TECHNICAL SPECIFICATIONS OF SOLUTIONS FOR INTEGRATED ENERGY CENTER IN SIERRA LEONE

This document includes the solar system design and Bill of Material (BOM) for the Integrated Energy Center located in Forbgo Community, Western Rural District.

THE INTEGRATED ENERGY CENTER

Please note that This system was Design with 30% increment for additional loads.
Based on the assessment analysis, it appears that the load requirements are as such, for the **the 5 rooms IEC which will have equipment (*Including lights, freezers, mobile charging, Tailoring machines, Laptop computer and Desktop computer & Dual Purpose printer with a consideration of 5 fans*)**.

LOAD DETAILS FOR THE IEC

Load Item		**Power (W)**	**Surge Power (W)**	**Quantity**	**Total Power (W)**	**Peak Power Rating (W)**	**Hours per Day**	**Energy Used (Wh/day)**
Desktop computer		25		2	50	**50**	8	400
Light 01		7		10	70	**70**	12	840
light 02		30		7	210	**210**	11	2310
Fridge		68	**204**	2	136	**408**	14	1904
tailoring machine		250	**750**	2	500	**1500**	8	4000
Laptop		60		1	60	**60**	4	240
Dual-printer		250	**750**	1	250	**750**	6	1500
Phones		5		30	150	**150**	4	600
Fans		65		5	325	**325**	8	2600

BOM FOR IEC

Max units of energy (kWh) usage per day (daily energy Demand)	16.4 kWh (units)

SL. No.	Products	Specification	Quantity
1	Solar PV Module (715W Pmp;Panel) in four parallel strings.	11.5 kWp	16
2	Solar Battery	46.8 kWh (48V Bus voltage) Lithium-ion (51.2V rating) (300 Ah, 48 V)	4
3	Roof Support Structure*	11.5 kWp Roof Support Structure should consist of both front and back legs to support the panels. Galvanized Iron (G.I) - Roof Support Structure is preferred	To be verified
4	Solar MPPT Inverter - 230 Vac, 50 Hz	12.5kW, 48 V Single Phase pure sine wave MPPT inverter with 94% efficiency	1 No.
5	Solar MPPT Charge Controller *(if the inverter does not have inbuilt Charge controller)*	75 A, 48V system also note that the CC max.string voltage of 200volt and CC max current of 15.1Kw, will be perfect.	1 No
6	Copper Cable Red + Black (Panel - Panel)	4 sq. mm (UV protected cable)	Based on the number of panels
7	Copper Cable Red + Black (Panel - Inverter)	6 sq. mm	To be determine
8	Copper Cable Red + Black (Battery - Battery)	16 sq. mm	To be determine
9	Copper Cable Red + Black (Inverter - Load)	6 sq.mm	To be determine
10		4 sq. mm	To be determine
11		2.5 sq. mm	To be determine
12		1.5 sq. mm	To be determine
13	Earthing Cable (PV connection box, Grid Input Protection Box, & Inverter)	10 sq.mm (Tin-coated copper lugs with insulation to be used at the cable - earth electrode interface)	To be determine

14	Earthing Kit	Chemical earthing powder, solid copper electrode, tin-coated copper lugs with insulation, clamps with nut-bolts assembly. Protective concrete construction to earthing pit (L x B x H 1.5 x 1.5 x 1.5 feet) with metallic lid should be made	2 Nos
15	Inverter elevation leg	Elevation rack with insulation Mat (or) 3 inch Leg Bush	1 Nos
16	PV Connection Box with SPD & MCB	Based on the panels connected in parallel	
17	Double Pole MCB (load side) with conduit box		
18	Consumables	Consumables	
19	Luminaries	As required based on design	To be verified
20	Solar Pump (Submersible)	1Hp, 120 Vac, 3 Phase	1
21	Solar Pump Controller	1Hp, 120 Vac, 3-Phase	1

**Roof Support Structure needs to be customized if the roof is tin sheet/ needs to be ground mounting.*

Notes:

The above provided solar system design is for IEC only

The solutions are AC powered only

The addition of extra loads will not be encountered in the system design and connecting beyond the mentioned capacity will result in system failure.

Solar panels have to be mounted in the south direction in a shadow-free area.

ANNEXURE 1 - TECHNICAL SPECIFICATIONS OF COMPONENTS

The proposed project shall be commissioned as per the technical specifications given below. Any shortcomings or deviations may lead to the cancellation of the Letter of Award, and in such a case the Competent Authority's decision will be final and binding on the bidder.

