



**RURAL ELECTRIFICATION AND RENEWABLE ENERGY  
CORPORATION**

**KENYA OFF-GRID SOLAR ACCESS PROJECT FOR UNDERSERVED COUNTIES  
(KOSAP)**

Volume II (Part 2)

Section VII

**Employer's Requirements, Technical Specifications and Drawings**

**Design, Supply, Installation and Commissioning of Solar Photovoltaic Generation Plants  
with Associated Power Distribution Network (Mini-Grids) in Turkana, Marsabit, Samburu  
and Isiolo Counties in Kenya with 7 Years Operations and Maintenance (O&M) Services.**

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**Employer's Requirements**

Section VII

**Employer's Requirements and Technical Specifications (ERTS)**

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## **1.0 SCOPE OF SUPPLY OF PLANT AND INSTALLATION SERVICES**

### **1.1 Introduction**

The Government of Kenya has pledged to stimulate economic growth and accelerate job creation to improve the economic wellbeing of Kenyans. Among the many interventions to achieve this is expansion of the power distribution system to be within reach and thus enable more Kenyans connect to the grid at affordable cost and hence initiate economic activities at the micro-economic level. Mini grids and standalone systems are considered as a solution where grid penetration remains limited.

The Kenya Off-grid Solar Access Project for underserved counties (KOSAP), financed by the World Bank and implemented by the Ministry of Energy, Kenya Power and Lighting Company PLC (KPLC) and Rural Electrification and Renewable Energy Corporation (REREC), aims at providing a comprehensive suite of investments to provide electricity services to households, enterprises and selected community facilities.

REREC will implement Mini-Grids for Community Facilities, Enterprises, and Households to support the electrification of areas where electricity supply through mini-grids represents the least-cost option from a country perspective through contractors. A single contractor will be responsible for construction of the generation system and distribution network of the mini-grids for each Lot (Supply and Installation (S&I) Phase). The same contractor shall provide Operations and Maintenance (O&M) services for 7 (seven) years. Therefore, two (2) Contracts will be signed; one between REREC and the Contractor for the S&I Phase and another between KPLC & the Contractor for O&M Phase.

### **General Scope**

The project works for this assignment includes Design, Supply, Installation, Metering and Commissioning of 31 No. Mini grids with 7 years Operations and Maintenance (O&M) services in the following Counties: Turkana, Marsabit, Samburu and Isiolo. The scope covers design, supply, installation and commissioning of Solar Power Generation Plant (SPGP) with associated Battery Energy Storage System (BESS) and Diesel Generator as well as Power Distribution Network (PDN) and connection to customers including installation of 15,235 electronic pre-paid energy meters (including earthing, cabling to the meter box at the customer premise and issuing statutory wiring documents). All other associated materials and accessories

on turnkey basis for completeness of works to be provided.

The project is packaged in Six (6) Lots. Each lot shall be signed as a separate works contract as detailed in Table 1:

**Table 1: Number of Lots and General Scope of Works per Lot.**

Lot Name	Counties	Scope of Works
KE-REA-176130-CW-RFB Lot 1	Parts of Turkana County (Turkana West & Turkana North Constituencies)	<ul style="list-style-type: none"> <li>• Design, Supply, Installation, Metering and Commissioning of Solar Power Generation Plant with associated BESS and Diesel Generator (SPGP) and Power Distribution Network (PDN) for 6 No. Mini Grids.</li> <li>• Customer connections to 2,242 No. customers</li> <li>• Provide O&amp;M services for 7 years</li> </ul>
KE-REA-176130-CW-RFB Lot 2	Parts of Turkana County (Turkana East, Turkana South, Turkana Central & Loima Constituencies)	<ul style="list-style-type: none"> <li>• Design, Supply, Installation, Metering and Commissioning of Solar Power Generation Plant with associated BESS and Diesel Generator (SPGP) and Power Distribution Network (PDN) for 6 No. Mini Grids.</li> <li>• Customer connections to 3,808 No. customers</li> <li>• Provide O&amp;M services for 7 years</li> </ul>
KE-REA-176130-CW-RFB Lot 3	Parts of Marsabit County (Saku & Moyale Constituencies)	<ul style="list-style-type: none"> <li>• Design, Supply, Installation, Metering and Commissioning of Solar Power Generation Plant with associated BESS and Diesel Generator (SPGP) and Power Distribution Network (PDN) for 5 No. Mini Grids.</li> <li>• Customer connections to 2,356 No. customers</li> <li>• Provide O&amp;M services for 7 years</li> </ul>
KE-REA-176130-CW-RFB Lot 4	Parts of Marsabit County (Laisamis & North Horr Constituencies)	<ul style="list-style-type: none"> <li>• Design, Supply, Installation, Metering and Commissioning of Solar Power Generation Plant with associated BESS and Diesel Generator (SPGP) and Power Distribution Network (PDN) for 5 No. Mini Grids.</li> <li>• Customer connections to 2,495 No. customers</li> <li>• Provide O&amp;M services for 7 years</li> </ul>
KE-REA-176130-CW-RFB Lot 5	Parts of Samburu County (Samburu West, Samburu North & Samburu	<ul style="list-style-type: none"> <li>• Design, Supply, Installation, Metering and Commissioning of Solar Power Generation Plant with associated BESS and Diesel Generator (SPGP) and Power Distribution Network (PDN) for 4 No. Mini Grids.</li> </ul>

	East Constituencies)	<ul style="list-style-type: none"> <li>• Customer connections to 1,874 No. customers</li> <li>• Provide O&amp;M services for 7 years</li> </ul>
KE-REA-176130-CW-RFB Lot 6	Parts of Isiolo County (Isiolo North & Isiolo South Constituencies)	<ul style="list-style-type: none"> <li>• Design, Supply, Installation, Metering and Commissioning of Solar Power Generation Plant with associated BESS and Diesel Generator (SPGP) and Power Distribution Network (PDN) for 5 No. Mini Grids.</li> <li>• Customer connections to 2,460 No. customers</li> <li>• Provide O&amp;M services for 7 years</li> </ul>

The Contract shall comprise but is not limited to the clearing of all working areas, quality assurance management, design, manufacture, supply, delivery to site, unloading, erection, setting to work, testing at site, commissioning and trial operation, complete in every respect and suitable for reliable operation in the respective environmental and climatic conditions, including and/or adjustment of defective material and workmanship for duration of the Defects Liability period of the equipment described in detail in the Specifications and Schedules. All works not expressly called for in the Specification and/or Schedules but are necessary for the complete and proper supply, erection, operation and maintenance of the Works shall be performed and furnished by the Contractor at no additional cost to the Employer.

## 1.2 Scope and characteristics of Solar Photovoltaic (SPV) mini grids

Scope and characteristics of the SPV mini-grids are shown in Table 2 to table 7. These tables summarize characteristics including the estimated number of residential consumers; number of non-residential (commercial, public facilities and small industrial) consumers; evaluated daily energy consumption in kWh; evaluated peak demand in kW; solar PV capacity in kW; battery capacity in kWh; PV inverter capacity in kW; battery inverter charger capacity in kW; diesel generator capacity in kVA; length of the low voltage distribution network in km; length of the medium voltage distribution network in km; step up and step down transformers capacities in kVA. The winning Bidders are responsible for confirming consumer, demand and other site data during design stage. The scope details are summarized as follows;

**1.2.1** Design, supply, installation, testing, metering and commissioning of Solar Power Generation Plants (SPGP) under Lots 1 to 6 are as per Tables 2-7.

**1.2.2** Design, supply, installation, testing, metering and commissioning of Power Distribution Network (PDN) of medium voltage of 11kV, and low voltage of 415V and 240V as per KPLC

Requirements/specifications are as detailed in Tables 2-7. Some sites will comprise of both medium voltage (three phase 11kV) and low voltage (three phase 415V and single phase 240V) networks while others will only have low voltage network.

**1.2.3** The geographical/location details of the sites spread across various parts of Kenya including Counties, constituencies, co-ordinates and size of land parcels are contained in Table 24 to table 28 in Appendix 1.

**Table 2: Lot 1 (Parts of Turkana County – Turkana West & Turkana North Constituencies)**

No	County	Constituency	Mini Grid Name	Residential Users No.	Non-Residential Users No.	Daily Energy Demand (kWh)	Peak Demand (kW)	Minimum PV Capacity (kWp)	Minimum Usable Battery (kWh)	Minimum PV Inverter (kW)	Max. String Inverter Capacity (kW)	Minimum Battery Inverter Charger Capacity (kW)	Diesel Gen-Set Prime Rating (kVA)	Fuel Tank L	LV Network km	MV Network (km)	Step Up TX kVA	Step Down TX KVA
1	TURKANA	T. NORTH	KAIKOR	623	11	562	104	175	438	175	70	120	120	2000	35.15	4.83	100	4 x 25
2	TURKANA	T. NORTH	KANAKURDIO	252	7	261	49	75	188	75	30	60	60	2000	16.21	4.28	50	2 x 25
3	TURKANA	T. NORTH	KIBISH	364	11	389	72	120	300	120	50	82	82	2000	9.01	0.00	0	0
4	TURKANA	T. NORTH	KOKURO	326	10	351	65	120	300	120	50	82	82	2000	6.76	1.82	100	1 x 50
5	TURKANA	T. NORTH	NACHUKUI	370	12	161	30	120	300	120	50	82	82	2000	3.22	0.00	0	0
6	TURKANA	T. WEST	OROPOI	200	9	407	76	100	250	100	40	60	60	2000	12.88	1.88	50	1 x 50
<b>TOTAL</b>								<b>710</b>										

**Table 3: Lot 2 (Parts of Turkana County–Turkana South, Turkana Central, Turkana East & Loima Constituencies)**

No	County	Constituency	Mini Grid Name	Residential Users No.	Non-Residential Users No.	Daily Energy Demand (kWh)	Peak Demand (kW)	Minimum PV Capacity (kWp)	Minimum Usable Battery (kWh)	Minimum PV Inverter (kW)	Max. String Inverter Capacity (kW)	Minimum Battery Inverter Charger Capacity (kW)	Diesel Gen-Set Prime Rating (kVA)	Fuel Tank L	LV Network km	MV Network (km)	Step Up TX kVA	Step Down TX KVA
1	TURKANA	T. CENTRAL	KALOKOL	1837	14	1411	262	450	1125	450	200	320	320	2000	48	14	315	6 x 50
2	TURKANA	T. CENTRAL	NAMUKUSE	463	5	355	66	120	300	120	50	82	82	2000	23	2	50	2 x 25
3	TURKANA	T. EAST	LOMUNYENA KWAN	400	8	373	69	120	300	120	50	82	82	2000	12	0	0	0
4	TURKANA	LOIMA	LORENGIPPI	313	4	247	46	75	188	75	20	60	60	2000	7	0	0	0
5	TURKANA	T. SOUTH	LOCHWAANGI AMATAK	352	9	375	70	120	300	120	50	82	82	2000	13	1	100	2 x 50
6	TURKANA	T. SOUTH	NAPOSIMORU	399	4	319	59	100	250	100	40	60	60	2000	14	0	0	0
<b>TOTAL</b>								<b>985</b>										

**Table 4: Lot 3 (Parts of Marsabit County –Moyale and Saku Constituencies)**

No	County	Constituency	Mini Grid Name	Residential Users No.	Non-Residential Users No.	Daily Energy Demand (kWh)	Peak Demand (kW)	Minimum PV Capacity (kWp)	Minimum Usable Battery (kWh)	Minimum PV Inverter (kW)	Max. String Inverter Capacity (kW)	Minimum Battery Inverter Charger Capacity (kW)	Diesel Gen-Set Prime Rating (kVA)	Fuel Tank L	LV Network km	MV Network (km)	Step Up TX kVA	Step Down TX KVA
1	MARSABIT	MOYALE	DIRDIMA	85	3	97	18	30	75	30	20	25	25	2000	3.32	-	0	0
2	MARSABIT	MOYALE	EL BOR	680	7	547	102	175	438	175	70	130	130	2000	14	0	0	0
3	MARSABIT	SAKU	KARGI	620	9	533	99	160	400	160	60	130	130	2000	18	2.15	100	2 x 50
4	MARSABIT	MOYALE	BORI	546	4	417	77	135	338	135	50	82	82	2000	14	1.09	50	1 x 50
5	MARSABIT	MOYALE	FOROLLE	396	6	344	64	100	250	100	40	60	60	2000	8.31	-	0	0
<b>TOTAL</b>								<b>600</b>										

**Table 5: Lot 4 (Parts of Marsabit County - Laisamis and North Horr Constituencies)**

No	County	Constituency	Mini Grid Name	Residential Users No.	Non-Residential Users No.	Daily Energy Demand (kWh)	Peak Demand (kW)	Minimum PV Capacity (kWp)	Minimum Usable Battery (kWh)	Minimum PV Inverter (kW)	Max. String Inverter Capacity (kW)	Minimum Battery Inverter Charger Capacity (kW)	Diesel Gen-Set Prime Rating (kVA)	Fuel Tank L	LV Network km	MV Network (km)	Step Up TX kVA	Step Down TX KVA
1	MARSABIT	LAISAMIS	GATAB	338	6	305	57	100	250	100	40	60	60	2000	17.15	2	50	1 x 50
2	MARSABIT	NORTH HERR	BUBISA	960	12	800	149	250	625	250	90	175	175	2000	25.44	2.42	100	2 x 50
3	MARSABIT	NORTH HERR	EL GADHE	255	5	237	44	75	188	75	30	50	50	2000	11.27	0	0	0
4	MARSABIT	NORTH HERR	GAS	367	4	298	55	100	250	100	40	60	60	2000	10	0	0	0
5	MARSABIT	LAISAMIS	SOUTH HERR	536	12	517	96	160	400	160	60	130	130	2000	20	3	100	2 x 50
<b>TOTAL</b>								<b>685</b>										



**Table 6: Lot 5 (Part of Samburu County - Samburu West, Samburu East and Samburu North Constituencies)**

No	County	Constituency	Mini Grid Name	Residential Users No.	Non-Residential Users No.	Daily Energy Demand (kWh)	Peak Demand (kW)	Minimum PV Capacity (KWp)	Minimum Usable Battery (kWh)	Minimum PV Inverter (kW)	Max. String Inverter Capacity (kW)	Minimum Battery Inverter Charger Capacity (kW)	Diesel Gen-Set Prime Rating (kVA)	Fuel Tank L	LV Network km	MV Network (km)	Step Up TX kVA	Step Down TX KVA
1	SAMBURU	S. NORTH	LATAKWENY	201	5	201	37	75	188	75	30	50	50	2000	16	0	0	0
2	SAMBURU	S. WEST	BARSALOI	466	7	404	75	120	300	120	50	82	82	2000	16	0	0	0
3	SAMBURU	S. NORTH	TUUM	475	9	437	81	135	338	135	50	100	100	2000	24	3	100	2 x 50
4	SAMBURU	S. EAST	SEREOLIPI	699	12	626	116	200	500	200	70	130	130	2000	31	0	0	0
<b>TOTAL</b>								<b>530</b>										

**Table 7: Lot 6 (Parts of Isiolo County - Isiolo North & Isiolo South Constituencies)**

No	County	Constituency	Mini Grid Name	Residential Users No.	Non-Residential Users No.	Daily Energy Demand (kWh)	Peak Demand (kW)	Minimum PV Capacity (kWp)	Minimum Usable Battery (kWh)	Minimum PV Inverter (kW)	Max. String Inverter Capacity (kW)	Minimum Battery Inverter Charger Capacity (kW)	Diesel Gen-Set Prime Rating (kVA)	Fuel Tank L	LV Network km	MV Network (km)	Step Up TX kVA	Step Down TX KVA
1	ISIOLO	ISIOLO NORTH	ERAS HARBORU	637	5	491	91	160	400	160	60	100	100	2000	17	0	0	0
2	ISIOLO	ISIOLO SOUTH	GARFASA	648	5	499	93	160	400	160	60	100	100	2000	22	3	100	3 x 50
3	ISIOLO	ISIOLO NORTH	KIPSING	327	7	311	58	100	250	100	40	60	60	2000	12	0	0	0
4	ISIOLO	ISIOLO SOUTH	BASSA	524	5	416	77	135	338	135	50	82	82	2000	20	0	0	0
5	ISIOLO	ISIOLO SOUTH	MALKADAKA	295	7	290	54	100	250	100	40	60	60	2000	9	5	50	1 x 50
<b>TOTAL</b>								<b>655</b>										

**1.2.4** Supply of connection cable, etc. and its installation for providing electricity service connection to consumers at their premises as per REREC requirements/specifications.

**1.2.5** Installation of meters (provided by KPLC) for providing electricity service connection to consumers at their premises as per REREC requirements/specifications.

**1.2.6** Carry out O & M Services for 7 years on behalf of REREC/KPLC as per KPLC requirements/specifications.

**1.2.7** Reliable Power supply to consumers on behalf of REREC/KPLC including timely attending to complaints of consumers/breakdowns to ensure regular supply to consumers as per KPLC Requirements/specifications.

**1.2.8** Collection of connection charges from consumers and ensure revenue collection from consumers on behalf of KPLC (including Disconnection and reconnection) and its deposit to Govt./KPLC Account as per KPLC Requirements/specifications.

**1.2.9** Supply, installation, operation and maintenance of a standby Diesel Generator (DG) duly integrated with solar plant in order to maintain the regular power supply to consumers in case of Solar Plant and BESS cannot meet the consumer requirement. Minimum installed capacity of the DG shall be as per Table 2 to table 7. Fuel tanks to hold diesel to be used in the diesel generators to also be supplied and installed of a capacity as shown in the price schedules for each mini-grid. The contractor will generate electricity from the DG as per requirement of KPLC.

**1.2.10** The supply of fuel during O&M period will be done by KPLC as per schedule to be discussed with the winning bidders.

**1.2.11** All fuel storage tanks supplied by the contractor, to be fitted with flow meters as per the Diesel Generator specifications in clauses 4.18-4.19.

### **1.3 Estimated Demand and Plant Sizes of Mini-Grids**

**1.3.1** The mini-grid data collection Consultant appointed by KOSAP developed details of each site that included an analysis of all existing residential, commercial and public facility consumers with likely load estimations including future load growth for the next 5 years as presented in table 2 to table 7.

**1.3.2** The bidder shall offer a complete design for each mini-grid based on the technical specification given in this document. The design of the Contractor (Successful Bidder) will be approved and the supplies will be made by contractor thereafter as per approved design and scope as per Employer's Requirement and Technical Specification (ERTS).

## **1.4 General Design Features**

**1.4.1** During the daytime, the Solar Power Generation Plant should supply power directly to the Loads in online mode, along with charging of the BESS in continuous mode. On most non-cloudy days during the year (“regular day”), batteries should get fully charged during the day time. In evening or morning (Sun period) battery should support the SPGP to meet the load, if required.

**1.4.2** Estimated energy consumption pattern: It has been observed from studies report of Consultants that

- i) Estimated Energy consumption by consumers during 6 PM to 7 AM: 70% of total estimated energy consumption during 24 hours.
- ii) Estimated Energy consumption by consumers during 7 AM to 6 PM: 30% of total estimated energy consumption during 24 hours.

**1.4.3** During 6 PM to 7 AM, all loads will be powered from BESS and or DG as per requirement.

**1.4.4** BESS is sized in such a way that they should not go beyond a depth of discharge of 80% for Lithium-Ion batteries, considering expected load growth for next 5 years.

**1.4.5** BESS would have (1) one day autonomy for designed demand for mini-grids.

**1.4.6** A properly configured Battery Management System (BMS) should be in place for managing the state of charge and state of health of each cluster of the BESS.

**1.4.7** SPGP mini-grid will work in un-electrified area where there will be no grid availability in the foreseeable future, however the mini-grid design will be suitable for eventual interconnection with the national grid. It will be initially a Solar Plant + BESS + Standby DG.

**1.4.8** The system should be capable of modular expansion (Solar and Storage) when needed.

**1.4.9** The system should explicitly allow, connect with and be capable of synchronizing with the State Grid, as and when connected. When State Grid is available, the SPGP of AC capacity will be integrated with State Grid and BESS may not be used. DG will always be standby.

**1.4.10** All the solar equipment and BESS should be at minimum height of 300mm from finished floor level so as to ensure safety from flooding. Foundations should be concrete or to employer’s approved alternative such that they can withstand annual low-level flooding for the lifetime of the Mini-Grid. Support structures and foundations shall be designed so as to withstand adverse weather conditions. Balance of system components, including but not limited to underground cables shall be rated for

conditions of use, including low-level flooding.

**1.4.11** Installation of meters will be done by the contractor for every connection including household/domestic and non-residential (commercial/community facilities e.g., schools and health facilities) consumers. Customer prepaid meters will be supplied by the employer.

**1.4.12** Separate meters for solar energy generation, DG output, export meter system to customers and local station consumption as well as DG flow meters to be supplied by the winning bidder as per REREC requirements/ specifications, accuracy class and grid codes.

