If necessary, several spikes shall be interconnected as a trench earth to achieve the required resistance of below 10ohm.

## *2.2 Earth Connections*

16mm<sup>2</sup> bare copper straps shall be used as earth straps to bind components to the earth electrode. Under no circumstances shall connection points, bolts, screws, etc. used for bonding or earthing be utilized for any other purpose. It shall be the responsibility of the Contractor to supply and fit earth terminals or clamps on equipment that must be earthed where these are not provided.

## *2.3 PV Array Structure Earthing*

Each array structure shall always be bonded directly to the earth electrode. If there is electrical discontinuity between module frames and the array structure, then 16mm<sup>2</sup> conductors shall be utilized for bonding the module frames to the structure. Since there are two PV arrays, it is recommended that a trench earth be used to bond the individual earth spikes together underground.

## *2.4 Equipment Earthing and Bonding*

All metal other equipment and casings (as outlined below) shall be bonded together, as they are inter-connected by the power cables. The bonding shall be made using copper conductors of 10mm<sup>2</sup> minimum. A separate conductor shall be used specifically for that purpose.

- The array structure shall be bonded directly to the main earth electrode with a resistance of less than 1.7ohms.
- The inverter casings shall be bonded (directly or indirectly) to the main earth electrode with a resistance of less than 1.7ohms.
- The resistance between any enclosures in any one location, shall be less than 0.2 ohms.
- The earth resistance of the earth electrode shall be less than 10ohms.

## **3. Lightning Protection**

Lightning protection is designed inherently into the system configurations, earthing, and some level of surge protection is built into the inverters themselves. For added protection, there is a need for additional protection or surge arrestors on the inverter DC inputs. This shall take the form of Class 2 protection on the DC cables in the PV Array junction box or Enclosure.

## **4. Labelling, Safety Signs and Notices**

There shall be labelling and signage as appropriate. All notices, labels or signs shall be durable and not removable except by determined and deliberate action. The inscriptions shall be legible and indelible. Where possible, standard approved symbolic safety signage shall be used. All distribution board labels shall be professional quality signage.

## **5. Compliance with Regulations and Codes**

The entire installation must be carried out in accordance with the latest revisions and amendments of IEC & ISO international standards, and the standards currently in force in Liberia.

- IEC 62548 latest edition: Installation and safety requirements for photovoltaic generators.

Where compliance is required in terms of codes and regulations, which is not already covered elsewhere in the Specifications, variations required after contract award and site visits shall be covered by contract variation orders if any.

## **6. Electrical PV Acceptance and Commissioning Tests**

The Acceptance Tests shall depend on the exact equipment supplied. Essentially, the Project Coordinator shall test the systems for electrical performance as specified. Quality of equipment and quality of installation inspections shall also be part of the Acceptance Tests.

## **7. Other Services**

The Contractor shall develop a simplified training manual (with graphic illustrations) in basic solar PV system maintenance and security and shall conduct a one-day training in the maintenance and security of solar PV systems for selected representatives of the beneficiaries.

## **8. Certification**

The Client shall certify completion and operational acceptance of the installation by issuance of completion and operational acceptance certificates respectively.

### *8.1 Certificate of Completion*

The Contractor shall be issued a Certificate of Completion by the Client after completing the services in accordance with all the terms and conditions of the Service Contract.

### *8.2 Certificate of Operational Acceptance*

The Contractor shall be issued a Certificate of Operational Acceptance one month after the issuance of Certificate of Completion, which shall be defect liability period of the service

### **Remote Monitoring:**

Remote monitoring: real-time & historical data with a storage capacity for main data (energy measurements, consumption data and alarms).

The minimum parameters to be monitored are (instantaneous and historical values)

- Total energy (kWh) and power (kW) produced by PV
- Energy (kWh) and power (kW) fed into battery for charging and supplied from the battery
- Energy (kWh) and power (kW) supplied from the genset (where appropriate)
- Total consumption of loads
- Solar fraction
- Battery SOC and temperature
- Alarms and configuration records

The monitoring system shall have an LCD display in English and provide monitoring reports through:

- 1) Internet connectivity (LAN; Wi-Fi etc.) and,
- 2) GSM connectivity,
- 3) Ability to store for minimum 6 months of monitoring data locally (solar PV system) in the event of extended internet/GSM outage.

**Bidders are required to include in their offers all the necessary elements (SIM cards, annual subscription, modem, data management/reporting) to make possible a monitoring system through GSM connectivity even for the sites with internet connectivity.**

**Technical Specifications.**

The equipment furnished to these specifications must meet or exceed all requirements herein. Modifications of or additions to basic standard equipment of less size or capability to meet these requirements will not be acceptable

**Site: Gbarpolu and Bomi**

Item	Descriptionn	Requirement	Observations/Quality assurance	Deviations/Non-compliance
1	Site assessment	Done. Vendors can conduct further site assessment	To fine-tune/adjust system design and to facilitate the planning of logistics/installations.	
2	Off grid PV system	8.0 KVA		
2.1	Solar Panels	15 kWp	Crystalline modules with 10 yearsmanufacturer guarantee	
2.2	Mounting structure (s)	required	To be fixed on the roof.	
2.3	Technical cabinet	required	Lockable, ventilated, and waterproof	
2.4	Solar Battery charger/con troller	required	MPPT solar input	

2.5	AC battery charger	required	Manual when genset is working	
2.6	Battery bank	30.0 kWh LiFePO4	90% DOD 4000 cycles guarantee	
2.7	Battery Management system	required	Protection from over-charge Protection from under-charge Battery-balancing Ability to report SOC	
2.8	Inverter continuous service	8.0 KVA single phase 230VAC	5 years warranty	
2.9	Monitoring	Local and remote	Remote monitoring system through GSM connectivity including SIM cards, annual subscription for one year, modem, data management/reporting.	
3	Rewiring of existing electric installation	Required	To segregate non-critical loads and critical loads. The PV systems to power only the critical loads. Other loads categorized as non-critical – such as air conditioners – must be powered exclusively by gensets (if any) or other external electricity source.	
4	Anti-theft and anti-tampering measures	required		
5	Guarantee and O&M	required	System guarantee of 12 months, including two preventive maintenance visits and as many repairs as required.	