1. SOLAR PV MODULE:

a. The PV modules used must qualify to the latest edition of IEC PV module qualification test or equivalent BIS standards Crystalline Silicon Solar Cell

Modules IEC 61215/IS14286. In addition, the modules must conform to IEC 61730 Part-2- requirements for construction & Part 2 – requirements for testing, for safety qualification or equivalent IS.

b. For the PV modules to be used in a highly corrosive atmosphere throughout their lifetime, they must qualify to IEC 61701/IS 61701.
c. The total solar PV array capacity should not be less than the allocated capacity and should comprise solar crystalline modules of minimum Wp mentioned in the bill of materials. Module capacity less than minimum mentioned kWp in the BoM / Purchase Order shall not be accepted.
d. PV modules must be tested and approved by one of the IEC authorized test centers. The module frame shall be made of corrosion-resistant materials, preferably anodized aluminum.
e. Protective devices against surges at the PV module shall be provided. Low voltage drop bypass diodes shall be provided.
f. The bidder shall carefully design & accommodate requisite numbers of the modules to achieve the rated power in his bid
g. Other general requirement for the PV modules and subsystems shall be the Following:
    i. The rated output power of any supplied module shall have tolerance of +/- 3%.
    ii. The peak-power point voltage and the peak-power point current of any supplied module and/or any module string (series connected modules) shall not vary by more than 2 (two) per cent from the respective arithmetic means for all modules and/or for all module strings, as the case may be.
    iii. The module shall be provided with a junction box with either provision of external screw terminal connection or sealed type and with arrangement for provision of by-pass diode. The box shall have hinged, weather proof lid with captive screws and cable gland entry points or may be of sealed type and IP-65 rated.
    iv. I-V curves at STC should be provided by bidder. **I. Module Warranty:**

Module Warranty is defined as: The manufacturer should warrant the Solar Module(s) to be free from the defects and/or failures specified below for a period not less than five (5) years from the date of sale to the original customer

i) Defects and/or failures due to manufacturing. ii) Defects and/or failures due to quality of materials

iii) Non-conformity to specifications due to faulty manufacturing and/or inspection processes. If the solar Module(s) fails to conform to this warranty, the manufacturer will repair or replace the solar module(s), at the supplier's sole cost

II. Performance Warranty

The degradation of power generated by the module shall not exceed 20% of the minimum rated power over the 25-year period and not more than 10% after the first ten years period.

III. Preferred Make

Canadian Solar,Seraphim Solar Panels, Yingli Solar Panels, Sharp solar, JA Solar
Bidder has to take prior approval from the Foundation with sufficient certifications if other brands than the above specified are considered by the bidder.

2) ROOF SUPPORT STRUCTURE (RSS):

a) Hot dip galvanized M.S/ anodized aluminum of size not less than 50 mm x 50 mm x 6 mm size (for legs) and other square tubes of 2 mm thick (Rafter and Purlin) shall be used for mounting the modules/ panels/arrays. Each structure should have an angle of inclination as per the site conditions to take maximum irradiation.

b) For a Flat roof R.C.C installation, the RSS should be a minimum 2-legged structure (1 front leg, 1 back leg) and many such leg pairs to exist along the length of the RSS, (Maximum distance between each row pair should be 6 ft) . Each leg of RSS shall have a base plate at its bottom. The base plate at each leg should be of the size 150*150*6 mm. The base plate should have four stiffeners. Each stiffener will be placed perpendicular to the side of the base plate. The base plate should house four wedge anchors at each corner. The steel wedge anchors used should be 2-3 inches long (Depending upon the RCC roof thickness).

c) The RSS should be designed such, it safely not only withstands the total panel weight but also withstand the high wind loads acting over it.

d) The PV panels should be clamped to RSS only at the allowable points along the panel frame, which is specified by the panel manufacturer. Each panel should be clamped to the purlins using 4 clamps (2 clamps on each opposite sides of the panel). The clamps used should be of minimum 35*3 mm size and that of anodized aluminum. The distance between the end clamp and the end of the rail (purlin end) should be minimum 25 mm long.

e) All panels and RSS should be grounded together with grounding bolts.

Cyclone prone zones, high altitude-high wind zones (Particularly for flat RCC roof):

Additional measures should be taken to install PV panels at such high-risk zones. Installations at such sites should have a low-elevation panel set-up made, along with “landscape” orientation of PV panels (This would require a custom-made RSS viz triangular RSS frame/short legged RSS, preferably made with G.I). The PV panels should be mounted over the RSS using the “clamping” method only. Anodized clamps of 45*4 mm size should be used here.