**1.4.13** DG shall provide support to Solar plant and BESS to meet the consumer load requirements

## **2. SOLAR POWER GENERATION PLANT**

### **2.1 Scope of Supply & Work of SPGP**

**2.1.1** Scope of supply & work includes all design, engineering, procurement & supply of equipment, and materials, inspection by third party and witnessed by officers nominated by the Employer, packing and forwarding, supply, unloading at site, associated civil works, services, permits, installation and incidentals, insurance at all stages, erection, metering, testing and commissioning of SPV power generation plant with associated equipment and materials on turnkey basis.

**2.1.2** The equipment and materials for PV Solar Power Generation Plant with associated BESS shall include but not be limited to the supply, erection, testing and commissioning of the following:

**2.1.2.1** Solar PV modules (either monocrystalline silicon or polycrystalline silicon), steel module mounting structures (MMS), aluminium support for the PV modules and reinforced concrete foundations for the structures that may include piles foundations, bolts and nuts for holding structures and module interconnection.

**2.1.2.2** Array junction boxes, combiner boxes & distribution boxes having fuse boxes, MCBs, surge arrestors also as per requirement.

**2.1.2.3** Inverters with data acquisition capability & weather monitoring system to check solar irradiation, plane-of-array (POA) irradiation, wind speed & ambient temperature.

**2.1.2.4** Digital voltage meter and ammeter, revenue-grade kWh meters and protection relays along with battery.

**2.1.2.5** DC cables including end terminations and other required accessories.

**2.1.2.6** Control cables including end terminations and other required accessories.

**2.1.2.7** 11kV (for MV mini-grids as per Table 2 to table 7, 415 V and 240 V AC power cables including end terminations and other required accessories for AC side of plant.

**2.1.2.8** BESS Lithium Ion, (including battery Inverter and charger) associated with battery system, capable of at least C/4 charge/discharge rate.

**2.1.2.9** Internal 240 volts, 415 volts, 11kV (for MV mini-grids as per Table 2 to table 7, interconnection as applicable.

**2.1.2.10** 0.415/11kV step up transformers and 11/0.415kV step down transformers as per requirement

**2.1.2.11** AC indoor panels, as applicable, having incoming and outgoing feeders with VCBs/MCB, CTs, PTs, bus bars, cables terminals kits for all the transformers and outdoor feeders as applicable.

**2.1.2.12** Supply of remote monitoring systems complete with associated equipment to enable

remote/local monitoring of all necessary parameters.

**2.1.2.13** Early Streamer Emission (ESE) lightning arrestors.

**2.1.2.14** Suitable electrical conduit, raceway, cable tray, and/or accessories/trenches.

**2.1.2.15** Protection /isolation systems at line end.

**2.1.2.16** Earthing system for PV array, DC power system, AC power system and lightning protection system along with fire-fighting tool kit.

**2.1.2.17** Security equipment such as a perimeter fence and locked gate, solar field barricade fence, CCTV system for 3 No. of sites specified in Table 17, perimeter lighting, SPGP area lighting and building(s) security lighting and manually activated sound alarm system at the guard house.

**2.1.2.18** Fire protection and firefighting equipment; fire detection, fire suppression system in the control room BESS section, fire extinguishers, signage, danger plates, name plate etc.

**2.1.2.19** Solar Meter at ACDB for recording export of Solar energy and import of Auxiliary energy; Meter to record Import/export of energy from BESS and with CT- PT as applicable having accuracy with main & check meter at Outlet of SPGP as per Grid code.

**2.1.2.20** Auxiliary supply / local loads interconnections.

**2.1.2.21** Streetlights mounted on 10-meter-high pole to be fixed at suitable location all around boundary/fencing in SPGP site.

**2.1.2.22** Diesel generator with required capacity of fuel tank and other associated equipment for interconnection with AC system of Solar Plant and BESS.

**2.1.2.23** Plinth foundation for mounting of diesel generator and a shed for the generator. The diesel generator housing shall be fenced off.

**2.1.2.24** Transportation of equipment for works to site.

**2.1.2.25** Loading & unloading of all supplied equipment on foundations at their respective places.

**2.1.2.26** Construction of access roads and internal SPGP station roads to enable O & M of the panels and equipment.

**2.1.2.27** Construction of containerised solution control room to accommodate all equipment, subject to approval by the employer.

**2.1.2.28** Construction of containerised office solution fitted with office furniture to accommodate two to three office operators and subject to approval by the employer.

**2.1.2.29** Solar support structures – galvanized steel structurers to elevate the PV panels at a minimum of 1 meter above the finished ground level and steel rails, mid and head clumps for mounting and support of PV panels and as per standard specifications.

- 2.1.2.30** 100mm layer of ballast aggregates to solar field platform.
  - 2.1.2.31** Construction of a masonry guard house structure with store room provision.
  - 2.1.2.32** Construction of a twin VIP masonry pit latrine structure.
  - 2.1.2.33** Carrying out basic survey, setting out and Geotechnical survey for the design of earthworks, site grading, levelling and foundations.
  - 2.1.2.34** Construction of the foundations for the module mounting structures as per approved design.
  - 2.1.2.35** Construction of associated cable network and conduits.
  - 2.1.2.36** Storm water harvesting and storage.
  - 2.1.2.37** Storm water drainage.
  - 2.1.2.38** Training of executive/technician.
  - 2.1.2.39** Testing, maintenance and monitoring equipment.
  - 2.1.2.40** Receipt, unloading, storage, erection, testing and commissioning of all supplied material.
  - 2.1.2.41** Disposal of solid waste, e-waste etc.
  - 2.1.2.42** Mandatory spares & consumable spares for 7 years O&M.
  - 2.1.2.43** Any other equipment / material required to complete the SPGP on turnkey Basis.
- 2.1.3** Bidder's scope includes design of SPGP and its associated civil, electrical & mechanical auxiliary systems including preparation of single line diagrams, electrical lay outs, electrical and physical clearance diagrams, design calculations, indoor and outdoor lighting/illumination, erection key diagrams, installation drawings etc., design memorandum and other relevant drawings and documents required for engineering of all facilities within the fencing to be provided under this contract.
- 2.1.4** Land development, design and construction of civil works including:
- 2.1.4.1** Conducting topographical and geotechnical survey of the SPGP area (including its neighboring territory)
  - 2.1.4.2** Associated earthworks, site grading, levelling, clearing of vegetation, slope protection and site restoration.
  - 2.1.4.3** Design and construction of module mounting structures and their foundations.
  - 2.1.4.4** Access road and Internal SPGP station Roads for O & M to enable safe and easy transportation of equipment and material at the SPGP site shall be made.
  - 2.1.4.5** Control room containerized solution to accommodate all indoor equipment, including BESS and Inverters and appropriate cable network.
  - 2.1.4.6** Office structure containerized solution fitted with office furniture.

- 2.1.4.7** Guard house masonry structure with a store room provision.
  - 2.1.4.8** VIP masonry Pit latrine structure.
  - 2.1.4.9** Civil foundation works as per design, guided from geotechnical survey and earthwork design, to achieve a uniform level for balancing of the PV array system; as well as civil foundations for all other electrical equipment as required.
  - 2.1.4.10** 100mm layer of ballast aggregates to solar field platform.
  - 2.1.4.11** Storm Water harvesting with adequate storage as per specified capacity in this document. A suitable arrangement of water shall be ensured to cater for the day-to-day requirement of drinking water and soft water for washing needs of Solar Photovoltaic module etc. during entire O&M period.
  - 2.1.4.12** Drainage works for the entire station. Good drainage design should be adopted to ensure proper evacuation of water.
  - 2.1.4.13** Associated Cable network trenches and conduits.
  - 2.1.4.14** Security 1-acre perimeter fence and associated guardhouse and gate, solar field Barricade fence, Security system including CCTV for 3 sites in high threat areas as specified in **Table 17**, manually activated sound alarm system at the guard house, perimeter lighting, SPGP Area Lighting and building(s) security lighting.
  - 2.1.4.15** Fire protection and suppression system in the control room BESS section, with Detection systems.
  - 2.1.4.16** Lightning Protection Structures.
  - 2.1.4.17** Any other works for the completeness of the mini-grids.
- 2.1.5** Erection work shall be performed with respect to the following but not limited to:
- 2.1.5.1** Solar PV modules, inverter, MMS etc.
  - 2.1.5.2** Battery Energy Storage System (BESS).
  - 2.1.5.3** All types of cables
  - 2.1.5.4** Earthing material
  - 2.1.5.5** Entire GI cable tray inside control room building.
  - 2.1.5.6** Fabrication, supply & erection of cable trays, support, brackets and accessories in case of site fabrication cable tray.
  - 2.1.5.7** Galvanized steel rigid/flexible conduits and accessories, Hume pipes, ferrules, lugs, glands, terminal blocks, galvanized sheet steel junction boxes, cable fixing clamps, nuts and bolts etc. as required.
  - 2.1.5.8** Supply of necessary steel materials for field fabrication of cable trays, supports, brackets, grounding system etc.



**2.1.5.9 Diesel Generator and its storage tank.**

**2.1.6** Pre-commissioning & commissioning of all supplied equipment. Test running of solar power generation plant as well as load trials at site, prior to handover and implementation of maintenance contract.

**2.1.7** Any other items not specifically mentioned in the specifications but that are required for erection, testing and commissioning in every respect and for safe and efficient operation and guaranteed performance of the SPGP are deemed to be included in the scope of the specification unless specifically excluded on turnkey basis.

**2.1.8** Obtaining statutory approvals /clearances from government departments related to Engineering, Procurement and Construction (EPC) work.

**2.1.9** The Bidder shall arrange deployment of manpower and required consumables during commissioning.

**2.1.10** Construction power & water as required for this contract are in scope of the Bidder.

**2.1.11** Total operation & maintenance (O&M) of solar photovoltaic power plant for the 7 year period including deployment of technical and security personnel, full time or part time as necessary.

**2.1.12** Submission of the following documents, drawings, data design and engineering information to Employer or its authorized representative for review and approval in four copies and a soft copy.

Detailed technical specification of all the equipment being supplied.

- i) Design criteria.
- ii) Design calculations for cable size, Module Mounting Structure (MMS) foundations, bus bar sizes, earthing system, lightning protection zone etc.
- iii) General arrangement and assembly drawings.
- iv) Topographical plan for the area before and after site grading activities.
- v) Solar insolation data and resource assessment.
- vi) Schematic diagram for entire electric system.
- vii) General Assembly (GA) drawings for all types of structures.
- viii) Quality assurance plans.
- ix) Test report (Type, Acceptance and Routine tests).
- x) O&M instruction's manuals and associated drawings.
- xi) And all other necessary drawings including:
  - Overall Plant layout
  - Earthing layout showing locations / details of Earthing mast and detail of earthing pits-  
Array yard earthing layout
  - Layout diagram of Switchgears (Indoor / Outdoor)

- DC – Single Line Diagram (SLD)
- AC- SLD
- DC Array Layout
- ACDB & DCDB Single Line Diagram
- General Arrangement Drawing- AC Distribution Board
- Schematic wiring Diagram
- Lighting Distribution board (LDB) SLD for (Array Yard)
- Lighting Distribution board (LDB) SLD for (Control Room Lighting)
- CT, PT, Metering arrangement drawings along with Technical and other details-Single Line Diagram Switch yard(s) (Indoor / Outdoor)
- The selection cable size based on detailed Engineering and calculation to ascertain the yield loss
- Copper cable of size (4/6 square mm & above) duly supported with it's design for yield loss
- Cable design calculations for proposed Aluminum cables between inverter to HT system / panels.
- Remote/local monitoring Architecture
- Module mounting structure design along with recommended tilt angle.
- Module Structure Foundation Design.
- Diesel generator equipment plinth foundations details, it's shed and fencing off details.
- Plant civil works layout.
- Topographical drawing and geotechnical survey report.
- Earthwork's layout and design.
- Architectural Plan, elevation & section (for office, control room, Guard house and pit latrine) Structural Plans (Foundations, Walls, Roof etc.)
- SPGP station layout, indicating all the structures to be developed in the proposed site, including the module mounting structures and foundations layout, sections and their respective details.
- Detailed structural designs and associated calculations.
- Drainage layout and detail for storm water.
- Access road layout and internal SPGP station road and details.
- Cable network and conduits details.
- Security perimeter fence layout and solar field barricade fence layout and details.
- Fire protection including fire suppression layout and details.

**2.1.13** All drawings shall be fully corrected to agree with the actual "as built" site conditions and submitted (4 sets in pdf and 4 soft copy on a Hard disk drive) to the Employer after commissioning of the SPGP for record purpose.

**2.1.14** The contractor shall forward to the Employer:

- i) Schedule for various activities in the form of PERT / Ms. Projects/ Gantt Chart within a week from the date of detailed work order.
- ii) Fortnightly site work progress report during construction period and
- iii) Daily generation and weekly O&M reports after commissioning of the SPGP.

**2.1.15** For all works, the Contractor shall submit a Plan for the sequence of construction, to follow the guidelines as follows:

- i) Preliminary Design (Topographical and Geotechnical survey, Approval of statutory documents, Civil and Electrical Works methodology, Standard Operating Procedures and a Quality Management Plan).
- ii) Design Stage (Relevant Standards and Specifications, Drawings and Designs, Revision of Drawings, Statutory Approvals/Requirements).
- iii) Works Program, Reporting System and Security Plans.
- iv) Closure (As-built drawings).

**2.1.16** Preparation and supply of detailed operation and maintenance manual of SPGP.

**2.1.17** Establishing a system to maintain an inventory of spare parts and tools, equipment, consumables and supplies for the facilities and operation.

**2.1.18** Employ and coordinate the training of personnel who will be qualified and experienced to operate and monitor the facility and to coordinate operations of the facility with the grid system where applicable.

**2.1.19** Adequate insurance coverage during EPC and O&M contracts period.

## **2.2 Operation and Maintenance Period**

**2.2.1** Operation and Maintenance (O&M) of the Solar Photovoltaic Power Generation Plant is required for a period of 7 (seven) years from the date of commissioning of the SPGP which shall be carried out at quoted Annual O&M cost as per the price schedule. The Annual cost of Operation and Maintenance includes supply and installation of all necessary replacement equipment and materials, spares & consumable spares and all services detailed in foregoing and following clauses of ERTS.

**2.2.2** The bidder should note that the Employer will pay quarterly O&M cost only as per Section IV, Schedule 6.

**2.2.3** In the event that a site has to be dropped/ added from the O&M schedule, the O&M cost of that

site shall be determined in the ratio of the SPV solar capacity with respect to the contract price.

## **2.3 Operation and Maintenance of SPGP**

**2.3.1** The Employer entrusts the total O&M activities of the SPGP (Solar Plant + BESS + DG) to the Contractor on turnkey basis for the 7 (seven) years O&M period as per price schedules.

**2.3.2** The period of Operation and Maintenance of SPGP for 7 years shall be deemed to commence from the date of commissioning of SPGP.

**2.3.3** The contractor (Successful Bidder) shall be responsible for all the required activities for the successful running (7 years O&M period), optimum energy generation & maintenance of the Solar Photovoltaic Power Generation Plant covering:

**2.3.3.1** Developing Operations and Maintenance manuals and maintenance schedules to be approved by the employer.

**2.3.3.2** Deployment of engineering and supporting personnel and regulation of their Duties.

**2.3.3.3** Deployment of security personnel and regulation of their duties.

**2.3.3.4** Successful running of SPGP for optimum energy generation.

**2.3.3.5** Operation and Maintenance including supply and installation of all necessary replacement of equipment and materials.

**2.3.3.6** Monitoring, controlling, troubleshooting, maintaining of records and registers.

**2.3.3.7** Supply of all spares, consumables and fixing / application, replacement of damaged modules, invertors, LA and other equipment/material etc. required during O&M period of 7 years.

**2.3.3.8** Supply & use of consumables (throughout 7 years O&M period) as per recommendations of the equipment manufacturers.

**2.3.3.9** Conducting periodical checking, testing, over hauling and preventive action.

**2.3.3.10** Operation and Maintenance of all civil and structural components in accordance to approved operation and maintenance manuals and schedule.

**2.3.3.11** Periodic general up-keeping including cleaning of all equipment, building, amenities, roads, SPGP land area etc.

**2.3.3.12** Submission of periodical (monthly, quarterly and annual) reports to the Employer on the energy generation (including plant availability details), operating conditions, breakdowns/loss of supply (reported date and start time of breakdown, action taken, resolution time and acknowledgement by the beneficiary of the resolution of the breakdown) of the SPGP.

**2.3.3.13** Taking care of the full security aspects of the SPGP.

**2.3.3.14** Insurance covering all risk (Fire & allied perils, earthquake, terrorist acts, floods, storms and burglary, for all Mini-grids.

**2.3.3.15** Arrangement & Maintaining Diesel for running the DG included in recurrent cost as per requirement and to meet the load demand of consumers.

**2.3.3.16** Maintain accurate and up-to-date operating logs, records and reports regarding the operation and maintenance of the Plant which shall include details of power output, other operating data, repairs performed, status of equipment and all other such records to be maintained for the complete O&M period of 7 years. Upon expiry of the O&M term, the Contractor shall hand over such records to the Employer. However, Employer shall have access to all such records at any time during O&M period.

## **2.4 Operation and Maintenance Monitoring of SPGP for O&M Period**

**2.4.1** Operation consists of maintaining the SPGP at the optimum capacity. Operation procedures such as preparation to start, routine operations with safety precautions, monitoring of SPGP etc. shall be carried out as per the manufacturer's instructions to have trouble free operation of the complete SPGP.

**2.4.2** Cleaning of modules, logging of the voltage, current, power factor, power and energy output of the SPGP will be the responsibility of the contractor. The SPGP operator shall record failures, interruption in supply and tripping of different relays, reason for such tripping, duration of such interruption etc. Another task of the operators is to check battery parameters including voltage, specific gravity and temperature etc. The operator shall record monthly energy output, down time, etc.

## **2.5 Routine Maintenance of SPGP over the O&M Period**

**2.5.1** The contractor shall carry out the periodical plant maintenance as given in the manufacturer's service manual and perform at least minimum requirement.

**2.5.2** Regular periodic checks of the modules, Inverters, BESS, transformer, DG etc. shall be carried out as a part of routine preventive maintenance.

**2.5.3** In order to meet the maintenance requirements stock of consumables are to be maintained as well as various recommended spares by the manufacturer.

**2.5.4** Particular care shall be taken for outdoor equipment to prevent corrosion. Cleaning of the junction boxes, cable joints, insulators etc. shall also be carried out frequently.

**2.5.5** Resistance of the earthing system as well as individual earthing is to be measured and recorded frequently. If the earth resistance is more than 3-ohm, suitable action is to be taken to bring down the same.

**2.5.6** According to the recommendations, stock of special tools and tackles shall be maintained for Modules, Inverters and other major electrical equipment.

**2.5.7** A maintenance record register is to be maintained by the contractor to record the regular maintenance work carried out as well as any breakdown maintenance along with the date of maintenance, reasons for the breakdowns, steps taken to attend the breakdown, duration of the breakdown etc.

**2.5.8** The maintenance schedules will be drawn such that some of the jobs other than breakdown, which may require comparatively long stoppage of the SPGP, shall be carried out preferably during the overnight period.

**2.5.9** The Contractor shall deploy enough manpower at solar photovoltaic power generation plant site to carryout work

- i) As per O&M manuals and
- ii) As specified in preventive maintenance schedules.

**2.5.10** The Contractor will attend to any breakdown jobs immediately for repair/replacement /adjustments and complete at the earliest working round the clock.

**2.5.11** The Contractor shall promptly report and record accidents, if any, to KPLC/REREC showing the circumstances under which it happened and the extent of damage and or injury caused as per OSHA and KPLC/REREC requirements.

**2.5.12** If negligence / mal-operation of the contractor's operator results in failure of any equipment then such equipment should be repaired/replaced by contractor at no cost to the client.

**2.5.13** The Contractor shall comply with the provision of all relevant acts of National or Concerned County Governments including Employment Act, Workmen's Compensation Act, Labour Relations Act, Trade Disputes Act, Energy Act 2019 and any other relevant laws.

**2.5.14** The contractor shall at their own expense provide all amenities to their workers as per applicable laws and rules.

**2.5.15** The Contractor shall ensure that all safety measures are taken at the SPGP to avoid any accident to Contractor's or sub-contractor's workers or members of the public.

**2.5.16** The Contractor is fully responsible for defects and equipment failure during the 7 years O&M period.

## **2.6 Quality Spares and Consumables**

**2.6.1** In order to ensure longevity & safety of the core equipment and optimum performance of the system, the contractor shall use only Original Equipment Manufacturer (OEM) spares.

## **2.7 Tools and Tackles**

**2.7.1** The Contractor shall arrange for all the necessary tools for carrying out all the maintenance work. List of such tools to be furnished by the bidder.