**Bill of Quantities**

Site: Gbapolou and Bomi				
Item	Description	Quantity	Unit price	Total Price (USD)
1	Detailed site assessment, including assessment report			
2	<b>Off grid PV system – Gbapolou, and Bomi County service center</b>			
2.1	Solar Panels	64		
2.2	Roof Mounting structure (s)	1		
2.3	Technical cabinet	1		
2.4	Solar Battery charger/controller	1		
2.5	AC battery charger (if required as per annex2)	1		
2.6	Battery bank	1		
2.7	Battery Management system	1		
2.8	Inverter continuous service	1		
2.9	Anti-theft and anti-tampering measures	64		
3	Remote monitoring system through GSM connectivity including SIM cards, annual subscription for one year, modem, datamanagement/reporting.			
4	Site preparation and civil works			
5	Ancillaries, protections, and Cables			
6	Rewiring of existing electric installation (adding auto transfer switch)			
7	Installation and Commissioning of the PV system			
8	Training on Operations and maintenance of the PV systems and provision of training materials and Operation manuals			
	Total Cost			

**Site: Lofa**

Item	Descriptionn	Requirement	Observations/Quality assurance	Deviations/Non-compliance
1	Site assessment	Done. Vendors can conduct further site assessment	To fine-tune/adjust system design and to facilitate the planning of logistics/installations.	
2	Off grid PV system	15.0 KVA		
2.1			Crystalline modules with 10 years manufacturer guarantee	
	Solar Panels	20 kWp		
2.2	Mounting structure (s)	required	To be fixed on the roof.	
2.3	Technical cabinet	required	Lockable, ventilated and waterproof	
2.4	Solar Battery charger/con troller	required	MPPT solar input	
2.5	AC battery charger	required	Manual when genset is working	
2.6	Battery bank	85.0 kWh LiFePO4	90% DOD 4000 cycles guarantee	
2.7	Battery Management system	required	Protection from over-charge Protection from under-charge Battery-balancing Ability to report SOC	
2.8	Inverter continuous service	15.0 KVA Three phase 400VAC	5 years warranty	
2.9	Monitoring	Local and remote	Remote monitoring system through GSM connectivity including SIM cards, annual subscription for one year, modem, data management/reporting.	

3	Rewiring of existing electric installation	Required	To segregate non-critical loads and critical loads. The PV systems to power only the critical loads. Other loads categorized as non-critical – such as air conditioners – must be powered exclusively by gensets (if any) or other external electricity source.	
4	Anti-theft and anti-tampering measures	required		
5	Guarantee and O&M	required	System guarantee of 12 months, including two preventive maintenance visits and as many repairs as required.	

**Bill of Quantities**

Site: Lofa				
Item	Description	Quantity	Unit price	Total Price (USD)
1	Detailed site assessment, including assessment report			
2	<b>Off grid PV system – River Cess County service center</b>			
2.1	Solar Panels	74		
2.2	Roof Mounting structure (s)	1		
2.3	Technical cabinet	1		
2.4	Solar Battery charger/controller	3		
2.5	AC battery charger (if required as per annex2)	1		
2.6	Battery bank	1		
2.7	Battery Management system	1		
2.8	Inverter continuous service	1		
2.9	Anti-theft and anti-tampering measures	74		
3	Remote monitoring system through GSM connectivity includingSIM cards, annual subscription for one year, modem, data management/reporting.			
4	Site preparation and civil works			
5	Ancillaries, protections and Cables			
6	Rewiring of existing electric installation (adding auto transfer switch)			
7	Installation and Commissioning of the PV system			
8	Training on Operations and maintenance of the PV systems and provision of training materials and Operation manuals			
	Total Cost			

*KLA*

Preliminary assessment of the Photovoltaic locations.

Lot No.	Name / Address	Current energy supply	Observations	PV field size (kWp)	Battery Capacity total (kWh)	Inverter AC output (KVA)	Inverter type
1	Gbarpolu County Service center 7.061944°, -10.490000° (07°03'43", -10°29'24")	One 65 KVA Genset from the County, feeding other buildings as well, and running.	Air conditioning Units are the major loads in the building.  Roofing length (24m X 11m)  Available space for solar equipment needs civil works.	15.0	30.0	8.0	1 phase
2	Tubmanburg, Bomi, County service center Liberia 6.886111°, -10.811667° (06°53'10", -10°48'42")	One 65 KVA Genset from the County, feeding other buildings as well, and running	Air conditioning Units are the major loads in the building.  Roofing length (24m X 11m)  Available space for solar equipment needs civil works.	15.0	30.0	8.0	1 phase
3	Voinjama, Lofa County Service center 8.421667°, -9.752500° (08°25'18", -09°45'09")	One 65 KVA Genset from the County, feeding other buildings as well, and running	By the time of assessment, we found the whole country service center without a roof due to bad weather	20.0	85.0	15.0	3 phases