The structure shall be designed to allow easy replacement of any module. The array structure shall be so designed that it will occupy minimum space without sacrificing the

output from the SPV panels. Installation of solar structures should not damage the roof in any way. If any concrete or foundation is required, it should be precast type.

Fixed tilt systems, south facing with 24-26 degree inclined towards north should be followed despite whatever roofing type is. This range is indicative and will depend on the actual location.

The structure also should be able to withstand wind speed of 200 - 250 km/h.

Bidders must follow any of the three types of roof mounting options and the solution is dependent on the type of roof at the location. a) Flat roof, b) standing seam c) Shingle roof. In all cases, considerations must be made for the roof's age, structural integrity, access to equipment, and necessary setbacks for fire and life safety requirements.

The RSS should be mounted to the RCC roof using wedge anchor fasteners and a concrete block of L x W x H = 1.5 x 1.5 x 1.5 feet respectively at each leg of the RSS. The sides of the cube and roof interface should be given a simple 1-inch filet construction. At the top side of the cubes, an upward taper should be formed from cube sides towards RSS leg.

3) DC COMBINER BOX/ARRAY JUNCTION BOX:

a. The junction boxes are to be provided in the PV array for termination of connecting cables. The Junction Boxes (JBs) shall be made of GRP/FRP/Powder Coated Aluminum /cast aluminum alloy with full dust, water & vermin proof arrangement. All wires/cables must be terminated through cable lugs. The JBs shall be such that input & output termination can be made through suitable cable glands.
b. Each Junction Box shall have High quality Suitable capacity Metal Oxide Varistors (MOVs) / SPDs, suitable Reverse Blocking Diodes. The Junction Boxes shall have suitable arrangement monitoring and disconnection for each of the group.
c. Suitable markings shall be provided on the bus-bar for easy identification and the cable ferrules must be fitted at the cable termination poincts for identification. The AJB should be placed in a shaded place, preferably at the mid-end of the RSS legs. IP67 grade AJBs should be used.

4) BATTERY:

The battery type proposed: Lithium.

a. All the batteries capacities mentioned are at 300Ah, 93% Efficiency and 75% DOD and the same should also be followed by the bidder. However, bidders quoting for battery banks with other capacities should add a justification note as annexure to why the particular voltage was opted for. The technical committee will consider this and take a decision on the suitability of such an option. The decision of the technical committee/technical member of the buyer on this matter will be final and binding on the bidder.
b. Battery should conform to the latest BIS/ IEC/International standards. A copy of the relevant test certificate for the battery should be furnished.
c. The battery should be warranted for a minimum of 7 years.

d. The battery should be installed inside the premises of consumers on a battery rack. The rack material size should be able to easily bear the battery load.
e. The battery rack should be of fireproof material and corrosion free (GI rack is preferable).
f. Acid absorbent mats should be provided below the battery. The non-reactive acid proof mat should be provided at the floor space of the battery bank.
g. Tin-coated copper lugs (Ring type) with insulation to be used at cable ends to connect each battery terminal.
h. Spring washers to be incorporated in the nut-bolt assembly at each battery terminal.
i. At each battery terminal, petroleum based Vaseline coating should be applied. ii. Battery terminal caps used, should be big enough to cover the entire terminal area and the nut bolt assembly.
i. All cables connecting batteries should be provided “conduit pipe” protection and tied to the outer sides of the battery body using cable ties.

5) Single Phase Solar Inverter/ AC Charger:

Solar Inverter of capacity & ratings as specified in the below for various capacities of Solar Power Plants should convert DC power into AC power. Preference will be given to power conditioning units conforming to standards IEC 61683.

The inverter should be tested from the accredited testing- calibration laboratories. In the case of imported inverter/AC charger units, these should be approved by international test houses.

In case of inverters with low ground clearance (smaller capacity inverters), a minimum of 3-inch elevation for the same should be incorporated. The elevating means should be a fireproof material (Leg bushes are preferable).

a. Inverter Specifications:

- MOSFET/IGBT based.
- Nominal Battery Voltage: 48 Vdc.
- Inverter efficiency should be more than 93%.
- Output voltage 230V, +/-2% pure sine wave for single phase.
- Output frequency: 45 - 65 Hz, +/- 0.5 Hz
- THD: Less than 3%
- Operating Temperature Range: -20°C to 55°C
- Operating humidity 95% maximum
- Environmental Protection Index Should be IP 20.

b. Protections:

- Over voltage (automatic shutdown)
- Under voltage (automatic shutdown)