### 3. STANDARDS AND SPECIFICATIONS

#### 3.1 Standards for SPGP & PDN

3.1.1 The standards to which equipment and material of SPGP and PDN shall comply are given in the table below:

**Table 8: List of Standards**

<b>Solar PV Panels</b>	
IEC 61215	Design qualification and type approval for crystalline silicon terrestrial photovoltaic modules
IEC 61701	Salt mist corrosion testing of photovoltaic (PV) modules
IEC 61853- Part 1	Photovoltaic (PV) module performance testing and energy rating –: Irradiance and temperature performance measurements, and power rating
IEC 61730-1,2	Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction, part 2: Requirements for testing
IEC 62804	Photovoltaic (PV) modules – Test methods for the detection of Potential-Induced Degradation (PID). IEC TS 62804-1: Part 1: Crystalline silicon (Mandatory for system voltage is more than 600 VDC and advisory for system voltage is less than 600 VDC)
IEC 62759-1	Photovoltaic (PV) modules – Transportation testing, Part 1: Transportation and shipping of module package units
IEC 62716	Photovoltaic (PV) Modules – Ammonia (NH <sub>3</sub> ) Corrosion Testing
<b>Solar PV Inverters / Battery Inverters</b>	
IEC 62109-1, IEC 62109-2	Safety of power converters for use in photovoltaic power systems Safety compliance (Protection degree IP 65 for outdoor mounting, IP 54 for indoor mounting)
IEC/IS 61683 (For stand Alone System)	Photovoltaic Systems – Power conditioners: Procedure for Measuring Efficiency (10%, 25%, 50%, 75% & 90-100% Loading Conditions)
IEC 62891	Overall efficiency of grid-connected photovoltaic inverters:
IEC 62116/ UL 1741/ IEEE 1547	Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures
IEC 60255-27	Measuring relays and protection equipment – Part 27: Product safety requirements
IEC 60068-2 (1, 2,14, 27, 30 & 64)	Environmental Testing of PV System – Power conditioners and inverters
IEC 61000- 2,3,5	Electro- magnetic interference (EMI), and Electro-Magnetic Compatibility



	(EMC) testing of PV inverters (as applicable)
IEC 62909- 1 IEC 62909- 2	Bi-directional grid connected power converters – Part 1: General requirements Bi-directional grid connected power converters - Part 2: Interface of GCPC and distributed energy resources and additional requirements to Part 1
EN 50530	Overall efficiency of grid-connected photovoltaic inverters
IEC 62509	Battery charge controllers for photovoltaic systems - Performance and functioning
<b>Fuses</b>	
IEC 60947 (Part 1, 2 & 3), EN 50521	General safety requirements for connectors, switches, circuit breakers (AC/DC)
IEC 60269-6	Low-voltage fuses – Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic systems
<b>Cables</b>	
IEC 60227, IEC 60502	General test and measuring method for PVC (Polyvinyl chloride) insulated cables (for working voltages up to and including 1100 V, and UV resistant for outdoor installation)
BS EN 50618	Electric cables for photovoltaic systems (BT(DE/NOT)258), mainly for DC cables
<b>Earthing /Lightning</b>	
IEC 62561 Series (Part 1,2 &7) (Chemical earthing)	IEC 62561-1 Lightning Protection System Components (LPSC) – Part 1: Requirements for connection components IEC 62561-2 Lightning Protection System Components (LPSC) – Part 2: Requirements for conductors and earth electrodes IEC 62561-7 Lightning Protection System Components (LPSC) – Part 7: Requirements for earthing enhancing compounds
<b>Transformers</b>	
IEC – 60076-1,2,3,4,5,7, &10	Specification for power transformer
IEC 60512	Connectors for electronic equipment
BS EN 10025	Hot rolled product of structural steels
Manual on transformer	Publication No 295 CBIP 2006

Department of Energy 10 CFR Part 431	Energy conservation program for commercial equipment: Distribution transformers energy conservation standing rule
IEC 60422	Mineral Insulating Oil in electrical equipment –Supervision and maintenance guidance
ISO 1461	Hot dipped galvanized coatings on fabricated iron and steel articles – Specifications and test methods
IEC 60554-3-1	Specification for cellulosic paper for electrical purposes –Part-3: specification for individual material sheet-1 – General purpose electrical paper.
IEC 60317-0-1	Specification of particular types of winding wires – Part 0 : General requirement – section 1 : Enameled round copper wire
IEC 60296	Specification for unused mineral insulating oil for transformers and switch gear
IEC 60641-3-1	Press board and press paper for electrical purposes –Part 3 : Specification for individual material –Sheet-1 : Requirements for press board , type B.0.1 , B.0.3 B.2.2, B.2.3, B.3.1, B.3.3 , B. 4.1, B.4.3, B.5.1, B.5.3 and B.6.1
ASTM D:1275	Fittings and accessories for power Transformer
IEC 60214	Tap changers Part-1: Performance requirements and test methods , Part-2 Application Guide
BS EN 50464-1	Three phase oil immersed distribution transformer 50 Hz from 50 KVA with highest voltage for equipment not exceeding 36 KV – Part-1: General requirement
BS EN 755 -6	Aluminum and aluminum alloys, Extruded rod / bar , tube and profile , Hexagonal bars , tolerance on dimensions and form
ASTM B - 49	Specification for copper wire rods
BS 381C	Specification for colors for Identification coding and special Purpose
IS: 6600	Guide for loading oil immersed Transformers
BS 2627	Specification for wrought aluminum for electrical purposes
IEC 60071	Insulation coordination: Part-1 definition , principles and rules
<b>Switch gear</b>	
IEC-298	A.C. Metal – enclosed and control gear for rated voltages above 1KV and including 72.5KV
IEC-60694	Common clauses for high voltage switchgear and control gear.

IEC-60255 & IEC-61330	Numerical Relays
IS-13118/ IEC-60056	Specification for high voltage ac circuit breakers.
IEC-529	Degrees of Protection.
IEC60909 Series	Short circuit current in three phase A C systems
BS EN 60044-1 :1999	Instrument transformer; Current transformer
BS EN 61810 Series	Electro mechanical elementary Relays
BS EN 61810 Series	Measuring relays and protection equipment
IEC TS 6100-6-5	Electromagnetic immunity Part 6.5 Generic Standards. Immunity for power Station and Substation Environment
IEC 60364-7-712:2002	Electrical installation of building – Special installation or locations – Solar Photo Voltaic (PV) power supply systems
ENA Engineering Recommendation P2/6 (2006)	Security of supply
BS EN 60947 Series	Low voltage switchgear and control gear
BS EN 60255 Series	Functional safety of electrical/electronic /programmable electronic safety related system
IEC60909 Series	Short circuit current in three phase AC system
<b>Surge arresters/ Lightning arresters</b>	
NFC17-102	E S E lightning conductor / arrester
IEC 99-4 Part.4	Surge arresters without gap for AC system.
IEC 61643-11:2011	Low-voltage surge protective devices – Part 11: Surge protective devices connected to low voltage power systems – Requirements and test methods
<b>Sub-Station Structures along with Required G.I. Bolts, Nuts,G.I. Step Bolts, Spring Washers Etc.</b>	
IS 802	Code of practice for use of structural steel in overhead transmission line
IS 802 PART-I	Load and permissible stresses
IS 802 PART-II	Fabrication, galvanizing, inspection & packing
IS 802 PART-III	Testing

IS 2062	Structural Steel (Standard quality)
<b>Porcelain Insulators for Overhead lines</b>	
IEC:575	Thermal mechanical performance test and mechanical performance test on string insulator units
IEC:815	Guide for the selection of insulators in respect of polluted conditions.
ASTMC151-93-a	Standard test method for autoclave expansion of port land cement.
ANSIC29-2-1992	American National Standard for insulators wet process porcelain and toughened glass suspension type.
IEC:383	Test on insulators of ceramic material or glass for overhead lines with a nominal voltage greater than 1000 V
IEC:372	Locking devices
IEC:797	Residual strength of string insulator unit of glass or ceramic material for overhead line after mechanical damage of the dielectric
IEC:433	Characteristics of string insulator unit of the long rod type.
IS: 7814	Phosphor Bronze Sheet & Strip
IS:2108	Black heart malleable iron casting
IS: 6603	Stainless steel bars and flats
<b>Surge Arresters for Distribution System</b>	
ISO1461	Metallic Coating- Hot dip galvanized coating on fabricated ferrous products- requirements
ISO 48	Rubber vulcanized or thermoplastic- Determination of hardness (Hardness between 10 IRHD and 100 IRDH).
IEC 60099	Surge arresters- Part 4: Metal –oxide surge arresters without gaps for AC systems- Part5: Selection and application recommendations.
IEC60270	High-Voltage test techniques- Partial discharge measurements
IEC 60721-3-2	Classification of environmental conditions. Classification of groups of environmental parameters and their severities. Transportation
IEC 60071	Insulation co-ordination- Part 1 definitions, principles and rules: - Part 2: Applications Guide
IEC 60507	Artificial pollution tests on high voltage insulators to be used on ac systems
IEC /TS 60815-1	Selection and dimensioning of high voltage insulators intended for use in polluted conditions- Part 1: Definitions, information and general principles
ANSI/IEEE C62.11	Design test report polymer distribution arresters
IEEE Std C62.22	Guide for the application of metal oxide surge arresters for alternation current systems.

IEEE Std 592	IEEE standard for exposed semiconducting shields on high voltage cable joints and separable connectors
<b>Fasteners and Washers for Overhead lines</b>	
ISO 898-1&-2	Mechanical properties of fasteners made of carbon steel and alloy steel – Part 1: Bolts, screws and studs with specified properties classes – Part2: Nuts with specified properties classes—Coarse thread and fine pitch.
ISO7094	Plain washers with round holes for wood construction
ISO 965-2	ISO general purpose metric screw threads—Tolerances –Party 2: Limits of sizes for general purposes external and internal screw threads – Medium quality.
ISO 262	ISO general purpose metric screw threads – selected sizes for screws, bolts and nuts
ISO 68-1	ISO general purpose screw threads—Part1: Basic profile
ISO 6157-1&3	Fasteners—Surface discontinuities –Part1: Bolts, Screws and studs for general requirements; screws and studs for special requirement.
ISO 2859-1	Sampling procedures for inspection by attributes—Part 1: Sampling schemes indexed by the acceptance quality limit (AQL) for lot-by-lot inspection
BS EN 14399-1, 3&6	High strength structural bolting assemblies for preloading. Part 1: General requirements; Part 3: Hexagon bolt and nut assemblies; Part 6: Plain chamfered washers.
BS 4190	ISO metric black hexagonal bolts, screws and nuts
DIN 436	Square washers with round hole for wood construction
ISO 1461	Hot dip galvanized coating on fabricated iron and steel articles specifications and test methods
<b>Multipurpose overhead line clamps</b>	
ISO 1461	Hot dip galvanized coating on fabricated iron and steel articles specifications and test methods
BS 4360	Specification for weld able structural steels
BS EN 1011-1&2	Specification for welding of metallic materials
ESI43.95	Steel works overhead lines
<b>Porcelain stay Insulators (UP to 33 kV)</b>	
IEC 60383	Tests on insulators of ceramic material or glass for overhead lines with a nominal voltage greater than 1000 V.
IEC 60060-1	High- Voltage test techniques Part 1 : General definition and test requirements
BS 137	Insulators of ceramic material or glass for overhead lines with a nominal

	voltage greater than 1000V
BS 183	Specifications for general purposes galvanized steel wire strand
<b>Composite Insulators Part 1: Suspension Tension Insulators</b>	
ISO 1461	Hot dip galvanized coating on fabricated iron and steel articles specifications and test methods
ISO 1460	Metallic Coatings- Hot dip galvanized coating on fabricated ferrous metals – Determination of mass per unit area – Gravimetric method
IEC 61109	Composite insulators for AC overhead lines with a nominal voltage greater than 1000V- Definitions, tests methods and acceptance criteria.
IEC 60120	Dimensions of ball and socket couplings of string insulator units
IEC 60815	Guide for the selection of insulators in respect of polluted conditions.
<b>Isolator (Dis-connector)</b>	
IEC 62271-102	High voltage switchgear and control gear – Part 102: Alternating current dis-connectors and earthing switches.
ISO1461	Hot dip galvanized coating on fabricated iron and steel articles specifications and test methods
<b>Steel structure for Overhead Lines</b>	
ISO 1461	Metallic Coating- Hot dip galvanized coating on fabricated ferrous products- Requirements
BS 5950	Steelworks design guide – Structural use of steelwork in building
BS EN 1011 Part 1	Welding recommendations for welding of metallic of materials. General guidance for arc welding.
BS EN 10056-1	Specification for structural steel equal and unequal angles.
BS EN 10025	Hot rolled products of structural steel
BS 6722	Recommendations for dimensions of metallic materials.
BS 4 Part 1	Structural steel selections. Specification for hot-rolled sections
BS EN 20273	Fasteners. Clearance holes for bolts and screws
BS 4-1:2005	Structural steel sections. Specification for hot rolled section
KS 02-572	Specification for hot-rolled structural steel sections
ENA TS 43-95	Steelwork for Overhead lines
<b>Specification for Civil Works</b>	
ASTM A 392	Standard Specification for Zinc-Coated Steel Chain-link fabric
ASTM A 120	Specification for Pipe, Steel, Black and Hot-Dipped Zinc-coated (Galvanized) welded and seamless
ASTM F 626	Standard Specification for Fence fittings
ASTM A 121	Barbed wire: ASTM A 121, 2.51 mm diameter wire in strand (No.12-1/2

	gauge), 2 strands with 4-point barbs spaced at 125 mm, Class 3 zinc coating
ASTM A123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
BS 8301	Code of practice for Building Drainage
BS 6031	Code of practice for Earthworks
BS CP 2005	Sewerage design and Construction
AASHTO T99	Standard Method of Test for moisture-density relations of soils using a 2.5kg rammer and a 305mm drop
BS 1377	Methods of test for soils for civil engineering purposes
AASHTO T180	Standard Method of Test for moisture-density relations of soils using a 5.4kg rammer and a 457mm drop
AASHTO T193	Standard Method of Test for the California Bearing Ratio
BS 882	Specification for aggregates from natural sources for concrete
BS 4449	Specification for the use of Structural steel in building
BS 8110	Structural Use of Concrete
BS 8004	Code of Practice for Foundations
BS 12	Specification for Portland Cement
BS 5950	Structural use of steelwork in building
BS 1490	Aluminium Alloy Specification.

### 3.2 Guidelines & Grid Codes

- a. Energy Act 2019.
- b. Kenya National Distribution Grid Code (KNDC), April 2017
- c. Draft Energy (Solar Photovoltaic Systems) Regulations 2019
- d. Connection guidelines for small scale renewable generating plant guidelines: Dec 2012
- e. Kenya Roads design manual (*for civil works*)
- f. Standard specification for roads and bridge construction (*for civil works*)
- g. BS 7430: 1999: Code of practice for earthing.
- h. BS 7354: Code of practice for design of open terminal stations.
- i. ENA Engineering Recommendation G59 / 2-1 (2011): Recommendations for connection of generating plant to the distribution systems of licensed distribution network operators.
- j. ENA Engineering Recommendation G83/1-1 (2008): Recommendations for connection of small-scale embedded Generators (up to 16A per phase) in parallel with public low voltage distribution networks.

- k. ENA Technical Specification 41-24 (1992): Guidelines for the design, installation, testing and maintenance of main earthing systems in substations.
- l. ENA Engineering Technical Report ETR 126 (2004): Guidelines for actively managing voltage levels associated with the connection of a single distributed generation plant.
- m. ENA Engineering Technical Report ETR 130 (2006): The application guide for assessing the capacity of networks containing distributed generation.
- n. BS 7671 2008 Requirements for electrical installations IEE wiring regulations: seventeenth edition.



## **4. TECHNICAL SPECIFICATIONS FOR SOLAR POWER GENERATION PLANT**

### **4.1 SPV Crystalline Modules**

**4.1.1** SPV Mono crystalline modules of minimum 72-cells; and minimum 19.5% module efficiency.

**4.1.2** Solar modules offered shall be

- i) Tier-1 Manufacturer
- ii) Certified as per IEC 61215
- iii) Qualify IEC 61730- Part -1: PV Module Safety Qualification Part -1 Requirement for Construction.
- iv) Qualify IEC 61730- Part -2: PV Module Safety Qualification Part -2 Requirements for Testing.

**4.1.3** As SPV modules shall be used in highly corrosive atmosphere throughout their life time so they must qualify IEC 61701.

**4.1.4** Solar PV Module design shall conform to following requirement:

- i) Weather proof, DC rated MC4 connector and a lead cable coming out as a part of the module, making connections easier and secure, not allowing any loose connections.
- ii) Resistant to water ingress, abrasion, hail impact, humidity, sea water & other harsh environmental factors for the worst situation at site.

**4.1.5** Module rating is considered under standard test conditions; however Solar Modules shall be designed to operate and perform under site conditions including high temperature, dusty conditions, high humidity and corrosive atmosphere.

**4.1.6** Identification and Traceability:

**4.1.6.1** Each PV module shall have Radio Frequency Identification (RFID) Tag. The following information must be mentioned in the RFID used on each module. This can be inside or outside the laminate but must be able to withstand harsh environmental conditions.

- i) Name of the manufacturer of SPV module.
- ii) Name of the manufacturer of Solar cells.
- iii) Month and year of the manufacturer (separately for solar cell and module).
- iv) Country of origin (separately for solar cell and module).
- v) I-V curve for the module.
- vi) Peak wattage,  $I_m$ ,  $V_m$  and PF for the module.
- vii) Unique Serial No and Model No of the module.
- viii) Date and year of obtaining IEC SPV module qualification certificate
- ix) Name of the test lab issuing IEC certificate Other relevant information on traceability of solar

cell and module as per ISO 9001 and ISO 14001.

**4.1.6.2** Any other markings as required in chapter 13 of the specifications shall also be made on the modules.

**4.1.7** Warranties for Modules:

**4.1.7.1** Product Warranty

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 ten (10) years from the date of sale to the original customer (“Employer”)

- 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.

**4.1.7.2** Performance Warranty

- i) A 25-year long-term performance warranty with a maximum linear decrease in peak power at STC of 2.5% in the first year, 0.6%/year in subsequent years. At year 25, the peak power shall be not less than 83%.
- ii) Bidder shall provide data sheet for solar PV module (under standard testing condition) along with their offer as per Guaranteed Technical Particular (Appendix 2).

**4.2** Module Mounting Structure (MMS)

**4.2.1** The MMS to be used for mounting the SPV modules shall be as under:

- i) Fixed-tilt type.
- ii) Azimuth: 0° True South/North.
- iii) Tilt angle: 10° -15° tilt angle shall provide for all sites with adequate spacing to prevent inter-row shading.

**4.2.2** Structure shall comply with IEC 61215/61646.

**4.2.3** The mounting steel structure and its galvanizing shall be as per standards listed in Table 10 of chapter 3 above.

**4.2.4** The mounting structure shall be suitably designed for mechanical and electrical installation. It shall support SPV modules at a given orientation, absorb and transfer the mechanical loads along with applicable wind loads to the base properly.

**4.2.5** While designing of MMS additional care is needed to ensure that the material size used is capable to withstand the wind forces generated on account of heavy wind speed of respective sea wind zone. MMS with documented results of wind tunnel testing and resonant frequency dampening is preferred.

**4.2.6** To reduce the pressure on structure and foundation, clear spacing between two adjacent modules shall be sufficient to allow wind passage.

**4.2.7** The minimum clearance between the lower edge of the modules and developed ground level shall be adequately elevated above relevant flood plain. Minimum 1000 mm or higher and to employer's approval.

**4.2.8** Contractor has to choose suitable foundation design(s) depending on soil conditions, geographical condition, regional wind speed, bearing capacity, slope stability etc.

**4.2.9** The structure shall be designed to allow easy replacement of any module.

**4.2.10** Spacing between rows shall be so designed that shadow of one row of modules to next is avoided.

**4.2.11** The Contractor (successful bidder) shall furnish detailed design calculation.

**4.2.12** Nut & bolts, supporting structures including module mounting structures shall have to be adequately protected against all climatic conditions prevailing in the area.

**4.2.13** All fasteners shall be of stainless steel of grade SS 304 or suitable equivalent.

**4.2.14** The mounting structure shall be grounded properly using maintenance free earthing kit.

**4.2.15** The mounting structure & foundation shall be designed to withstand applicable speed of wind zone of the applicable site as given in relevant International/Kenya wind load codes / standards. Suitable fastening arrangement such as grouting and clamping should be provided to secure the installation against the specific wind speed. The contractor shall ensure that the design has been certified by a recognized lab/ institution in this regard and submit the same to the Employer.

### **4.3 Array Junction Boxes (AJB)/String Monitoring Box (SMB)**

**4.3.1** To receive the DC output from field array, junction box / string monitor Box (SMB) as per design requirement shall be provided in between solar array and DCDB/PV Inverters. They shall be rated for 600/1000V and comply with IEC61439-2, UL1741 and standards.

**4.3.2** AJB can also be integrated into Inverter for space saving.

**4.3.3** AJB having polycarbonate enclosure of dust & vermin proof shall conform to IP 65 protection.

**4.3.4** Array junction box allows several PV strings to be connected in parallel.

**4.3.5** Suitable capacity MCBs/MCCB shall be provided for controlling the DC power output to the inverter along with necessary surge arrestors.

**4.3.6** A DC dis-connector switch must isolate the array DC circuit as per requirement.

#### **4.4 DC Distribution Board/DC combiner box**

**4.4.1** To receive the DC output from junction box /string monitor box (SMB) as per approved design requirement DCB to be provided in between JCB/SMB and PV inverter. They shall be rated for 600/1000V and comply with IEC61439-2, UL1741 and standards.