- Overload - Short circuit (circuit breaker & electronics protection against sustained fault)
- Over Temperature
- Battery reverse polarity

c. Indicators

- Battery connected, charging
- Inverter ON
- Grid charger on
- Load on Grid/ Bypass
- Grid on
- warning /Fault

d. Display Parameters

- Charging current
- Charging voltage
- Voltage of PV panels
- Output voltage
- Grid voltage
- Inverter loading (kW) & Energy Generation (kWh)
- Output frequency
- Fault / fault code

e. Cooling: cooling mechanism required - Air Cooled

f. Preferred Make:

Studer, Victron, Schneider, SMA

Bidder has to take prior approval from the Foundation with sufficient certifications if other brands than the above specified are considered by the bidder**.**

6) Charge Controller Specifications:

Charge Controller contains an MPPT (Maximum Power Point Tracking) algorithm that continuously tracks the maximum power point and automatically charges the batteries in an optimal way with all the available solar power.

- Indoor based
- Charging Stages: 4 Stages: Bulk, Absorption, Floating, Equalization.
- Battery temperature compensation: 3mV/°C/Cell (25°C ref) default value with adjustable -8 to 0 mV/°C.
- Operating ambient temperature range: -20 to 55°C.
- Conversion efficiency should be more than 95%. ● Comprehensive display.
- Environmental Protection Index should be IP 54.

I. Protections:

- Over voltage (automatic shutdown)
- Under voltage (automatic shutdown)
- Overload - Short circuit (circuit breaker & electronics protection against sustained fault)
- Over Temperature
- Battery, PV reverse polarity

II. Indicators

- Array on
- MPPT charger on
- Battery connected, charging
- Battery status
- Fault/ warnings

III. Display Parameters

- Charging current
- Battery voltage
- Voltage of PV panels
- Energy Generation (kWh)- Today's and cumulative
- Fault / warning

IV. Preferred Make:

Studer, Victron, Schneider, Outback, Tristar, SMA.

Bidder has to take prior approval from the Foundation with sufficient certifications if other brands than the above specified are considered by the bidder**.**

7) Data Acquisition System/Plant Monitoring:

- Data acquisition system for the entire Solar System.
- Cloud based and local monitoring.
- Data logging provision for plant control and monitoring, time and date stamped system data logs for analysis with the high quality, suitable PC, metering and instrumentation for display of systems parameters and status indication to be provided.
- The following parameters are accessible via the operating interface display in real time separately for solar plant:
  - AC Voltage
  - AC Output Current

- Output Power
- Power Factor
- DC Input Voltage
- DC Input Current
- Power Produced
- Energy kWH - today's and cumulative.

8) Protections

The system should be provided with all necessary protections like earthing, lightning protection.

9) Lightning Protection

The main aim in this protection shall be to reduce the over voltage to a tolerable value before it reaches the PV or other sub system components. The source of over voltage can be lightning, atmosphere disturbances etc. The entire space occupying the SPV array shall be suitably protected against lightning by deploying the required number of lightning arresters.

To increase the coverage area of protection, the lightning arrestor should be given an additional elevation by using anodized aluminum pole. The height of the lightning arrester point should be minimum 3 meters above the height of the panels set. Insulation should be provided between the lightning arrestor and the elevation pole. Down conductor should be provided with saddle insulation along its length.(i.e. from the lightning arrestor till the earthing pit). Not more than 1m gap should be maintained between two saddle insulators. Down conductors should maintain 0.5 m distance from panels, arrays and other power cables around.

The lightning arrestor setup should always be vertical and should be stable against high wind loads. The lightning arrestor setup should be provided with anchor fasteners along with civil work made at its base plate. A concrete cube (Civil work) of 1.5 ft x 1.5 ft x 1.5 ft (L x B x H) dimensions should be set. If required, support wires should be used for additional stability of the lightning arrestor. The lightning arrester should be placed preferably at the back of the array and at the sides, with a separation distance of 0.5 meters only.

The entire lightning arrester set up (Air terminal pole, spikes and base plates should be of solid copper)

10) Earthing

Earthing is a way of transmitting any instant electricity discharge directly to the ground by providing a low resistance path (using electrical cables wires with no joints or metal strips with lesser joints). This instant electricity discharge is mostly in the form of lightning, surge voltages entering through grid lines and due to fault current/leakage current in the system . The goal is to protect the appliances from voltage surges and protect the users from the risk of electrocution due to leakage/fault current in the system.

- Earthing type - Chemical Earthing
- Earth electrodes should be that of solid copper.