**4.4.2** Sufficient no. of switchboards / DC DB wherever required shall be provided.

**4.4.3** DCDB should be equipped with appropriate functionality, safety (including fuses, grounding, etc.) and protection.

**4.4.4** The terminals will be connected to bus-bar arrangement of proper sizes to be provided. The panels/ boxes will have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables.

**4.4.5** DC DB enclosure of dust & vermin proof shall conform to IP 65 protection if out door.

**4.4.6** DC DB allows requisite connections from JB/SMB to be connected in parallel.

**4.4.7** Suitable capacity MCBs/MCCB shall be provided for controlling the DC power output to the PV inverter along with necessary surge arrestors.

**4.4.8** DC DB shall be provided with the purpose of providing option for isolating the battery bank.

**4.4.9** There shall be copper bus bars of desired size/rating and can either be independent or integrated in PSU.

**4.4.10** A DC dis-connector switch in DCDB must isolate the array DC circuit as per requirement.

#### **4.5 PV Inverter for solar plant**

**4.5.1** Inverters for SPV Solar Plant, working as off grid/ stand alone in initial stage and Grid interactive on arrival of state Grid, shall be string inverters type with associated control, protection and data logging/ monitoring devices etc. all integrated into inverter.

**4.5.2** It shall be collectively capable of running in isolated as well as grid synchronized mode (multi-Mode inverter).

**4.5.3** SPGP shall be integrated with BESS and DG.

**4.5.4** String inverters as per design shall be of requisite numbers having equal to total AC capacity as per requirement of each site.

**4.5.5** Maximum Power Point Tracker (MPPT) shall be integrated into the inverter to maximize energy drawn from the solar PV array. MPPT shall be microprocessor/micro controller based to minimize power losses and maximize energy utilization. The details of working mechanism of MPPT shall be mentioned by the Bidder in its proposal. The MPPT unit shall conform to IEC 62093 for design qualification.

**4.5.6** The Inverter shall always give preference to Solar power, and will use BESS power only when

the solar power is unable to meet the loads requirement.

**4.5.7** Inverter should comply with IEC 61683 for efficiency and measurements and should comply with IEC 60068-2 for environmental testing.

**4.5.8** The efficiency of the string inverter shall be more than 95% at full load. The inverter shall have high overload capacity. The Bidder should specify the overload capacity in the bid.

**4.5.9** The DC energy produced has to be utilized to maximum and supplied to the bus for inverting to AC voltage to extract maximum energy from solar array.

The solar inverter DC input parameters shall guide the stringing of the solar panels. The DC input should fit the range as per best practice.

**4.5.10** AC Voltage and Variation

i) AC voltage 3-ph, 415V AC

ii) Voltage variation (+10% to – 10%),

iii) Frequency variation 50+/-1.5 Hz

iv) Total harmonic voltage distortion less than 3% to synchronize with standard /local grid.

**4.5.11** Communication interface shall be an integral part of inverter and shall be suitable to be connected to local computer and also remotely via the web.

**4.5.12** Inverters must operate in synergy and intelligently to optimize maximum generation at all times with minimum losses.

**4.5.13** The Inverter shall be capable of controlling power factor dynamically. Inverters should be equipped with components required to support reactive power.

**4.5.14** The Inverters shall be designed for continuous, reliable power supply as per specification and shall have internal protection arrangement against any sustained fault in the feeder line and against lightning strikes in the feeder line.

**4.5.15** The PV inverter shall have the required protection arrangements against earth leakage faults.

**4.5.16** Specifically, the inverter shall be three phase power conditioning unit using static solid-state components. DC side of inverters shall have contactors / MCBs of suitable rating to allow safe start up and shut down of the system.

**4.5.17** The Inverter shall be suitably designed for parallel operation. Each solid-state electronic device shall have to be protected to ensure long life of the inverter as well as smooth functioning of the inverter.

**4.5.18** Each DC distribution board and sub-array junction box/ SMU etc (as per requirement) shall have suitably rated MCBs / fuses for its connection if integrated in inverter.

**4.5.19** The Inverters shall be capable of complete automatic operation including wake-up, synchronization & shut down independently & automatically.

**4.5.20** The Inverter must have the feature to work in tandem with other similar Inverters and be able to be successively & automatically switched “ON” and “OFF” based on solar radiation variations during the day.

**4.5.21** Degree of protection of the indoor Inverter shall be at least IP-54 and that of outdoor at least IP-65.

**4.5.22** Built in with data logging to remotely monitor plant performance through external PC shall be provided (PC shall be provided along with SPV Plant).

**4.5.23** The system should be capable of providing all the data including that of meter and Inverter to the central software on IEC-104 protocol. All the equipment/hardware /software for complying with the same will be in the Bidder’s scope.

**4.5.24** Both AC & DC lines shall have suitable fuses, surge arrestors and contactors to allow safe start up and shut down of the system. Fuses used in the DC circuit should be DC rated.

**4.5.25** Inverters front panel shall be provided with display (LCD or equivalent) to monitor the following:

- i) DC power input
- ii) DC input voltage
- iii) DC current
- iv) AC output power
- v) AC voltage (all the 3 phases)
- vi) AC current (all the 3 phases)

Provision should be available in the Inverter for remote monitoring of all the parameters.

**4.5.26** Protection required in Inverter

- i) Input side disconnection switch
- ii) Ground fault monitoring
- iii) DC reverse polarity protection
- iv) DC over voltage / current limitation protection
- v) AC short circuit protection
- vi) AC over voltage / current limitation protection
- vii) DC and AC side surge protection (MOV) built-in
- viii) Any other protection in view of battery.
- ix) Anti-islanding protection

**4.5.27** It should have user friendly LED/LCD display for programming and view on line parameters.

**4.5.28** The Inverter shall have arrangement for adjusting DC input current and should trip against sustainable fault downstream and shall not start till the fault is rectified.

**4.5.29** The output power factor of inverter is suitable for all voltage range or sink of reactive power.

**4.5.30** The Inverter shall be able to withstand an unbalanced load conforming to IEC standard and relevant electricity condition. The Inverter shall include appropriate self-protective and self-diagnostic features to protect itself and the PV array from damage in the event of Inverter component failure or from parameters – beyond the Inverter’s safe operating range due to internal or external causes.

**4.5.31** The Inverter shall go to shutdown/standby mode, with its contacts open, under the following conditions before attempting an automatic restart after an appropriate time delay.

- i) When the power available from the PV array is insufficient to supply the losses of the Inverter, the Inverter shall go to standby/shutdown mode.
- ii) The Inverter control shall prevent excessive cycling of shut down during insufficient solar radiance.

**4.5.32** Operation outside the limits of power quality as described in the technical data sheet should cause the power conditioner to disconnect the grid. Additional parameters requiring automatic disconnection are

- i) Neutral voltage displacement
- ii) Over current
- iii) Earth fault
- iv) And reverse power

In each of the above cases, tripping time should be adequate to protect the inverter.

**4.5.33** Internal surge protection shall consist of three MOV type surge-arrestors connected from +ve and –ve terminals to earth (via Y arrangement).

## **4.6 Battery Energy Storage System (BESS)**

**4.6.1** Supply of Battery Energy Storage System (BESS) with Lithium-ion Battery pack, conforming to IEC standards with warranty of 10 years, 3,500 cycles minimum. Complete in all respects as under and conforming to Employer’s Requirement & technical specification, consisting of;

- i) Lithium-ion Battery Power Packs for required energy capacity, or equivalent as per approved design, minimum 80% Depth of Discharge (DOD) for Lithium-Ion. Batteries should be capable of at least C/4 charge and discharge rate.
- ii) Enclosures conforming to IP35 for Indoor /IP65, or better for outdoor.
- iii) All accessories for correct installation, foundation, connection, controls, and operation of BESS.

**4.6.2** Batteries are charged by Battery Inverter / Charger. Thus, batteries charging mechanism should

be part of the BESS.

**4.6.3** BESS with Lithium ion with a minimum of 80% DOD. No additional battery chemistries will be considered.

**4.6.4** Warranted number of cycles for the BESS at the supplier recommended depth of discharge should not be less than 3,500 cycles at full DOD indicated by the battery manufacturer specifications.

**4.6.5** The battery warranty should be 10 years minimum. If due to any reason battery is required replacement, then the Contractor is to replace the same in warranty period without any extra cost to the Employer.

**4.6.6** Load demand requirement of each site, design concept of BESS, Inverter rating, Battery rating etc. is elaborated in Table 2 to table 7. Contractor should submit the detailed drawing for approval demonstrating the meeting of load requirements of consumers for each Mini-Grid.

**4.6.7** System voltage of 48V. All equipment to have matching voltages (Batteries, Battery inverter etc)

**4.6.8** Suitable number of corrosion resistant and acid-proof storage racks shall be supplied to accommodate the cells, testers and other accessories. The rack design shall be such that minimum space is required, without any way obstructing the maintenance requirements. For metallic racks, standards specified for control panel enclosures and other metallic shall govern.

**4.6.9** There shall be no environmental hazards caused due to:

- i) Improper use and maintenance of the battery bank.
- ii) Improper disposal of batteries at the time of replacement.
- iii) Any manufacturing defects.

**4.6.10** All technical and other details pertaining to the storage cells shall be supplied including but not limited to the following:

- i) Rated voltage and ampere-hour capacity of each storage cell as the rated discharge rate,
- ii) Permitted maximum DOD,
- iii) Self-discharge rate,
- iv) Cycle life of the storage cell and the anticipated life (in years) of the battery bank.
- v) Total number of storage cells in use.
- vi) Details on cell interconnections, if any
- vii) Charging system used for battery

**4.6.11** The system should allow for the load current to be supplied at the same time as the battery charging current.

**4.6.12** The contractor shall submit (in 4 sets) complete design and expected performance of BESS calculations, drawings, reports and data for approval of the Employer during detailed engineering.



The design of BESS with critical parameters such as response time discharge duration, Depth of Discharge, frequency of discharge, cycle life, round trip cycle efficiency performance degradation, self-discharge characteristics, short time discharge rating, transient response characteristics, auxiliary system requirement etc shall be included in the detailed engineering.

**4.6.13** Suitable Fire protection and suppression system shall be designed for BESS in line with IEC or international requirements/specifications regulation as applicable and system requirement considering project site.

BESS to be housed in one room in the control room/building. The battery room shall have an automated fire detection, prevention and suppression system fitted with a dry aerosol agent to put-out Lithium-Ion battery fires. The system shall include smoke detectors, horn strobes and other components required to enable it function properly and suppress fires while preventing unintended release.

**4.6.14** BESS conforming to International Safety and Electrical Standards shall be Complete in all respect consisting of:

- i) Battery inverter / charger for supply voltage, as per clause 4.7 below, multi-mode (DC to AC and AC to DC), wave type sinusoidal.
- ii) Complete with programmable control and regulation parameters, protection system, control system, surge protection system etc.
- iii) Site Master Controller System.
- iv) Requisite numbers of battery pack, the combination of which shall equal or exceed the estimated capacity shown in design characteristics in this document, with Minimum. 80 % DOD,
- v) Enclosures conforming to IP35 for Indoor.
- vi) All accessories and connection for correct installation and operation of BESS.
- vii) All cables for inter connection with main AC distribution board.
- viii) Support structure to keep batteries at a suitable clearance level from ground to take care of water flooding etc. The design shall be submitted to the employer before its implementation.
- ix) Test certificate and test reports as per IEC62133, IEC61959 and IEC 61960 or other international equivalent standard applicable to battery technology shall be submitted for approval of the Employer. All other test certificate and test reports as per international standards and requirements/specifications for large scale BESS shall be submitted for approval of the Employer during submission of detailed engineering.

**4.6.15** Suitable protection/isolation for the battery system should be provided with proper rating of

fuses and isolators for DC application. This should be connected between battery bank and battery inverter/charger.

**4.6.16** End-of-Life (EOL) plan for all batteries and other potentially hazardous e-waste at the end of its useful life. Bidder shall prepare and submit an EOL recycling and disposal plan for all batteries to be safely processed at a certified facility for the specific battery chemistry being proposed at each facility included in the proposal for each Lot. To the extent that the selected battery chemistry has some residual value as a result of the recycling process, this value can be considered as funds set aside to offset the handling and transport of materials at the end of their useful life. Any remaining cost obligations to ensure compliance with National and International laws and standards, must be set aside in an escrow reserve fund to be established by the Bidder.

#### **4.7 Battery Inverter/ Charger**

**4.7.1** The inverter must be 3-phase multi-mode (DC to AC and AC to DC), bi-directional, four-quadrant capability.

**4.7.2** The power factor capability must be at least 0.80 lagging to 0.80 leading.

**4.7.3** Battery's Battery Management System (BMS) to be integrated with inverter's firmware.

**4.7.4** Inverter shall be capable of operating in either grid-forming mode.

**4.7.5** The efficiency of the Inverter shall be more than 95% at full load.

**4.7.6** DC voltage to match battery system voltage (48VDC)

**4.7.7** Supply Voltage and Variation

i) AC Voltage three phases, 415V AC

ii) Voltage variation (+5% to - 5%)

iii) Frequency variation 50+/-1.5 Hz

iv) Total harmonic voltage distortion less than 3% to synchronize with standard /local grid.

**4.7.8** The inverter shall have high overload capacity. The Bidder should specify the overload capacity in the bid.

**4.7.9** Inverters to have pure sinewave output waveform.

**4.7.10** Inverter should comply with IEC 61683 for efficiency and measurements and should comply with IEC 60068-2 for environmental testing.

**4.7.11** The inverter shall be capable of controlling power factor dynamically and be equipped with components required to support reactive power.

**4.7.12** The Inverters shall be designed for continuous, reliable power supply as per specification and shall have internal protection arrangement against any sustained fault in the feeder line and against lightning strikes in the feeder line.

**4.7.13** The inverter shall have the required protection arrangements against earth leakage faults. Specifically, the inverter shall be three phase power conditioning unit using static solid-state components.

**4.7.14** The inverter shall be suitably designed for parallel operation. Each solid-state electronic device shall have to be protected to ensure long life of the inverter as well as smooth functioning of the inverter.

**4.7.15** Degree of protection of the indoor inverter shall be at least IP-54 and that of outdoor at least IP-65.

**4.7.16** The system should be capable of providing all the data including that of SPV energy meter and inverter to the central software on IEC-104 protocol. All the equipment/hardware /software for complying with the same will be in the Bidder's scope.

**4.7.17** Communication interface shall be an integral part of inverter and shall be suitable to be connected to local data monitoring system and also remotely via the web.

**4.7.18** The inverter shall have the capability to store data for at least 6 months.

**4.7.19** Inverter front panel, supplemental metering, or remote monitoring interface shall be provided with display or remote monitoring of the following:

- i) DC power input
- ii) DC input voltage
- iii) DC current
- iv) AC output power
- v) AC voltage
- vi) AC current

**4.7.20** Both AC & DC lines shall have suitable fuses, surge arrestors and contactors to allow safe start up and shut down of the system. Fuses used in the DC circuit should be DC rated.

**4.7.21** Protection required in Inverter

- i) Input side disconnection switch
- ii) Ground fault monitoring
- iii) DC reverse polarity protection
- iv) DC over voltage / current limitation protection
- v) AC short circuit protection
- vi) AC over voltage / current limitation protection
- vii) DC and AC side surge protection (Metal Oxide Varistor (MOV) built-in
- viii) Any other protection in view of battery.
- ix) Anti-islanding protection

**4.7.22** The inverter shall include appropriate self-protective and self-diagnostic features to protect itself from damage in the event of inverter component failure or from parameters beyond the inverter's safe operating range due to internal or external causes.

**4.7.23** Operation outside the limits of power quality as described in the technical data sheet should cause the inverter to disconnect the grid. Additional parameters requiring automatic disconnection are

- i) Neutral voltage displacement
- ii) Over current
- iii) Earth fault
- iv) And reverse power

In each of the above cases, tripping time should be low enough to protect the inverter.

**4.7.24** Internal surge protection shall consist of three MOV type surge-arrestors connected from positive and negative terminals to earth (via Y arrangement).

**4.7.25** Inverters shall have a minimum 10-year warranty.

#### **4.8 AC Distribution Board (ACDB)**

**4.8.1** The AC power output of the inverter shall be either directly fed to the ACDB.

**4.8.2** Sufficient no. of ACDB / Switch Boards wherever required shall be provided.

**4.8.3** All boxes/ panels should be equipped with appropriate functionality, safety (including fuses, grounding, etc.) and protection.

**4.8.4** The terminals will be connected to bus-bar arrangement of proper sizes to be provided. The panels/ boxes will have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables.

**4.8.5** The ACDB to comprise of;

- Medium Voltage (MV) 11kV ACDB (floor mounted type) with outgoing line(s) and transformer control and relay panel etc as per requirement for MV mini-grids.
- Low Voltage (LV) ACDB (floor mounted type) with separate bay for each Circuit for string inverter, LT side transformer, Battery, Auxiliary supply etc as per requirement of plant.
- The 3 phase 415 V or 11kV as per plant requirement of particular site plant synchronization system with Grid (in future) shall be provided by the Contractor and covered in scope of this Bid.
- The design of the ACDB to be approved by the employer.

**4.8.6** The ACDB shall be fitted with suitable rating & size copper bus, MCCB, HRC fuses/circuit

breaker/isolator, indicators for all incomer and outgoing terminals, LED voltmeter & Ammeter with suitable selector switches to monitor & measure the power to be evacuated.

**4.8.7** Nut & bolts including metallic shall have to be adequately protected against atmosphere and weather prevailing in the area.

**4.8.8** ACDB shall control the AC power from inverter, and should have necessary surge arrestors.

**4.8.9** All switches and the circuit breakers, connectors should conform to IEC 60947, part I, II and III.

**4.8.10** All the panels shall be metal clad, totally enclosed, rigid, floor mounted, air -insulated, cubical type.

**4.8.11** The panels shall be designed for minimum expected ambient temperature of 45 degree Celsius, 90 percent humidity and salty humid weather.

**4.8.12** All indoor panels will have protection of IP54 or better. All outdoor panels will have protection of IP65 or better.

**4.8.13** All the 415V / 230 V/11kV devices / equipment like bus support insulators, circuit breakers, SPDs, VTs etc., mounted inside the switchgear shall be suitable for continuous operation and satisfactory performance as per Grid code requirements of voltage and frequency.

#### **4.9 Lightning Protection**

**4.9.1** The SPV Power Plant shall be provided with Lightning protection connected to proper earth pits. Earthing pits shall be measured to have an earthing resistance of  $10\Omega$  or less at the time of installation. If this level cannot be obtained with the soil at the facility, then soil conditioning (engineered backfill) shall be implemented to improve the earthing resistance within acceptable levels.

**4.9.2** Lightning protection, placed at strategic locations, shall be used to protect the arrays against lightning protection. The bidder shall give detailed design showing location of Lightning Conductor / masts and the protection coverage on array without causing any shadow on the modules to the Employer. All designs shall be submitted to the Employer for approval before its implementation.

**4.9.3** For transformer area suitable mast / conductor protection system is to be provided. All design shall be submitted to the Employer before its implementation.

**4.9.4** Necessary concrete foundation for holding the lightning conductor in position to be made after giving due consideration to maximum wind speed and maintenance requirement at site in future.

**4.9.5** The lightning conductor shall be earthed through Copper conductor strips and connected to with earth pits per applicable International Standards. Suitable number of earth pits shall be provided for each lightning arrester. Each lightning conductor shall be fitted with individual earth pit as per

required Standards including accessories.

**4.9.6** Early Streamer Emission (ESE) lightning arrestors to be provided.

#### **4.10 11kV Step Up Transformer**

**4.10.1** The transformer shall conform in all respects to the relevant standards and requirements and international standards specifications with latest amendments. Distribution transformer shall be as per KPLC/KP1/6C.1/13/TSP/11/32 (Appendix 3)

#### **4.11 Metering at SPGP**

**4.11.1** Separate meters for solar energy generation, DG output, export meters system to customers, and local station consumption as well as DG flow meters to be supplied by the winning bidder as per KPLC requirements/specifications, accuracy class and grid codes.

**4.11.2** Solar Energy meter to record energy from Solar PV area at ACDB with appropriate CT,VT (where applicable) and all necessary accessories as per KPLC/REREC requirements/specifications and grid code requirements shall be provided. Exported energy recorded in this meter will be used for checking annual performance test of Solar PV System. All calibration rules/regulations as specified by KPLC including calibration in KPLC approved lab etc shall be followed.

**4.11.3** Export Energy meters system complete with CT, VT Set where necessary and accuracy class as per KPLC requirements/specifications and grid code requirements. It should also be supplied with meter reading instrument also includes user manual, universal battery charger, RS 232 communication cable, rubber boot, carrying case and one number software for downloading of data to PC for Report generation for each plant.

**4.11.4** Energy meter to record energy from DG with appropriate CT with Isolator /MCCB/MCB etc before interconnection to Solar Output system / ACDB shall be as per KPLC requirements/specifications and grid code requirements. All calibration rules/regulations as specified by KPLC viz calibration in KPLC approved lab etc shall be followed.