- Earth pit should be 1 foot by diameter and 4 ft by depth.
- Separate earthing should be provided for these components: Lighting arrester, A.J.B, Grid input protection box and Inverter.
- Minimum of 3 m distance between each pit must be maintained and 1.5 m from building foundations and sumps.
- Should not combine AC earthing & DC Earthing.
- Earthing pits should have a chamber set above the ground and should be closed with a metallic lid/FRP lid.
- Proper cable-to-rod & strip-to-rod clamps should be used. ● Clamp materials should be that of copper alloys.

11) Cables

Cable size as mentioned in the bill of materials to be used in the project shall have the following characteristics:

- Temperature range: -10^{o}C to +80^{o}C.
- Excellent resistance to heat, cold, water, oil, abrasion, UV radiation ● Flexible

Sizes of cables between array interconnections, array to junction boxes, junction boxes to Inverter etc. shall be selected to keep the voltage drop (power loss) of the entire Project to the minimum. The cables (as per IS) should be insulated with a special grade PVC compound formulated for outdoor use.

The Cable should be so selected that it should be compatible up to the life of the solar PV panels i.e., twenty-five (25) operational years.

Cable ends should be crimped to cable lugs thoroughly using appropriate lugs. This lug interface has to be Insulated.

Tin-coated copper cable lugs with respect to cable sizes should be used and they should be of required current ratings.

Conduit pipe protection to be given to cables connecting 1. Battery to battery, 2. Battery to inverter, 3. All cables entering the inverter.

DC cables from the PV array and earthing cables should be given outdoor PVC (CPVC/UPVC) pipe protection. DC cables entering the conduit pipes from the panel should be protected from the rainwater with Sealing Gel.

Cable Tie for Outdoor application should be UV resistant.

Outdoor “L” bend pipes to be used wherever the cables pass through sharp edges/roof edges/angles in the wall.

Load wiring:

Load wiring is to be redone in case of damaged (or) faulty wiring detected (Multiple cross connections/power tapping). If in case, load wiring is not available at the health center, then a new load wiring must be done for the energy efficient devices (Solar loads - Critical medical equipment, luminaires and fans only) which are being installed in the center. For a new load wiring proper solid conduit pipe protection should be provided. Cables of appropriate size should be used. Cable color coding should be followed. Provision should be made during the wiring such that solar power is not consumed by heavy loads and non-critical equipment in the center.

a. **Preferred Make:** East African cables, Aberdare Power Cables, CBI African Cables

12) Tools & Tackles And Spares:

After Completion Of Installation & Commissioning Of The Power Plant, Necessary Tools & Tackles Shall Be Maintained By The Successful Bidder For Maintenance Purposes At The Local Service Center.

13) Safety Measures:

The Bidder Shall Take Entire Responsibility For Electrical Safety Of The Installation(S) And Follow All The Safety Rules & Regulations Applicable

14) Luminaries and Accessories

Preferred Make:

Led Bulbs/Tubes: Phillips,Osram, Energiser

Ceiling Fan : Atomberg, Orient, Super Fan, Arizon.

15) Operation And Maintenance Manual

An Operation, Instruction And Maintenance Manual In English And/Or Local Language Should Be Provided Along With The Solar System. The Following Minimum Details Must Be Provided In The Manual:

- Basic Principles Of Photovoltaics.
- A Block Diagram On Solar Pv System - Showing Interconnection Of Its Components Viz Pv Modules, Batteries, Inverters & Charge Controls And Loads.
- A Small Write Up On Expected Performance Of The Spv Systems.
- A List Of The Loads (Luminaire And Medical Equipment) That Are Connected To The Solar Pv System.
- A Separate List Of Heavy Loads Which Are Never To Be Connected To The System.
- A List Containing Specification Details Of Panels, Batteries, P.C.U., Showing Type Of The Model Used, Model Number, Voltage & Current Capacity

- A List Of Total Numbers Of Items (Solar Panels, Battery, Inverter, Earthing Pits, Lightning Arresters, Luminaries, Fans And Medical Equipment) That Are Provided To The Center.
- Significance Of Audio And Visual Indicators Of The Solar Pv System.
- Clear Instructions On Regular Maintenance And Troubleshooting Of The Solar Pv System.
- A List Of Dos And Don'ts Practices While Handling The Solar Pv System.
- Name, Address And Contact Details Of The Customer Care Service/Service Provider For Repair Complaints And Scheduled & Unscheduled Maintenance Services.

16) Annual Maintenance:

- Two Scheduled Visits Per Year With 6 months Of Interval Gap Should Be Done.
- Schedule Visits Should Consist Of Basic Maintenance Of The System - Cleaning Of Panels, Checking Of Wiring And Respective Connections, Cleaning Of Batteries, Filling Of Distilled Water.
- Checking And Verifying System Performance With Prescribed Format Provided.