**4.11.5** All VTs, CTs, meters and MCBs must meet KPLC requirements/ specifications

**4.11.6** Current and Potential Transformer Connected Meters; The technical specification for Current and Potential Transformer Connected Meters shall comply with KPLC standard specification document no. KP1/6C/4/1/TSP/14/020 (Appendix 3)

**4.11.7** Single-Phase Static Meters for Active Energy; The technical specification for Single Phase Static Meters for active energy shall comply with KPLC standard specification document no. TSP 14.11 (Appendix 3)

## **4.12 Surge Arresters**

**4.12.1** Surge arresters shall be provided at line terminal end.

**4.12.2** Standards: The Surge arresters shall conform to standards in chapter 3. Surge arresters shall comply with KPLC standard specification document no. KP1/6C/4/1/TSP/11/036 (Appendix 3).

## **4.13 Breakers for Switchgears**

**4.13.1** The circuit breaker / metal enclosed switchgear and all other equipment shall comply with the requirement of latest editions of relevant IEC standards and as per chapter 3 above.

## **4.14 Design Parameters for 11 kV System:**

**4.14.1** Design parameters for the 11kV system shall be as per the Kenya Grid codes.

## **4.15 Earthing Protection**

**4.15.1** Earthing system shall be as per REREC requirements/specifications and as per standards in chapter 3.

**4.15.2** Earthing system network / earth mat shall be of interconnected mesh as per REREC requirements/specifications. The earth conductors shall be free from pitting, laminations, rust, scale and other electrical or mechanical defects.

**4.15.3** Metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthing system, each of 100% capacity with the exception of solar panels, for which alternate means of code-compliant earthing shall be admissible if integrated with racking design.

**4.15.4** Metallic sheaths / screens, and armor of multi-core cables shall be earthed at both ends. Metallic Sheaths and armor of single core cables shall be earthed at switchgear end only unless otherwise approved.

**4.15.5** Each continuous laid lengths of cable tray shall be earthed at minimum two places to earthing system, the distance between earthing points shall not exceed 30m/as per REREC Requirements/specifications. Wherever earth mat is not available, necessary connections shall be done by driving an earth electrode in the ground.

**4.15.6** Neutral connections and metallic conduits / pipes shall not be used for the equipment earthing.

**4.15.7** Lightning protection system down conductors shall be terminated to separate earth electrodes & not be connected to other earthing conductors.

**4.15.8** Connections between earth leads and equipment shall normally be of bolted type. Contact surfaces shall be thoroughly cleaned before connections. Equipment bolted connections after being tested and checked shall be painted with anti-corrosive paint / compound.

**4.15.9** Back filling material to be placed over buried conductors shall be free from stones and harmful

mixtures. Back filling shall be placed in layers of 150 mm.

**4.15.10** Earth pit shall be constructed as per IEC standards. Minimum spacing between electrodes shall be 2000 mm/ as per REREC requirements/specifications. Earth pits shall be treated with salt and charcoal/chemical Powder Earthing.

**4.15.11** Earth resistance at earth terminations shall be measured and recorded. All equipment required for testing shall be furnished by successful bidder.

**4.15.12** Each array structure of the SPV Yard / shed shall be grounded properly as per standard. The Array Structure is to be connected to earth pits as per standards. Junction boxes shall be connected to the main earthing conductor / electrode.

**4.15.13** The arrays shall be in protected zone of lightning arrester / spheres by installation of suitable Lightning surge diverters / Lightning arrestors. The earth electrodes for the same shall have to be completely separate from the plant / array earthing.

**4.15.14** All metal casing / shielding of the plant shall be thoroughly grounded in accordance with REREC requirements/ specifications. Total earthing system installation shall be in strict accordance with REREC requirements/ specifications

**4.15.15** Necessary test point provision shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance.

**4.15.16** All non-current carrying metal parts shall be earthed with two separate and distinct earth continuity conductors to an efficient earth electrode.

**4.15.17** Earthing Design and Layout

- i) The successful bidder shall submit Design along with drawings showing the location of lightning arresters and protection zones to cover all arrays against lightning for approval from Employer.
- ii) The earth mesh system design consisting of G.I Flat shall be submitted for approval of Employer.
- iii) Total plant earthing system shall be designed to give an earth resistance of less than 1 ohm all along the earth mesh.
- iv) Earthing conductors in outdoor areas shall be as per REREC requirements/standards and as per approvals. The conductors shall be buried 1.5 to 2M below finished graded level and these buried conductors shall be brought 500 mm above ground level for making tap connections to the equipment.
- v) All the electrodes shall be as per REREC requirements/specifications

**4.15.18** Each phase of LA shall be earthed connected to an individual earth electrode/ as per REREC requirements/specifications.



**4.15.19** Air brake switches and DO fuses shall also be earthed to the main earthing.

**4.15.20** Metallic conduits and pipes shall not be used as earth continuity conductor.

**4.15.21** Conductors shall be provided for earthing the lighting fixtures, receptacles, junction boxes, lighting conduits and this conductor in turn shall be connected to the main earthing conductor / electrode.

#### **4.16 Remote Monitoring**

Supply of remote monitoring systems complete with associated equipment to enable remote/local monitoring of all necessary parameters including; Energy yield from the Solar PV, Real time power from the PV, Solar Module temperature, Solar Insolation and wind density for Solar PV parameters. For battery, the following to be incorporated but not limited to; Battery charging and discharging parameters, Battery temperature, System events, system logs and Daily charging curve.

#### **4.17 Cables**

**4.17.1** Cables and Wiring:

**4.17.1.1** All instruments and Panel wiring shall be of heat resisting and self-extinguishing type in compliance with International Standards. Plastic or porcelain cleats of the limited compression type shall be used for holding wiring runs. All wires shall be suitable for bending to meet the terminal studs at right angles.

**4.17.1.2** Metal cases of all apparatus mounted on panels shall be separately earthed by means of copper wire or strips.

**4.17.1.3** The following color scheme of the wiring shall be used as per standard.

a) AC three phase circuits:

- i) No.1 Phase : Red
- No.2 Phase : Yellow
- No.3 Phase : Blue

ii) Neutral Conductor : Black

iii) Connection to Earth : Green

b) D.C. circuits : Brown for positive (+) and Grey for negative (-)

**4.17.2** Cables and Accessories:

**4.17.2.1** Cables of appropriate size to be used in the system shall have the following characteristics:

- i) Shall meet IEC 60227/IS 694, IEC 60502/IS1554 standards
- ii) Temp. Range:  $-10^{\circ}\text{C}$  to  $+80^{\circ}\text{C}$
- iii) Voltage rating 660/1000V for 415 volts 3 phase.
- iv) Excellent resistance to heat, cold, water, oil, abrasion, Ultraviolet (UV) radiation.

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

**4.17.2.2** All the cables shall conform to the requirements of the related standards and codes for:

- i) DC cable for photovoltaic system
- ii) XLPE / PVC insulated (heavy duty) electric cables for working voltages up to and including 1100V.
- iii) Recommended current ratings
- iv) Low carbon galvanized steel wires formed wires and tapes for armoring of cables
- v) PVC insulation and sheath
- vi) Cross linked polyethylene insulated PVC sheathed cables
- vii) Conductors for insulated electrical cables and flexible cords.
- viii) Standard test method for density of smoke from the burning or decomposition of plastics.
- ix) Tests on gases evolved during combustion of electric cables.
- x) Tests on electric cables under fire conditions.

**4.17.2.3** Technical Requirements:

- i) The cables shall be suitable for laying on racks, in ducts, trenches, trestles, conduits and underground buried installation with chances of flooding by water.
- ii) All cables of module area if laid on cable trays shall be covered. If cables are to be laid underground, laying shall be as per latest relevant code.
- iii) Cables with Copper conductor on DC side & that with aluminum conductor in AC side to be used as power cables shall have tensile strength as per relevant standards. Conductors shall be stranded.
- iv) Cables with XLPE insulation, PVC sheathed & armored suitable for a continuous conductor temperature of 90<sup>0</sup>C and short circuit conductor temperature of 250<sup>0</sup>C shall be used.
- v) PVC insulation shall be suitable for continuous conductor temperature of 70<sup>0</sup>C and short circuit conductor temperature of 160<sup>0</sup>C.
- vi) Only terminal cable joints shall be accepted. No cable joints to join two cable ends shall be accepted.
- vii) Cables inside the control room shall be laid in suitable Cable Trays of approved type.
- viii) Cable terminations for LT cables shall be made with suitable cable lugs & sockets etc.

crimped properly and passed through brass compression type cable glands at the entry and exit point of the cubicles.

- ix) The panels' bottoms shall be properly sealed to prevent entry of snakes / lizard etc. inside the panel.
- x) The terminal end of cables and wires are to be fitted with good quality letter and number ferrules of proper sizes so that the cables can be identified easily.

#### **4.17.3 Cable Selection & Sizing:**

**4.17.3.1** All LT power cables of sizes more than 90 sq.mm shall be XLPE insulated, PVC sheathed and armored. Cables shall be sized based on the following considerations:

- i) Rated current of the equipment
- ii) DC cable: Minimum voltage drop in the cable during full load running condition, maximum voltage drop shall be limited to 1% of the rated voltage.
- iii) AC cable: Minimum voltage drop in the cable during full load running condition, maximum voltage drop shall be limited to 2% of the rated voltage.
- iv) Short circuit withstand capability.
- v) De-rating factors for various conditions of installations including the following shall be considered while selecting the cable sizes:
  - a) Variation in ambient temperature for cables laid in air.
  - b) Grouping of cables.
  - c) Variation in ground temperature and soil resistivity for buried cables.
  - d) Cable lengths shall be considered in such a way that straight through cable joints is avoided. Cables shall be armored type if laid in yard area or directly buried.

**4.17.3.2** DC Cable employed for series connection of PV modules through MC4 connectors shall be of 4/6 sq. mm size subject to voltage drop value within acceptance.

#### **4.17.4 Cable Constructional Features**

##### **4.17.4.1 1.1 kV Grade Cables:**

- i) 1.1 KV grade XLPE power cables on AC side shall have compacted aluminum conductor, XLPE insulated, armored, inner & outer PVC sheathed conforming to REREC requirements/specifications.
- ii) Withstanding 90°C continuous conductor temperature and 250°C during short circuit, inner sheathed with heat resistant elastomeric compound, nylon cord reinforced, outer- sheathed with heat resistant, oil resistant and flame-retardant heavy-duty elastomeric compound conforming to KPLC requirements/specifications.
- iii) Cables laid in trenches and using Galvanized Cable trays of adequate strength shall be on

structural (Mild Steel) supports.

#### 4.17.4.2 Control Cables

- i) 1.1 KV Grade control Cables shall have stranded copper conductor, PVC insulated with appropriate grade shall be used for all control cables required for the SPGP. The cables shall be terminated using Cu. Lugs of adequate cross section area with miller insulation between each pair and tinned copper screening.
- ii) Control cables shall have minimum conductor cross-section of 1.5Sq.mm.

#### 4.17.4.3 DC Side Cables

- i) DC cables in the plant shall be with copper conductors to be used between
  - a) Module to Modules inter connections.
  - b) Strings to String Combiner Box.
  - c) String Combiner Boxes (SCBs) / Array Junction Boxes (AJBs) to DC Distribution Board (DCDB) & or SCBs / AJBs to Inverters
- ii) Their guiding factor selected cables shall be the current carrying capacity after the considered reduction factors which shall be higher than 1.25 times of  $I_{sc}$  under STC as per IEC 60364-7-712 and the annual energy yield loss is less than 1% as per prevailing requirements/specifications and to be considered in the Energy Yield Estimation analysis.
- iii) The selected cables for the Mini-Grid shall be
  - a) 1 Core, 4 Sq. mm copper conductor (Electrolytic Tinned Copper IEC 60228, Class 5) or higher size, rated 600/1000V AC, as per module manufacturer recommendations for module-to-module interconnection (normally comes along with modules). The cable shall be solar grade cables with UV and weather resistant protected cables suitable for outdoor applications and confirming to TUV: 2 PfG 1169 / 08.2007.
  - b) 1 Core, 6 Sq. mm copper conductor (Electrolytic Tinned Copper IEC 60228, Class 5) rated 600/1000V AC, solar grade cable with UV and weather resistant protected cables suitable for outdoor applications according to TUV: 2 PfG 1169 / 08.2007, Ethylene Propylene Rubber (EPR) insulation with Ethylene-Vinyl-Acetate (EVA) outer sheath or higher size as per approved design shall be used for cable joining the string-to-string combiner box (called as home run cables).
  - c) 1.1 kV grade, single core with copper conductor, XLPE insulation, armored, with inner & outer PVC sheaths. The cable connecting the SCBs and inverters / DCDB shall be suitable underground laying and shall be 90 -120 sq.mm or more in size.
  - d) Cables of appropriate size to be used in the system shall have the following characteristics:
    - i) Temp. Range  $-10^{\circ}\text{C}$  to  $+80^{\circ}\text{C}$ .

- ii) Excellent resistance to Heat, Fire, oil, cold, water, abrasion, UV radiation.
- iii) Flexible Cabling on DC side of the system shall be as short as possible to minimize the voltage drop in the wiring
- iv) All parts shall be corrosion resistant.

#### **4.17.4.4 Low Tension (LT) Cables**

- 1.1 kV Grade, Al. conductor PVC armored cables in AC Side shall be used for all LT power cables between control cubicles, Motor Control Centers (MCC), respective feeders, etc.

These cables shall be laid on structural supports and using galvanized cable trays of adequate strength.

The cable shall be terminated using Al. Lugs of adequate cross section area.

## **PART I - GENSET AND ASSOCIATED COMPONENTS SPECIFICATIONS**

### **4.18 Diesel Generator**

#### **4.18.1 Diesel Gen-Set Specifications**

**4.18.1.1** 415V 3-ph **Enclosed** Diesel Gen-sets complete with super silenced residential exhausts, respective air circuit breaker and other associated equipment. The exhaust height should be at least 6m above ground level applying an extended pipe.

**4.18.1.2** Power and control cables set for each generator so as to facilitate its connection to the Solar PV control switchgear at the station

**4.18.1.3** Fuel connecting pipework

#### **4.18.1.4 Manuals**

**4.18.1.4.1** Original Equipment Manufacturer (OEM) Operator's manuals shall be provided for all system equipment. The manuals shall include outline, interconnection, wiring, and control drawings accurately describing the equipment provided.

**4.18.1.4.2** Provide 2 sets of original OEM hard copy of the following: (scan or photo copies not acceptable.)

- (a) Operations and maintenance manuals
- (b) Engine workshop manuals
- (c) Spare part and Specification Catalogues

#### **4.18.1.5 Generator Set – Prime Power**

The generator set shall run at 1500 rpm to supply power at 50Hz. The prime Power rating of the set shall be slightly above the stated kVA, at temperatures up to 45°C and Altitude at site elevation. There shall be a 10% overload capacity available for one hour in twelve. The gen-set shall be enclosed in a standard 6m shipping steel container with a super silenced residential silencer having stainless steel flexible bellows and exhausting 6m above ground level applying an extend pipe. The noise level must be below 85db at 1m.

#### **4.18.1.6 Shed for the Genset**

**4.18.1.6.1** Provide an iron sheet roofing shed for the Genset. The design to be subject to employer's approval.

**4.18.1.6.2** The Genset area is to be fenced off

#### **4.18.1.7 Reinforced precast concrete block support**

- a) Bidder shall provide reinforced concrete foundation (as per Genset dimensions) on which the Genset is to be placed, as per approved design.
- b) Provision should for collection of spillage of oil, fuel and water in to ground hence prevent

pollution of the environment.

#### **4.18.1.8 Performance**

##### **4.18.1.8.1 Voltage regulation**

The voltage regulation shall be +/- 0.5% at any power factor between 0.8 lagging and unity, at any load from no load or rated load, at any temperature from hot to cold and at speed droop variations up to 4.5% of rated speed

##### **4.18.1.8.2 Frequency regulation**

The frequency regulation shall be isochronous from steady state no load to steady state rated load. The random frequency variation shall not exceed +/- 0.25% of its mean value for constant loads at any load from no load to rated load.

#### **4.18.1.9 Engine**

Engine accessories and features shall include: -

**4.18.1.9.1** Engine coolant drain tap.

**4.18.1.9.2** Electronic governor system to provide automatic frequency regulation. The speed control from no load to rated load shall be adjustable from 0% droop (isochronous) to 5% droop.

**4.18.1.9.3** The engine shall be cooled by a base frame mounted radiator and cooling system rated for full load operation in an ambient temperature of 50 degrees centigrade measured at the generator air inlet. The radiator shall be provided with a duct adapter flange. The cooling system shall be filled with 50/50 ethylene glycol/water mixture by the equipment supplier. Rotating parts shall be guarded against accidental contact in accordance with EN 294 requirements.

**4.18.1.9.4** Liquid level switch to sense loss of engine coolant. When the coolant level is below that recommended by the engine manufacturer, a "Low Coolant Level" alarm shall be given on the Generator Set Control panel.

**4.18.1.9.5** Engine mounted sensor to detect engine coolant temperature. When the engine coolant temperature is above that recommended by the engine manufacturer, a "High Engine temperature" alarm shall be given on the Generator Set Control panel.

**4.18.1.9.6** Electric starting motor(s) capable of three complete cranking cycles without overheating.

**4.18.1.9.7** Positive displacement, mechanical, full pressure, lubrication oil pump.

**4.18.1.9.8** Engine mounted sensor to detect engine oil pressure. When the engine oil pressure is below that recommended by the engine manufacturer, a "Low Oil Pressure" alarm shall be given on the Generator Set Control panel.

**4.18.1.9.9** Engine mounted manual pump to enable the lubricating oil to be pumped from engine sump during routine oil change operation

**4.18.1.9.10** Engine driven, mechanical, positive displacement fuel pump. Fuel filter with

replaceable spin-on canister element.

**4.18.1.9.11** Heavy-duty replaceable dry element air cleaner with restriction indicator.

**4.18.1.9.12** Flexible supply and return fuel lines.

**4.18.1.9.13** Engine mounted battery charging alternator, 35 ampere minimum, and solid-state voltage regulator.

#### **4.18.1.10 AC Generator – Prime Power**

**4.18.1.10.1** The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 per cent above or below rated voltage.

**4.18.1.10.2** A permanent magnet (PMG) exciter and 3 phase voltage regulator shall be included to provide optimum generator excitation and output voltage regulation performance.

**4.18.1.10.3** The generator shall be fitted with a kit to reduce emissions of RFI and to improve immunity to RFI (Radio Frequency Interference).

**4.18.1.10.4** The generator shall be provided with a voltage regulator having shunt excitation to reduce field current in response to transient frequency dips when large electrical loads are connected to the generator set.

**4.18.1.10.5** The generator shall be provided with a paralleling droop compensator for adjusting the share of total reactive current carried by each generator set.

#### **4.18.1.11 Engine-Generator Set Control**

The enclosed control panel shall be mounted on the generator set with anti-vibration mountings. The generator set mounted control panel shall include the following features and functions

##### **4.18.1.11.1 Three-position control switch labeled RUN/OFF/AUTO**

- (a) In the RUN position the generator set shall manually start, and accelerate to rated speed and voltage.
- (b) In the OFF position the generator set shall immediately stop, bypassing all.
  - Time delays. The position is also used to clear a fault and allow restarting.
  - The generator set after it has shut down for any fault condition.
- (c) In the AUTO position the generator set shall be ready to accept signal from.
  - A remote device to start and accelerate to rated speed and voltage.

##### **4.18.1.11.2 Generator Set AC Output Metering**

The generator set shall be provided with a metering set with the following features and functions:

- (a) Digital metering set, 0.5% accuracy, to indicate generator voltage, frequency, output current, output kW, kW-hours, and power factor. Generator output voltage display shall be available in line-to-line or line-to-neutral voltage simultaneously.



#### **4.18.1.11.3 Generator Set Alarm and Status Display**

The generator set shall be provided with alarm and status indicating lamps to indicate existing alarm and shutdown conditions. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of the following alarm and shutdown condition on the display panel:

- (a) Low oil pressure (shutdown)
- (b) High coolant temperature (shutdown)
- (c) Emergency stop operated (shutdown)
- (d) Over speed / over frequency (shutdown)
- (e) Battery charge alternator failed (alarm)
- (f) Under speed / under frequency (shutdown)
- (g) Coolant low (alarm)
- (h) Coolant low (shutdown)
- (i) Set failed to start (shutdown)

#### **4.18.1.11.4 Engine Status Monitoring**

The following information shall be available from devices and from a digital status panel on the generator set control:

- (a) Engine coolant temperature (degrees C)
- (b) Engine oil temperature (degrees C)
- (c) Engine speed (rpm)
- (d) Number of hours of operation (hours).
- (e) Number of start attempts.
- (f) Battery voltage (DC volts)
- (g) Fuel consumed (litres)

#### **4.18.1.11.5 Control Functions**

(i) The control system provided shall include a cycle cranking system, which shall be for 3 cranking periods of 10 seconds each with 10 second rest period between cranking periods.

(ii) The control system shall include an engine speed governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control will include adjustments for gain, damping and a ramping function to control engine speed and limit exhaust smoke while the unit is starting. The governor control shall be suitable for use in paralleling applications without component changes.

(iii) The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop

(adjustable 0-600 seconds) functions.

(iv) The control system shall include all interfaces necessary for proper operation with the paralleling equipment provided under this contract. The contractor shall be responsible for complete compliance to all specification requirements for both the generator set and the paralleling equipment.

#### **4.18.1.11.6 Generator Control Functions**

(i) The generator set shall include an automatic voltage regulation system that is matched and tested with the engine speed governing system provided. It shall be immune from malfunction due to load – induced voltage wave form distortion and provide a pulse width modulated output to the generator exciter.

(ii) The voltage regulation system shall be equipped with three-phase RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below a threshold of (48/49 or 58/59 HZ).

(iii) The voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alphanumeric LED readout to indicate setting level.

(iv) The voltage regulation system shall include provisions for reactive load sharing and electronic voltage and frequency matching for paralleling applications. Motorized voltage adjust pot is not acceptable for voltage matching.

(v) Controls shall be provided to monitor the output current of the generator set and initiate an alarm when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the generator.

(vi) Controls shall be provided to monitor the kW load on the generator set, and initiate an alarm condition when total load on the generator set exceeds the generator set rating for in excess of 5 seconds.

(vii) Controls shall include a load-shed control, to operate a set of volt-free contacts (for use in shedding customer load devices) when overload of the generator set occurs.

(viii) An AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.

(ix) A battery monitoring system shall be provided which initiates alarm when the DC control and

starting voltage is less than 12/25 VDC or more than 32 VDC. During engine starting, the low voltage limit shall be disabled, and if DC voltage drops to less than 14.4 volts for more than two seconds a “weak battery” alarm shall be initiated.

#### **4.18.1.12 Base Design and Anti-vibration Mountings**

**4.18.1.12.1** The engine-generator canopy shall be mounted such as to maintain alignment between components with bonded rubber anti-vibration units positioned between the engine and alternator support feet and the baseplate.

#### **4.18.1.13 Auxiliaries**

##### **4.18.1.13.1 Fuel storage tank**

- i. There should be provision of fuel reservoir (storage) tank at least 2000 Litre capacity as per specifications in clause 4.19 below.
- ii. The tanks shall have Fuel Flow Meter of type Positive Displacement Meter (PDM) with digital output and flow rate that matches fuel consumption rate of the generator.

##### **4.18.1.13.3 Fuel Pipe-work**

- (i) Unless otherwise stated, all exterior pipe work shall be Carbon Steel, conforming to ASTM 53, Grade B.
- (ii) The pipe work design shall incorporate flanges for easy dismantling and service.
- (iii) The pipework shall be well secured by clamping to rigid supports to adequately protect them from mechanical damage.

##### **4.18.1.13.4 Super Silenced Residential Exhaust System**

- (i) Super silenced residential engine exhaust system shall be provided for each engine, size and type as recommended by the generator set manufacturer to meet the sound attenuation level of a residential environment of not more than 85 dBA at 1 meter.
- (ii) Exhaust system shall be installed according to the recommendations of the generator set manufacturer and applicable codes and standards.
- (iii) The exhaust system shall be designed and installed in such a way that the exhaust fumes are released not less than six (6) meters above the ground.

##### **4.18.1.13.5 Flexible Exhaust Pipe Connection**

Flexible exhaust pipe for connecting the engine exhaust outlet to the exhaust system as recommended by the generator set manufacturer.

##### **4.18.1.13.6 Lead-Acid Starting and Control Batteries**

Starting battery bank, heavy-duty conventional Lead-Acid type, 12 volt DC, sized as recommended by the generator set manufacturer, shall be supplied for each generator set with battery leads and connectors. A battery tray and holding down clamps shall be incorporated within the rails of the

baseplate.

#### **4.18.1.13.7 Generator Circuit Breaker**

A 4-pole air circuit breaker (ACB) with a capacity of rated Maximum Gen set amperes shall be fitted on the generator output. The ACB shall be fitted with adjustable trip unit for protection.

#### **4.18.1.13.8 Audible Alarm**

Audible alarm horn to signal a generator set shutdown fault condition. When any condition that causes the control to shut-down the generator set, the audible alarm horn shall be activated. Means shall be provided to mute the alarm and reset the detection circuit in the generator Set Control panel.

#### **4.18.2 Standard Tool Specifications**

**4.18.2.1 For this section Bidder to Provide 1 set for each Lot and centrally placed.**

**4.18.2.2** Please note that all the tools noted below shall be supplied from a reputable Brand and the electrical or electronic tool/equipment be accompanied with Manufacturer's warranty card.

**4.18.2.3** Below are the set of tools;

**Table 9: Set of Tools**

1	<b>Mechanical Workshop 450+ Pieces Drawer Tool Trolley</b> with Plastic/Foam Modular Inlay Tool Control System Chrome-Vanadium material. Robust, Sturdy Lockable. Metric.
2	<b>Socket Spanner Tool Set</b> ¾" Drive 22 pieces: (must include 15, 17 19 and 22 mm socket) 12 Point (Bi-Hexagon) spline socket. (Hexagonal sockets will not be acceptable). Chrome- vanadium Heavy Duty Contained in Sturdy Sheet Steel Case
3	<b>Electrical Workshop 55+ Piece Inlay Tool Set</b> Contained in a carry case
4	<b>Battery Charger 12/24 Volt</b> Heavy Duty Portable, Automatic;

	<p>Input Voltage 150-300vac;  Constant/Float Charging;  Boost 40a; Float 8a;</p>
5	<p><b>Electric Hand Drill</b>  Chuck Capacity Of 1.5 – 13 Mm  240V ~ 700W ~ 8Amp  Hammer drill  reversible  Contained in a carry case</p>
6	<p><b>Angle Grinder</b>  Size 4 ½ ’  Contained in a carry case</p>
7	<p><b>Wire Cup Brush Wheel for Angle Grinders</b>  4’ X 5/8- 11UNC-  <b>(Twist Knot)</b> –  Max speed 12500 RPM</p>
8	<p><b>Wire Cup Brush Wheel for Angle Grinder</b>  4’ X 5/8” -11UNC  <b>(Fine Crimped)</b> –  Max Speed 12500 RPM</p>
9	<p><b>Electric Blower</b>  220-240V - ~800W  Flow rate ~ 4.5m3/min  With dust extraction feature and dust bag.</p>
10	<p><b>Electric Heat Gun,</b>  240V – 2000Watts  Heavy Duty; Adjustable heat range 50°C ~ 600°C  Carry Case with nozzle adapters included.</p>
11	<p><b>Electrical Digital Multi Meter</b> (Set to comprise of one Electrical Digital Multi Meter per mini-grid site)  Professional  Rugged  Calibrated</p>

12	<b>Electrical Clamp-On Meter</b> (Set to comprise of one Electrical Digital Multi Meter per mini-grid site) Professional Calibrated
13	<b>Arc Welding Machine</b> Single Phase
14	<b>Steam Water Pressure Cleaner</b> (WF 400-800 l/hr: Pressure 30-150Pa: Temp 155/80 °C: Motor rating 6.4kw; Pressure hose length 10m)
15	<b>Cordless Impact Wrench Complete</b> ( 18v, 3.0ah); supplied with 2 x b18 3.0 ah li-ion batteries, Contained in a carry case.
16	<b>Workshop Bench</b> Dimensions (1½ x 1)M : Sheet Metal Top; Steel Metal Frame Rigid, Sturdy/Robust
17	<b>Bench Vice</b> 8” – 25Kg Heavy Duty Engineers vice, Quick release feature,
18	<b>Belt Tension Dial Gauge,</b> Universal

#### 4.18.3 Special Mechanical Tools – Specifications

4.18.3.1 Shall be provided as listed in the Diesel Generator Workshop or Service Manual.

4.18.3.2 Shall be genuine Original Equipment Manufacturer OEM.

4.18.3.3 Delivered in original branded packaging complete with Logo and seals.

4.18.3.4 The table below list the sample requirements but should be guided as per the workshop manual.

**4.18.3.5** The bidder to Provide 1 set for each unique Genset size in a Lot and centrally placed.

**Table 10: Special Mechanical Tools**

No.	Description	Qty
1	Cylinder Liner Puller with Puller Plate	1
2	Liner Installation Tool	1
3	Piston Ring Expander	1
4	Piston Ring Wear Gauge	1
5	Piston Ring Compressor Sleeve	1
6	Valve Seat Extractor Kit	1
7	Valve Spring Compressor	1
8	Connecting Rod Guide Pins	1
9	Main Bearing Cap Puller	1
10	Injector Adjustment Tool	1
11	Camshaft Bushing Removal/Installation Kit	2
12	Injector Puller	2

**4.18.4 Minimum Diesel Generator Critical Spares – Specifications (per mini-grid site)**

**4.18.4.1** Shall be original, genuine and branded.

**4.18.4.2** Supplied in original packaging, brand logo and anti-counterfeit or tamper proof seals.

**4.18.4.3** Manufacturer’s warranty.

**4.18.4.4** The spares are listed below.

**Table 11: Minimum Diesel Generator Critical Spares**

No.	Description	Qty
1	Fan belt	1
2	Fan Hub	1
3	Water pump (complete)	1
4	Alternator belt	1
5	Oil pressure sensor	2
6	Thermostat	1
7	Diodes set	2
8	AVR	2
9	ECM Auto start control module/ actuator, where applicable	1

	(similar to genset)	
10	Fuel Injectors	6
11	12V Starting Battery Lead acid (conventional) supplied with no acid	4

#### **4.18.5 Minimum Diesel generator consumable spares – Specifications (per mini-grid site)**

**4.18.5.1** Shall be original, genuine and branded.

**4.18.5.2** Supplied in original packaging, brand logo with anti-counterfeit or tamper proof seals

**4.18.5.3** Bidder to provide adequate numbers of consumable spares to avoid downtime due to lack of spares

**Table 12: Minimum Diesel generator consumable spares**

<b>No.</b>	<b>Description</b>	<b>Qty</b>
1	Oil filter (Primary)	Minimum 1
2	Oil filter (Secondary) if applicable	Minimum 1
3	Fuel filter (primary)	Minimum 1
4	Fuel filter (secondary) if applicable.	Minimum 1
5	Water filter	Minimum 1
6	Engine Oil (litres)	Minimum 1
7	Battery Water (litres)	Minimum 1
8	Engine coolant 50/50 premix ethylene-glycol (litres)	Minimum 1



## **PART II - POWER CABLES SPECIFICATIONS**

### **4.18.6 LV Single Core Aluminium Cables (PVC)**

#### **4.18.6.1 Fore Word**

**4.18.6.1.1** This standard lays down specification for LV single core PVC insulated cables.

**4.18.6.1.2** This specification is intended for procurement of materials and does not include provision of contract.

**4.18.6.1.3** This specification is based on IEC 502 and BS 6346. It is subject to revision as and when required.

**4.18.6.1.4** This specification supersedes all specifications for LV single core PVC insulated cables issued before the revision date.

#### **4.18.6.2 Scope**

**4.18.6.2.1** This specification is for single core, stranded aluminum conductors, polyvinyl chloride (PVC) insulated, armoured, PVC outer sheathed power cables for operation up to and including 600 volts to sheath and 1000 volts between conductors.

**4.18.6.2.2** The cables shall be of armoured Aluminium conductor PVC insulated or armoured copper conductor PVC insulated of adequate size, subject to employer's approval.

#### **4.18.6.3 Materials and Construction**

**4.18.6.3.1** The cable shall be made from circular stranded compact plain Aluminium conductor as per IEC 228.

**4.18.6.3.2** The insulation shall be polyvinyl chloride (PVC) complying with the requirement of IEC 502 for type PVC/A.

**4.18.6.3.3** The insulation shall be applied by extrusion process and shall form a compact homogeneous body. The insulation shall concentrically cover the conductor

**4.18.6.3.4** Extruded over-sheath shall be of black polyvinyl chloride (PVC).

**4.18.6.3.5** The cable shall be clearly and permanently embossed with the following information throughout the length of the over-sheath. Letters and figures raised and consist of upright block characters. Minimum size of characters not less than 15% of average overall cable diameter.

XXX<sup>1</sup> VOLTS PVC CABLE

Year of manufacture

(Example: 'XXX VOLTS PVC CABLE 1996')

#### **4.18.6.4 Standard Sizes and Characteristics**

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<sup>1</sup> Specify the cable size

**4.18.6.4.1** The characteristics of the cables shall comply with the following table;

**Table 13: Cables Characteristics**

<b>Item</b>	<b>Characteristics</b>
Conductor resistance	Not more than the value indicated
A.C. withstand voltage	To withstand the indicated value for 5 min.
Insulation resistance	Not less than the value indicated
Tensile strength	PVC
Ageing requirement*	PVC
Tensile strength, minimum	12.5N/mm (1.27 Kg/mm)
Elongation, Minimum percentage of unaged value	150%  75 - 125%
* Treatment	PVC
Temperature duration	100 - 20°c  168 hrs

**4.18.6.4.2** The cable shall conform to the requirements of the different Gen set size subject to employer's approval. (Bidder to provide appropriate size with respect to Gen set Size.)

**4.18.6.5 Tests**

**4.18.6.5.1** The cable core, sheath and completed cable shall be tested in accordance with the requirements of BS 6346.

**4.18.6.6 Packing**

**4.18.6.6.1** The cable shall be wound on wooden drums such as to prevent damage during transportation. The wooden drums shall be made from treated timber resistant to termite attack.

**4.18.6.6.2** The following description shall be marked on one flange of the reel

- (a) Direction of rotation of the reel
- (b) Type of cable
- (c) Number of conductors and size
- (d) Length
- (e) Net weight and gross weight
- (f) Manufacturer's name
- (g) Year of manufacture

#### **4.18.6.7 References**

**4.18.6.7.1** The following documents were referred to during the preparation of this specification.

In cases of conflict, the provisions of this specification shall take precedence.

Unless otherwise specified, the latest revision, edition and amendments shall apply.

- i) IEC 502:(1983): Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV.
- ii) IEC 228(1978): Conductors of insulated cables.
- iii) BS 6346 PVC insulated cables for electricity supply

## **PART III – CABLE TRAY SPECIFICATIONS**

### **4.18.7 LV Cable Tray Specifications**

**4.18.7.1** Route the cable trays to cause minimum amount of obstruction. Independent cable trays shall be provided for power and communication cables.

**4.18.7.2** Obtain approval of the route and fixing method before erecting cable trays.

#### **4.18.7.3 Power cable trays**

Extra heavy duty return flange; gauges shall be a minimum of 1.5mm over 600mm and flange height shall be a minimum of 75mm.

#### **4.18.7.4 Communication cable trays**

Gauges shall be a minimum of 1mm for tray up to 225mm, 1.2mm between 225-300mm, and 1.5 mm above 300mm. flange height shall be a minimum of 12mm.

#### **4.18.7.5 Cable trays general.**

**4.18.7.5.1** All cable trays shall be manufactured from pre-galvanized mild-steel to BS EN 101442 and BS EN 10143:2006 with a minimum coating weight of 275g/m<sup>2</sup>.

**4.18.7.5.2** Cable tray and cable fitting shall be fully perforated; slot sizes shall be 20mm x 7mm (or similar) running parallel to the length of the cable tray and 13.5 x 11.0 (mm) (or similar) running perpendicular to the length of the cable tray and shall be

**4.18.7.5.3** Cable trays shall be supported on purposely made suitably treated mild steel supports which shall permit easy adjustments and modification or by suitable channel, brackets and accessories to BS 6946 at intervals necessary to provide a rigid fixing in accordance with manufacturers recommended fixing centers.

**4.18.7.5.4** The Channels shall be manufactured to BS 6946 from 2.5mm materials conforming to BSEN10142:2000 and BSEN 10143:2006.

**4.18.7.5.5** The Brackets shall be manufactured to BS6946 from 6mm mild steel, 40mm wide, hot dip galvanized after manufacture to BSEN ISO 1461 and shall have a hole size of 14mm dia. to accept M12 setscrews

**4.18.7.5.6** The cable trays shall be capable of carrying without undue deflection, the total weight of the cables likely to be inserted regardless of the location of the joints.

**4.18.7.5.7** Ventilated Cable tray covers shall be provided to all external trays and shall be secured using proprietary clips and fixing in accordance with manufacturers recommendations.

**4.18.7.5.8** Cables shall be fixed to the trays by means of copper or brass saddles and clips. All saddles, clips, straps etc. shall be fixed to the trays by means of brass screws or bolts or nuts.

NB. Steel wire or PVC tie-wraps of any description will not be permitted.

**4.18.7.5.9** Earth continuity connectors shall be fitted between each length of cable tray to ensure compliance with BS 7671

#### **4.19 Fuel Tank for the diesel Genset**

**4.19.1** A tank to store diesel to be used in the diesel generator is to be provided. The capacity of the tank shall be as per the requirements outlined in the price schedules (Volume III – Schedule of Rates and Prices) for each mini grid.

**4.19.2** The fuel tank shall meet the following requirements;

- Bunded Steel Tank (3mm)
- 4x Steel Feet/Supports (Included in quoted height dimension)
- Dispense Equipment Cabinet (Lockable)
- Top lifting points (empty only)
- 2" spare socket
- 1" socket in bund
- 240V Fuel Transfer Pump where necessary.
- 4m Hose/Auto Nozzle
- Water/Particulate Filter
- Clock Contents Gauge
- Clock Bund Gauge
- 2" BSP Fill Point Assembly including lever valve & fill cap
- 2" Bund to Atmosphere Vent incl cap
- Isolation Valve
- Overfill Prevention Valve
- Bund Alarm
- High/Low/Bund Alarm
- Fuel Management System (various available)
- Roller Shutter Door Upgrade

**4.19.3** The tanks shall, as a minimum, be equipped with:

- Pressure/ vacuum relief valves
- A tank level gauging system
- Pressure transmitters
- High level switch connections
- Low level switch connections

- Tank side remote display unit
- Product temperature measurement
- Roof and shell man ways
- Manual dip point
- Dipping tape
- Fuel offloading pump of suitable size as per fuel tank

#### 4.19.4 Mechanical Works.

- Fabricate and install all foam distribution piping
- Fabricate and install process, drain and vent piping.
- Install valves and actuators.
- Fabricate equipment supports as necessary for the Works.
- Undertake Non-Destructive Testing of the tanks and process, drain and vent piping as required by applicable codes and standards.
- Hydrostatic pressure testing of tanks as per API 650 code and standard and piping as per ASME B31.3 & 31.4. This includes de-watering. The piping shall be purged with nitrogen.
- Prepare and paint all piping, plant and equipment to the satisfaction of KPLC.
- Undertake all pre-commissioning checks and calibration as necessary.
- Prepare ‘As-Built’ drawings and records of the Works.
- Undertake any other works as may be required for successful completion of the project.

#### 4.19.5 The fuel tanks to have 110% bund wall containment

4.19.6 The tanks shall have **Fuel Flow Meter** of type Positive Displacement Meter (PDM) with digital output and flow rate that matches fuel consumption rate of the generator

#### 4.19.7 Codes and Standards

4.19.7.1 The oil tanks shall be new, welded steel, fixed roof, above ground and shall be designed and constructed in accordance with API 650 – Welded Steel Tanks for Oil Storage- Latest Edition.

#### 4.19.7.2 Relevant codes are:

API 2000	Venting atmospheric and Low-pressure Storage Tanks
ASME B16.5	Pipe Flanges and Flanged Fittings
ASME B16.21	Non-Metallic Flat Gaskets for Pipes
SIS 55 05 5900	Preparation of Steel Substrates before application of points and related products – visual assessment of surface cleanliness
BS 2654	Manufacture of Vertical Steel Welded Non- Refrigerated Storage Tanks with Butt-Welded shells for Petroleum Industry

BS 7079	Preparation of Steel Substrates before application of paints and related products
ASME B31.3	Process Piping
ASME B31.4	Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia and Alcohol
BS 4515	Welding of steel pipelines on land and offshore.
BS EN 499	Welding Consumables - Covered Electrodes for Manual Metal Arc Welding of Non-Alloy and Fine Grain Steels
ASME IX	Boiler and Pressure Vessel Code Welding and Brazing Qualifications
API 1104	Welding of Pipelines and Related Facilities
ASME V	Boiler and Pressure Vessel Code – Non-Destructive Examination
BS EN 462	Non-Destructive Testing - Image Quality of Radiographs
BS 3971 S	Specification for Image Quality Indicators for Industrial Use
ASTM E94	Guide for Radiographic Testing.
ASTM E1316	Terminology for Non-Destructive Examinations

#### **4.20 Auxiliary Power Supply**

**4.20.1** An independent auxiliary power supply to keep battery inverters on at any given time mostly when the batteries are below the minimum DOD, to enable keep master inverters on standby and ensure continuous battery charging shall be supplied.

**4.20.2** The auxiliary power supply shall also meet essential DC power requirement of switch gear, control panel, protection relay panel and inverter monitoring Units.

**4.20.3** The auxiliary power system shall be of suitable capacity and voltage to meet the required loads.

**4.20.4** The design of the auxiliary power supply to be approved by the employer.

#### **4.21 Danger Boards/Plates**

**4.21.1** Danger boards/ plates should be provided as per grid codes and requirements/specifications of REREC and must be affixed at various appropriate locations for safety of personnel.

#### **4.22 Construction**

**4.22.1** The installation shall be carried out by an electrical and a civil contractor holding a valid license as required by the Government authorities.

**4.22.2** The contractor shall provide necessary drawings and documents required by statutory authorities and obtain the approval before taking up erection. It shall be the sole responsibility of the contractor to obtain safety certificates/approval from local statutory authorities.

**4.22.3** Any modification in the equipment or installation that may be demanded by the inspecting

authorities shall be carried out by the contractor at no additional cost to the Employer.

**4.22.4** In accordance with the specific installation instruction as per the manufacturers drawings or as directed by the Employer, the successful Bidder shall unload, assemble, erect, install, test, commission and hand over all electrical equipment included in this contract.

**4.22.5** Erection materials including all consumables, tools, testing instruments or any other equipment required for successful commissioning shall be arranged by the successful Bidder in a timely manner.

**4.22.6** Clearing the site after completion, of erection as well as regular clearance of unwanted materials from site, returning excess materials supplied by Employer back to Employer's stores shall also be included under this scope of work.

**4.22.7** All equipment and instruments, indoor and outdoor, shall be marked with Numbers and provided with suitable danger boards as per REREC requirements/specifications before commissioning.

**4.22.8** The contractor shall touch up the surface with non-corrosive paint of same shade for equipment, which are scratched and / or damaged during transportation and erection before commissioning.

**4.22.9** The contractor shall employ skilled and semi-skilled laborers for erection, testing and commissioning as required. All the electricians, cable jointers, wiremen, welders and others employed shall possess valid certificates / license recognized by competent authorities.

**4.22.10** The contractor shall set up his own facilities at site at allocated place to undertake fabrication/assembly jobs etc.

#### **4.23 Civil works**

The Contractor shall carry out civil engineering works as specified in the scope of works, including but not limited to the following tasks:

**4.23.1** Adhere to quality control measures for civil materials and works to guarantee quality.

**4.23.2** Design the control room, office building, guard house, roads and any other structural component as per specification and relevant standards for the civil works (British standards/ASTM/Eurocodes)

**4.23.3** Include resistivity test in Geotechnical investigation scope.

**4.23.4** Provide SPGP station layout for approval. The layout should indicate all the structures to be developed in the proposed sites, which includes the perimeter fence, the location of the CRB, Gate, access roads, the Solar panels, the Water tank structure, the future bay for expansion etc.

**4.23.5** Construction of guardhouse with a provision of a store room space and construction of a VIP pit latrine.



- 4.23.6** Construction of access road, SPGP internal road and associated works.
- 4.23.7** Construction of 1-acre perimeter boundary fence, solar field barricade fence, gates, CCTV system in 3 potentially high security threat areas/sites as specified in **Table 17**, Manually activated sound alarm system at the Guard house, perimeter lighting, buildings lighting and SPGP area lighting.
- 4.23.8** Cable network and conduits.
- 4.23.9** Solar support structures – Galvanized Steel for elevation from the ground level and Steel rails, mid and head clumps for mounting and support of PV panels.
- 4.23.10** Spread of 100mm layer of ballast aggregates to solar field platform.
- 4.23.11** Water works; Storm water Harvesting and storage.
- 4.23.12** Earthwork’s design and implementation.
- 4.23.13** Firefighting-Fire extinguishers in the solar field and control room and fire suppression in the BESS section at the control room.
- 4.23.14** Drainage of storm water.
- 4.23.15** Foundations for modules structures in ground mounted SPGP.
- 4.23.16** Construction of Genset Plinth, its shed and fencing off of the genset.
- 4.23.17** Mounting platform of ACDB, DC boards, Inverters and associated cable trenches/conduits etc. in the control room.
- 4.23.18** Control room to accommodate BESS, the Inverter/extension required for Inverter and AC Distribution Board, DC Distribution Board and all indoor panels and communication equipment subject to employer’s approval.
- 4.23.19** Office structure for O&M staff.
- 4.23.20** All minor civil works such as fixing of foundation bolts, cutting holes in walls, chipping of floor and ceiling etc. and making good the same after installation of the equipment.
- 4.23.21** All applicable foundations for equipment under scope of work and required to complete the associated work for SPGP only.
- 4.23.22** Any other minor civil works advised by the Employer for completion of the work related to SPGP has to be carried out and this is deemed to be included in the bid price.

#### **4.24 Earthing testing after installation**

- 4.24.1** Tests to ensure continuity of all earth connections.
- 4.24.2** Tests to obtain earth resistance of the complete network by using earth tester. The test values obtained shall be within required limits as per REREC requirements/specifications.

#### **4.25 Preparation of the Equipment for Commissioning**

- 4.25.1** After completion of the installation at site and for the preparation of plant commissioning, the

contractor shall check all the equipment and installation in accordance with the agreed standards, latest relevant code of practices of Kenyan Standards, specific instructions furnished by the particular equipment suppliers/manufacturers and REREC requirements/specifications.

**4.25.2** Checks required to be made on all equipment and installations at site shall comprise, but not limited to, the following:

**4.25.2.1** Physical inspection of Modules for removal of any foreign bodies, external defects, such as damaged, loose connection in Junction Boxes & Inverter etc. loose foundation bolts etc.

**4.25.2.2** Check for the free movement of mechanism for the circuit – breaker, rotating parts of the rotating machines and devices.

**4.25.2.3** Check for tightness of all cable joints and bus bar termination ends as well as earth connections in the main earthing network.

**4.25.2.4** Check for clearance of live bus bars and connectors from the metal enclosure.

**4.25.2.5** Check for proper alignment of all the modules etc.

**4.25.2.6** Continuity checks in case of power and control cables.

**4.25.2.7** Checking of all mechanical and electrical interlocks including tripping of breakers using manual operation of relay.

**4.25.2.8** Checking of alarm and annunciation circuits by manual actuation of relevant relays.

**4.25.2.9** Check and calibrate devices requiring field adjustment/calibration like adjustment of relay setting etc.

**4.25.2.10** Check for proper connection to earth network of all non-current carrying parts of the equipment and installation.

**4.25.3** The relevant tests shall be carried out in accordance with relevant IS/IEC of latest issue and as per REREC requirements/specifications.

**4.25.4** The tests which are to be carried out on the equipment shall include, but not be limited to, testing of all electrical equipment as well as the system as a whole shall be carried out to ensure that the equipment and its components are in satisfactory condition and will successfully perform its functional operations. The inspection of the equipment shall be carried out to ensure that all materials, workmanship and installations conform to the following:

- i) Completeness of the installation.
- ii) Each pole to earth insulation resistance test.

**4.25.5 Cables**

- i) Insulation resistance test shall be conducted by Megger for cables rated up to 1.1kV grade.
- ii) All 1.1 kV cables shall be subjected to high voltage test after joining and terminating but before commissioning as per relevant standards.

- iii) In each test, the metallic sheath / screen / armor should be connected to earth.
- iv) Continuity of all the cores, correctness of all connections as per wiring diagram, correctness of polarity and phasing of power cables and proper earth connection of cable glands, cable boxes, armor and metallic sheath, shall be checked.

#### **4.26 Testing & Commissioning**

The testing and commissioning for all electrical equipment at site shall be according to the procedures listed below:

**4.26.1** All electrical equipment shall be tested, installed and commissioned in accordance with the latest relevant standards and code of practices published by Kenyan Standards wherever applicable and stipulations made in relevant general specifications and as per REREC requirements/specifications.

**4.26.2** Accepted design, engineering and construction standards, as well as accepted code of practices and stipulations made in the relevant general specifications.

**4.26.3** The contractor in the presence of representative / Consultant of Employer shall carry out all tests using his own calibrated instruments, testing equipment as well as qualified testing personnel.

**4.26.4** The results of all tests shall conform to the specification requirements as well as any specific performance data, guaranteed during finalization of the contract.

**4.26.5** A suitable variable load bank to be provided by the contractor for use during testing and commissioning. The load bank to be suitably sized for the mini-grid capacity.

#### **4.27 Design and Drawings for Buildings and Civil and structural works of Each Plant**

**4.27.1** The bidder is to provide requisite buildings as per his optimized design for each SPGP. For indoor type equipment / Inverter/ battery etc. containerized technology solutions are required while for Genset equipment, a shed structure is required. The bidder is to supply complete civil layout plan, elevation, details of each amenity, trenches in rooms and structural foundation detailed designs applicable for each building along with required sizes of different rooms for approval. Bidders are also required to consider aesthetical view of the structures while considering the design of each structure. The implementations/construction of the designs shall be subject to approval by the employer.

**4.27.2** Submission of Drawings by contractor for Approvals

**4.27.2.1** The Contractor shall submit designs, drawings, calculations, and datasheets as applicable for each mini-grid within 25 – 45 days in stages from the date of award for approval by the Employer. The timely approval of design and drawings are critical for timely completion of work.

#### 4.28 Warranties of Major Equipment

The warranties of major equipment of both generation (SPGP) and PDN are found in the table below;

**Table 14: Minimum Warranty Requirement for Major Equipment.**

	<b>Equipment</b>	<b>Minimum Warranty Requirement</b>
1.	Solar Photovoltaic Modules	<p>a) Product Warranty: 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 ten (10) years from the date of sale to the original customer ("REREC")</p> <ul style="list-style-type: none"> <li>• Defects and/or failures due to manufacturing.</li> <li>• Defects and/or failures due to quality of materials.</li> <li>• Non conformity to specifications due to faulty manufacturing and/or inspection processes</li> </ul> <p>b) Performance Warranty: A 25-year long-term performance warranty with a maximum linear decrease in peak power at STC of 2.5% in the first year, 0.6%/year in subsequent years. At year 25, the peak power shall be not less than 83%.</p>
2.	Batteries	Minimum 10 years Warranty
3.	PV Inverter	Minimum 10 years Warranty
4.	Battery Inverter	Minimum 10 years Warranty
5.	Diesel Generator	Minimum 2 years Warranty
6.	Transformers (step up and step-down transformers)	Refer to specification document KP1/13D/13/TSP/10/001-02 and KP1/13D/13/TSP/10/001-03 in Volume IV for warranty details
7.	Concrete Poles (10m, 11m, 12m)	Refer to specification document

		KP1/6C/4/1/TSP/03/005-1 in Volume IV for warranty details
8.	Conductors (75 mm <sup>2</sup> Aluminium Conductor Steel Reinforced (ACSR), 100 mm <sup>2</sup> Bare All Aluminium Conductor, 50 mm <sup>2</sup> Bare All Aluminium Conductor)	Refer to specification document KP1/6C/13/TSP/06/022-2 and KPLC1/3CB/TSP/06/020-2 in Volume IV for warranty details
9.	Service Cables (10 mm <sup>2</sup> Single Phase Concentric Aluminium cables and 25mm <sup>2</sup> 4-Core Aluminium cables)	Refer to specification document KP1/3CB/TSP/05/004 and KP1/3CB/TSP/05/001 in Volume IV for warranty details
10	Line Insulators (11kV and LV)	Refer to specification document KPLC1/3CB/TSP/04/017/1, KPLC/3CB/TSP/04/017/2, KP1/3CB/TSP/04/017-3 and KPLC1/3CB/TSP/04/011 in Volume IV for warranty details

## 5. CIVIL AND STRUCTURAL WORKS

### 5.1 Types of works

5.1.1. The civil and structural works to be constructed under this Contract include the following:

- Work for access and SPGP internal road.
- Earthworks for SPGP platform and associated works.
- 100mm layer of ballast aggregates to solar field platform.
- Water harvesting and Storage.
- Storm water drainage.
- 1-acre perimeter fence, solar field barricade fence, gate, guard house with provision of a storeroom, CCTV system in 3 No. of sites in potentially high threat areas as specified in **Table 17**, manually activated sound alarm system at the Guard house, perimeter lighting, SPGP area lighting and buildings security lighting.
- Concrete foundation bases and Mounting works.
- Genset Plinth foundation, its shed and fencing off of the genset.
- Cable network and conduits.
- Control room containerized technology to accommodate all indoor equipment including BESS.
- Office building containerized technology fitted with furniture (cabinets, chairs and office table) to accommodate two to three operators.
- VIP Pit latrine.
- Lightning protection system.
- Fire protection system. (Fire extinguishers, fire detection and fire suppression)
- Any other works necessary for full completeness of SPGP.

5.1.2 The turnkey contractor shall be responsible for designs of all the civil and structural components and implementation of approved designs. Detailed Geotechnical investigation and Topographical survey at required locations for the purposes of foundation design will be done. The required locations for the geotechnical survey shall be agreed with the employer. The details of beacons and benchmarks shall be provided in the topographical drawings.

## **5.2 Control Room**

**5.2.1** The control room shall be Containerized Solution. The containers to be made of corrugated steel mounted on reinforced concrete foundations raised to allow for self-drainage subject to employer's approval. The flooring to be made of either chequered plate steel covered with pvc or wood. Metalwork shall be carried out in accordance with the provision of B.S. 5950 and other relevant BS standards. The size of the control room to be a minimum 40 feet container with a minimum height of 9 feet and a standard width of 8 feet. The container shall be portioned into two with a separate room to accommodate the BESS system and the other rooms to accommodate other equipment subject to employer's approval. The wall mounted equipment shall be erected on Medium Density Fireboard (MDF) mounting boards, fixed to design and subject to approval. A separate key board shall be provided for hanging of equipment keys. Adequate cable conduits rails shall be mounted to design and approval for cabling purposes with all trays and fittings provided with a separation between the control and power cables. Cladding of the ceiling and the wall shall be done with materials suitable for insulation and control of temperatures and subject to employer's approval and painted with three coats of silk vinyl emulsion paint to improve on the aesthetics appearance. The external wall shall be painted with the first coat of red Oxide primer and then consequently painted with Zinc Chromate, anti-rust primer to approved layers and the final coat of paint shall be in accordance to the employer's approved company color codes. A roof shall be constructed above the container, to allow for heat insulations as well as provide a catchment surface for water harvesting.

**5.2.2** The Control room shall accommodate the following:

- The Battery Energy Storage System (BESS)
- The inverters.
- AC/DC distribution Boards.
- Remote/local monitoring equipment.
- All other indoor electrical equipment/switchgear

**5.2.3** The control room shall be fitted with Fire extinguishers to be mounted both indoor and Outdoor on positions approved by the employer.

**5.2.4** The control room shall be fitted with Air Conditioners as specified in this document. The sizes of all ACs shall be optimized design based on the room spaces, temperature and equipment type (including Lithium Ion batteries as per manufacturers specifications) and subject to employer's approval.

**5.2.5** An emergency door exit to be provided in the control room, subject to approval by the employer.

Note:

The control room design shall be subject to employer's approval.

### **5.3 Office Building.**

**5.3.1** The office building shall be Containerized Solution. The containers to be made of corrugated steel mounted on reinforced concrete foundations raised to allow for self-drainage and to employer's approval. The flooring to be made of tiles to project manager's approval. Metalwork shall be carried out in accordance with the provision of B.S. 5950 and other relevant BS standards. The size of the control room to be a minimum 20 feet container with a minimum height of 9 feet and a standard width of 8 feet. The container walls and ceiling shall be cladded internally with material suitable for control of temperatures and subject to employer's approval and painted with three coats of silk vinyl emulsion paint to improve on the aesthetics appearance. The external wall shall be painted with the first coat of red Oxide primer and then consequently painted with Zinc Chromate, anti-rust primer to approved layers and the final coat of paint shall be in accordance to the employer's approved company color codes. A roof shall be constructed above the container, to allow for heat insulations as well as provide a catchment surface for water harvesting.

**5.3.2** Office furniture (cabinets, chairs and office table) to employer's approval shall be supplied and fixed to accommodate a minimum of three operators.

**5.3.3** Fire extinguishers shall be mounted on positions approved by the employer.

**5.3.4** Sufficient windows and ventilation to be provided for lighting and cooling taking into account the expected high temperatures in the proposed project areas.

### **5.4 Guard House**

**5.4.1** A guard house with a provision of a guard room and a separate lockable store room located at the main gate shall be constructed. The guard house shall be of Masonry. The guard house design shall be subject to employer's approval.

### **5.5 Pit Latrine**

**5.5.1** A twin VIP masonry pit latrine to design, shall be constructed. The walling and floor to be tiled and doors to be made of steel. A ventilation pipe of minimum 150mm to be installed and the roof sheeting shall be hot dip galvanized troughed mild steel sheeting and shall be of minimum thickness 0.5 mm. A security light shall be provided for purpose of lighting at night.

### **5.6 Sequence of Construction**

**5.6.1** The Contractor must complete all the civil and structural works in time to provide a clean and complete site for the mechanical and electrical erection.

**5.6.2** The Contractor shall be responsible for timely delivery of materials to site and for compliance with the specified or agreed construction Programme.



**5.6.3** The office building, control room, guard house and pit latrine shall be constructed away from the solar field to avoid shading effect.

## **5.7 Drawings**

**5.7.1** Any Drawings issued with these documents are for tendering purposes only. Drawings for this project shall be made by the Contractor or his civil consultant, and shall be to the approval of the Employer.

## **5.8 Plan of Operations and Temporary Works**

**5.8.1** The Contractor shall, submit to the Employer a fully detailed programme showing the order of procedure and method by which he proposes to carry out the construction and completion of the Civil Engineering works, and particulars of the organization and staff proposed to direct and administer the performance of the Works.

**5.8.2** The information to be supplied to the Employer shall include Drawings showing the general arrangements of his temporary offices, camps, storage sheds, buildings and access roads, and details of Constructional Plant and Temporary Works proposed.

## **5.9 Water Supplies, Storage and Reticulation**

**5.9.1** The Contractor shall make his own arrangements for the supply of palatable water for his staff on site and water for construction works and all the mini-grids water needs for the O&M period including soft water for regular cleaning of solar panels as per specifications.

**5.9.2** The Contractor shall obtain the Employer's or the Project Manager's prior approval before utilizing any water source for the Works.

**5.9.3** The quality of water shall be safe for drinking and washing of panels, and should be tested to meet the requirements. Important to Note is that, washing of solar panels does not require salty water and also the quality of drinking water should be within acceptable standards as guided by relevant authorities, otherwise it should be treated and purified if it does not meet the threshold. Storage tanks and distribution tank shall be provided, with one 10,000 liters water tank and one 5000 liters water tank for water harvesting, both ground mounted to supply water in the mini-grids.

**5.9.4** The cleaning of the panels shall be done using soft water or any other suitable alternative method subject to employers' approval.

**5.9.5** The Contractor must make all arrangements to abstract water and must pay royalty to the owners. These costs shall be included in his prices.

## **5.10 Employer's Approval of Finished Works**

**5.10.1** The Contractor shall obtain the approval of the Employer for each section and each stage of

construction. The Contractor shall not proceed with any subsequent stage, until all tests required by the Employer have been carried out, and the results have shown that the section complies with the Specification. Any works rejected by the Employer as not complying with the Specification and quality standards, shall be replaced by the Contractor at his own expense.

### **5.11 Basic Survey and Setting Out**

**5.11.1** The Contractor will survey the sites in detail, and the exact locations shall be agreed with the Employer.

**5.11.2** The details of beacons and benchmarks shall be provided in the topographical drawing.

**5.11.3** The Works shall be located on the drawings and the Contractor shall appoint a suitably qualified Surveyor to set out the Works from the beacons and shall plot cross sections at 20 m intervals and submit to the Employer for approval.

**5.11.4** No separate payment will be made for any work in connection with the setting out of the Works, nor any other Works required by the Contractor to ensure the accurate location and construction of the Works.

### **5.12 Earthworks**

**5.12.1** Earthworks shall be under the contractors' scope and considered fully priced by the contractor. The turnkey contractor is responsible for making the site ready by clearing of bushes, removal of trees (if required), leveling of ground (wherever required) etc. for commencing the SPGP.

**5.12.2** The contractor is also responsible for any necessary earthworks (cut and fill) to modify the site to suitable profiles. Slope protection and landscaping shall also be carried out on any areas with steep Cuts or fills.

**5.12.3** All earthworks up to formation shall be formed and completed to the correct lines, slopes, widths and levels shown on the Drawings and with the sub grade parallel to and at the correct depth below the profile, camber, cross fall or super elevation shown for the finished level, unless otherwise directed by the Employer.

**5.12.4** Embankments and fills shall be constructed only of suitable material obtained from the excavation of cuttings. If the Contractor encounters material which he considers unsuitable for earthworks, then he shall forthwith inform the Employer, who shall instruct the method of use or disposal of such material. If insufficient material can be obtained from the cuttings, additional material may be borrowed from approved borrow pits.

**5.12.5** The Employer may direct that certain soils be excluded from certain layers and other soils set apart or obtained from borrow and used only for these layers, in which case the Contractor shall comply with the Employer's or the Employer's directions and shall allow in his price for such selection

of materials.

**5.12.6** Where, in the opinion of the Employer, unsuitable material occurs in cuttings, the Contractor shall excavate it to the depths and widths specified in the Geotechnical report and replace it with selected fill material to form an improved formation.

### **5.13 Order of Work**

**5.13.1** The construction of cuttings, side drains and embankments shall proceed in a methodical and orderly manner. It shall be solely the Contractor's responsibility to arrange his methods and programme of work so as to ensure that the earthworks are carried out by the most efficient and economical method possible with the type of plant employed on the Works.

**5.13.2** All trimming of cuttings and embankments, drains and shoulders to the specified slopes and shapes, shall be carried out concurrently with the earthworks that are being carried out at that particular site and level.

### **5.14 Fill Material**

**5.14.1** "Fill-material" shall mean material deposited in accordance with these specifications from any of the classes specified in order to build up an earthworks construction to formation level as shown on the Drawings or as ordered by the Employer. The Contractor shall obtain the fill material from a source approved by the Employer.

**5.14.2** After doing the necessary earthworks (cut and fill) to modify the SPGP site to suitable approved design profiles, the contractor shall fill the finished ground level (FGL) of the solar field with Murram and compact to the designed FGL formation. In addition to the murram layer at the solar field, a ballast surfacing of minimum thickness of 100mm will be done.

**5.14.3** Fill materials will generally be obtained from cuttings. If the material obtained from this source is insufficient or unsuitable, extra material shall be obtained from borrow areas. All fill material (other than rock fill in lower layers) shall pass 75mm BS sieve size. The aggregates for the solar field ballast surfacing will be obtained from the nearest quarry, subject to employer's approval.

**5.14.4** The following materials are generally unsuitable for construction of fills.

- All materials containing more than 5% by weight of organic matter (such as top soil, materials from swamps, plants and vegetable matter)
- All expansive soils such as black cotton soils with swells of more than 3% as measured in the CBR test.
- All clay soils with plasticity index exceeding 50.
- All materials having a moisture content of 105% of the optimum moisture content (standard compaction)

**5.14.5** Rock fill can be used provided that boulders greater than 0.2 M3 in volume or 600 mm in size are not used and that this material is not placed within the top 600 mm to formation level. The best materials from cuttings or borrow areas should be reserved for the upper layers of the fill.

### **5.15 Compaction of fill**

**5.15.1** Embankments and fills shall be laid out and compacted to achieve a stable platform with sufficient bearing capacity and stability.

**5.15.2** Materials other than rock fill shall be placed in layers of compacted thickness not exceeding 300 mm. Thicker layers can only be permitted where very heavy compacting equipment is available and trial sections have proved that the required compaction will be readily achieved over the layer depth. The minimum layer thickness shall be twice the maximum particle size of the compacted material.

**5.15.3** Fill material shall be compacted throughout to a dry density of at least 95% MDD at OMC (standard Compaction AASHTOT99) except the top 300 mm of the fill which shall be compacted to 100% MDD (AASHTO T99).

**5.15.4** Where rock fill is used it should be placed in the bottom of the embankment. The largest sizes shall be placed in layers of 1.0 meter thick. The interstices shall then be filled with smaller rocks and approved filler material. The whole layer shall then be compacted until the interstices are completely filled or until the required settlement is obtained. Heavy vibratory rollers are generally the most suitable machines for compacting rock fill.

**5.15.5** The specified compaction shall be achieved over the full width of the embankment.

Any area inaccessible to the roller shall be consolidated and compacted using approved mechanical tampers.

### **5.16 Compaction of in situ Sub grades**

**5.16.1** After removing the top soil and/or 600 mm of unsuitable /expansive soils or as directed in the geotechnical report and before placing fill, improved sub grade or gravel wearing course, the upper 300 mm of in situ sub grade will be compacted to 100% MDD standard compaction. Compaction in cuts without improved sub grade will likewise be compacted to 100% MDD standard compaction.

### **5.17 Spoil Material**

**5.17.1** "Spoil-material" shall mean material excavated in accordance with these specifications from any of the classes specified, and which, being obtained from the excavation of side drains, cuttings or below the road, embankment is unsuitable for the requirements of the Works. Spoil material shall be removed from the Site to a spoil tip which should be to an approved site acceptable by respective

local authorities and shall be approved by the Employer.

### **5.18 Expansive Material**

**5.18.1** When expansive material is encountered, it shall be removed to a depth 600 mm below the formation or the existing ground level, whichever is greater. Material removed shall be stockpiled for later use in slope protection or spoiled to a tip as instructed by the Employer.

### **5.19 Surplus Material**

**5.19.1** "Surplus-material" shall mean material excavated in accordance with these specifications from any of the classes specified and which is temporarily surplus to the fill requirements and shall be carted to a designated stockpile for re-use later elsewhere in the Works, or to an approved spoil tip.

### **5.20 Excavation in "Rock"**

#### **5.20.1 Excavation Level**

Unless otherwise directed, the formation of the platform can be founded on rock. However, rock shall be excavated to an average level 150 mm below the formation and in no place less than 100 mm below the formation.

#### **5.20.2 Backfilling for Surfaces**

Any excess excavation in rock below the formation shall be backfilled and compacted. Excess excavation in the invert of drains shall not be backfilled, but the rock surfaces shall be trimmed, and all loose particles removed, to allow free drainage of water.

#### **5.20.3 Excess Excavation of Slopes**

Where side slopes are over-excavated, no backfilling will be required but the slopes shall be trimmed to a neat shape and safe angle as is acceptable to the Employer. The sloping sides of all cuttings shall be cleared of all rock fragments, which move when prized with a crowbar.

#### **5.20.4 Hard Material**

The provisions of this Clause do not apply to hard and common materials, which materials shall be excavated to the lines and levels shown on the Drawings or as instructed, within the permitted tolerances.

### **5.21 Drainage of Earthworks**

**5.21.1** All cuttings, embankments and borrow pits shall be kept free of standing water and drained during the whole of the construction.

**5.21.2** Should water accumulate on any part of the earthworks, either during construction or after construction, until the end of the maintenance period, giving rise to soaking or eroding conditions in the earthworks, the Employer may order the Contractor to remove and replace at the Contractor's

expense any material which has been so affected.

**5.21.3** All drains shall be maintained throughout the Contract in proper working order.

**5.21.4** The Contractor must allow in his price for draining the earthworks satisfactorily at all stages during the construction and arrange his methods and order of working accordingly.

**5.21.5** The entire platform shall be adequately drained and all buildings; control room and office should be well drained.

## **5.22 Removal of Top Soil**

**5.22.1** The top soil within the areas of the development of SPGP shall be stripped to an approximate depth of 200 mm and stockpiled at locations agreed with the Employer for later use on embankment slopes or dumped in approved areas.

**5.22.2** Overburden in the borrow pit shall also be stripped to a depth specified by the Employer and stockpiled for later use in rehabilitation.

## **5.23 Access and Internal Road**

**5.23.1** Suitable approach road and internal access road in all mini-grids within the complex boundary of SPGP as per approved design shall be made to ensure safe and easy transportation of equipment and material.

**5.23.2** Where necessary access roads to the SPGP sites shall be constructed to gravelling / murrum standard. In general, for gravel access, gravel wearing course materials should comply with the following:

- They should have sufficient cohesion to bind the particles together and prevent the surface from raveling and becoming corrugated in the dry season.
- The amount of fines and plasticity should be limited so as to avoid the occurrence of dusty and slippery conditions during the dry and wet weather respectively.

**5.23.3** Gravel materials are excessively coarse in their “as dug” state. Appropriate processing is therefore necessary to bring them to the required gradation. This is normally done on the road by using grid, cleat or sheep’s foot rollers. Oversized particles which cannot be broken down to the required size shall be removed.

**5.23.4** The minimum thickness of a compacted layer shall not be less than 125 mm.

**5.23.5** Internal SPGP road and walk paths shall be compacted to 100% MDD after grading. The road shall have a well-done gravel finish. The road shall be constructed to a fall that will allow proper drainage of the road. The road shall have adequate drainage provided. The design shall be to road design manuals. The road shall have minimum width of Four (4) meters.

**5.23.6** For the gravel finish internal SPGP road, the single gravel layer should consist of a minimum

thickness necessary to avoid excessive compressive strain in the sub grade and to compensate for the expected gravel loss under traffic during the period between re-gravelling.

**5.23.7** Where the top 300 mm layer of the formation level embankment or natural ground sub grade has a CBR greater than 5%, the following thicknesses shall be provided:

- Roads not subjected to heavy commercial vehicles– The minimum compacted thickness of 125mm.
- Access roads outside the SPGP plant and roads within the site likely to be subjected to heavy commercial vehicles during construction and during periodic maintenance. – Provide a 250 mm thick compacted layer.

In addition to the above, where the in-situ sub grade or the embankment material has CBR strength of less than 5% then:

- Top 300 mm layer of the fill / embankment shall be made with selected imported material with CBR (after 4 days soak) of between 7 and 13%.
- Where in situ sub grade, an improved sub grade 300 mm thick of imported materials with CBR (4 days Soak) of between 7 and 13% shall be laid.

The above thickness shall extend to cover the shoulders. A cross fall of 4% shall be provided.

**5.23.8** Compaction will be in layers not thicker than 200 mm and will achieve compacted densities of 95% MDD (Modified AASHTO T180) at compaction moisture contents of between 80% and 105% OMC.

## 5.24 Grading Requirements

**5.24.1** Grading curve of the gravel should be within the class 1 envelope (initial daily number of commercial vehicles less than 150) to guarantee good stability. The grading to consider is that obtained after processing and compaction.

**Table 15: Gravel Grading Requirements**

Grading after compaction		
Sieve Size (mm)	% Passing by weight	
	Class 1	Class 2
37.5	-	100
28	100	95 – 100
20	95 – 100	85 – 100
14	80 – 100	65 – 100
10	65 – 100	55 – 100

5	45 – 85	35 – 92
2	30 – 68	23 – 77
1	25 – 56	18 – 62
0.425	18 – 44	14 – 50
0.075	12 – 32	10 – 50

## 5.25 Plasticity Requirements

**5.25.1** Plasticity index of the gravel should not exceed 15 and shall not be less than 5 in wet areas (annual rainfall greater than 500 mm per year). In dry areas (annual rainfall less than 500 mm per year) maximum plasticity index shall be 30 but subject to a minimum of 10.

## 5.26 Bearing Strength Requirements

**5.26.1** A minimum CBR (after 4 days soak) of 20% at 95% MDD and OMC (Modified AASTO T180) is required.

## 5.27 Quality Control

**5.27.1** Tests shall be performed by the contractor on soils and gravels undergoing compaction under the supervision of and at frequencies determined by the Employer and shall include:

- Determination of the Atterberg Limits in accordance with BS 1377.
- Determination of particle size distribution in accordance with BS 1377.
- Determination of dry density / moisture content relationship in accordance with BS standard compaction and modified AASHTO T180 as appropriate.
- California Bearing ratio (CBR) in accordance with AASHTO T193.
- Field dry density as set out in BS 1377.

## 5.28 Tolerances

**5.28.1** The following tolerances will be permitted in the finish of the formation to roads and platform:

- a) The level of the formation should be within +/- 100 mm of that specified.
- b) On the final trimmed slope of earthworks, a variation of + or - one fifth of the specified slope will be allowed.
- c) The tolerances permitted in the overall width of the bottom of cuttings shall be plus or minus 150 mm in the distance between center lines and the toe of cuttings slopes, and plus 150 mm in the case of embankments.



## **5.29 Materials for The Works**

### **5.29.1 General**

**5.29.1.1** All materials shall comply with appropriate local or regional standards unless otherwise required hereinafter. Such standards shall be to the approval of the Employer.

**5.29.1.2** The Contractor shall before placing any order for materials or manufactured articles for incorporation in the Civil and structural Works, submit for the approval of the Employer the names of the firms from whom he proposes to obtain such materials, etc., together with a list of the materials and manufactured articles giving the origin, quality, weight, strength, description, etc., which he proposes that the firms should supply. No materials or manufactured articles shall be ordered or obtained from any firm of which the Employer shall not have previously approved.

**5.29.1.3** All materials shall be delivered to the site within sufficient period of time before they are required for use in the Works to enable the Employer to take such samples as he may wish for testing and approval. Any materials condemned as unsuitable for Works shall be removed from the Site at the Contractor's expense. Contractors price to include these testing of materials.

**5.29.1.4** The Contractor may propose alternative materials to those specified, provided that they are of equivalent quality and, subject to the Employer's or the Employer's approval such materials may be used in the Works.

### **5.29.2 Standards**

Concrete pipes, porous concrete pipes, cast iron manhole covers and gratings, bricks, concrete kerbs, bituminous surfacing, cement, steel and aggregates shall comply with local or regional standards as per specified standards in the document.

### **5.29.3 Stone for Pitching**

Stone for pitching to drains, inlets and outlets of culverts, to embankments and around structures shall consist of sound un-decomposed rock. Precast concrete tiles may also be used.

### **5.29.4 Stone for Solar Field Platform Surfacing**

**5.29.4.1** The stone shall be hard and durable crushed rock with a maximum particle size of 60 mm and not more than 15% shall pass a 9.5 mm sieve.

**5.29.4.2** The stone layer to be spread uniformly over the finished surface of the platform shall have a thickness of 100 mm.

## **5.30 Drainage and Storm Water**

**5.30.1** The contractor shall construct the SPGP station to a fall that will allow proper self-drainage of the site. This shall be done in conjunction with the earthworks design to ensure no flooding shall be experienced within the site. The drainage designs shall refer to data acquired from the Kenya

Meteorological department with site specific criteria over a period of minimum 50 years and shall provide for the worst-case scenarios. The number of runs and outfalls and pipe sizing must be sufficient to cope with the severest precipitation, with a factor of safety of 1:2 within the SPGP site and other areas in the site. The drainage must allow uninterrupted access.

**5.30.2** Drainage shall be in accordance with relevant Codes for Practice published by authoritative Standards organization such as the British Institution, e.g., BS 8301, BS 6031 and Eurocodes.

**5.30.3** Embankments and cuttings are to have drainage facilities at their top or bottom. The formation level of the site is to be formed with uniform cross-falls of about 1 in 300 in the same direction as the natural drainage path of the surrounding environment. Drainage minimum slope shall be 1 in 200.

**5.30.4** Surface water from roofs of buildings shall be drained to down pipes, which connect with the general site drainage system. Surface water from the control room building and office roof shall be drained to the main storage reservoir tank.

**5.30.5** In areas where there is a risk of water runoff the SPGP Plant shall be protected from failure by means of gabions, retaining walls, and stone pitching or otherwise to the employer's approval.

### **5.31 Boundary Fencing and Additional Security Measures**

#### **5.31.1 Fencing**

The contractor shall fence approximately minimum of 1 acre of the acquired land, to secure the developed area (Solar Field, Office, Control room etc.). In the case where the land acquired is more than 1 acre, the contractor shall ensure that the beacons of the land is permanently marked and secured, and only fence off 1 acre where the developments will be done. There shall be a second fence to barricade the solar field, located at a sufficient distance from the solar panels, to avoid shading effect. The Contractor shall construct all the two fences including gates where necessary and shall comply with the requirements of the following Clauses. The design of the fences shall be subject to employer's approval.

**5.31.1.1** All the perimeter fences shall be of chain link with concrete posts. The fencing shall have barbed wire on top of the perimeter fence. Perimeter lighting shall be provided to employer's approval.

**5.31.1.2** The Solar Field fence shall be of chain Link with steel sections of optimized design, with a minimum height of 1.5m, to barricade unauthorized persons from accessing the Solar plant area.

#### **5.31.2 Dimensions**

Height of chain link fabric for the perimeter fence:	2 400 mm
Height of chain link fabric for the Solar Field:	1500 mm

**5.31.3 Barbed wire:** 3 wires above fabric, height of 300 mm, on supporting arms facing outwards

from Site at 450 angles.

Maximum distance between posts or columns: 3 000 mm, except where interrupted by gate.

**5.31.4 Tension bars and bands:** located at terminal posts to fix fabric, bottom wire and barbed wire.

**5.31.5 Top rail:** "extra-strong" pipe, 43 mm outside diameter.

**5.31.6 Braces:** "extra-strong" pipe, 43 mm outside diameter for attaching end and gate posts to adjoining posts. Use two braces at corner and restraining posts.

**5.31.7 Gate width:** free distance between 2 gate posts, 1 500 mm for single gate, 5 000 mm double gates.

**5.31.8 Double gates:** one leaf for normal traffic, other leaf to remain closed by means of drop bolt locking into center rest, inoperable from exterior.

**5.31.9 Gates:** able to open in either direction to 90°.

**5.31.10 Gate hardware:** three hinges, latch with padlock accessible from either side of gate, latch catch.

**5.31.11 Top of posts and uprights:** weatherproof tops.

#### **5.31.12 Materials**

**5.31.12.1 Fabric:** ASTM A 392, 2 000 mm high, 3.8 mm diameter (No. 9 gauge) steel wire, 50 mm diamond pattern, twisted and barbed finish at top, knuckled wires at bottom, zinc coated.

**5.31.12.2 Pipes:** ASTM A 120, steel pile, hot-dipped zinc coated after welding, diameter and weight size as shown on drawings, unthreaded ends, free from burrs.

**5.31.12.3 Fence fittings:** ASTM F 626, hot-dipped zinc coated according to ASTM A 123.

**5.31.12.4 Barbed wire:** ASTM A 121, 2.51 mm diameter wire in strand (No.12-1/2 gauge), 3 strands with 4-point barbs spaced at 125 mm, Class 3 zinc coating.

**5.31.12.5 Bottom wires:** 5 mm (No. 6 gauge) steel wire, 500 g/m<sup>2</sup> zinc coating. This shall be surrounded by a concrete beam (C20), to hold down the fabric.

**5.31.12.6 Fence fittings:** ASTM F 626, steel tension bars and bands, nuts and bolts, weather proof tops of commercial aluminium alloy, malleable cast iron, or rolled or pressed steel, cast iron and steel fittings hot-dipped galvanized with 500 g/m<sup>2</sup> according to ASTM A123.

**5.31.12.7 Concrete:** 20MPa at 28 days

#### **5.31.13 Installation**

**5.31.13.1** Install fencing and gates according to ASTM F 567 unless otherwise indicated, and to drawings and this Specification.

**5.31.13.2** Level ground surface so that space between finished ground surface elevation and bottom of fabric does not exceed 50 mm.

**5.31.13.3** Plumb and align posts to within 10 mm.

**5.31.13.4** Install posts of the gate at same elevation regardless of difference in ground level.

**5.31.13.5** Set posts in concrete footings in form of truncated cone, according to ASTM F 567, and as follows:

**Table 16: Chain Link Concrete Post Footings Guidelines.**

FOUNDATIONS (Dimensions)	ORDINARY SOIL		SOLID ROCK	
	Line Posts	Terminal Posts	Line Posts	Terminal Posts
Depth	1000 mm	1600 mm	300 mm	500 mm
Diameter at top	250 mm	300 mm	150 mm	150 mm
Diameter at bottom	350 mm	400 mm	150 mm	150 mm

Make joints in fabric at terminal posts.

**5.31.13.6** Fasten as follows:

- a) Every 450 mm along top rail, braces and bottom wire;
- b) Every 300 mm on line posts.

**5.31.13.7** Secure barbed wire to terminal and gate posts with tension bands, and to gate uprights with hooks.

**5.31.13.8** Install bottom wire in middle of last line of mesh.

### **5.32 Additional Security Measures**

The contractor shall provide the following additional security measures;

**5.32.1** Warning plates/danger plates etc. shall be provided in sufficient numbers all around the fencing as per safety requirements.

**5.32.2** A closed-circuit television (CCTV) Camera system shall be fitted with minimum four (4) No. Cameras fitted with all necessary accessories in only 3 high threat security areas /sites as specified in Table 17. The CCTV design and quality of the system, shall be subject to employers' approval.

**5.32.3** Manually activated sound alarm system shall be installed at the Guard house.

**Table 17: High Threat Security areas that needs use of CCTV as additional security measures**

No	Lot	County	Mini Grid Prone to Terror Threat	Recommendation
1	Lot 1	Turkana	Kibish	Use of CCTV system with all its accessories for surveillance of the sites.
2	Lot 2	Turkana	Lorengippi,	
3	Lot 3	Marsabit	N/A	
4	Lot 4	Samburu	Latakweny	
5	Lot 5	Isiolo	N/A	

## **5.33 Concrete Works**

### **5.33.1 Soil Investigations**

The contractor shall collect all data he deems necessary for preparation of his bid. The foundation design shall be based on the bearing strength data, obtained from the geotechnical survey.

The Contractor shall be required to perform sub-soil tests within the area of the SPGP to the depth and by the method of test specified by the Employer. The details of performing the test, tools and equipment to be used for, shall be submitted to the Employer for approval.

The sub-soil tests shall be carried out by any method as stated hereafter under the supervision of a qualified person, who shall be subject to approval of the Employer.

### **5.33.2 Excavation**

Excavation for concrete foundations shall be carried out in strict accordance with the requirements of the Employer and to fit in with the programme of construction.

### **5.33.3 Shoring and Timbering of Excavation**

The Contractor shall be entirely responsible for the safety of all excavations, for the prevention of injury to workmen and for the stability of the faces of the excavation.

The adjacent road surfaces must remain trafficable, and cracking or cave-ins must be avoided. All shoring and timbering shall be done to the approval of the Employer, who may order such shoring or timbering to be strengthened or altered if he considers this necessary in the interests of the work or to safeguard against accidents to workmen or cave-ins. For the purpose of measurement, the following categories of shoring shall apply:

### **5.33.4 Dewatering**

The whole Works shall be constructed in dry conditions and the Contractor shall be held responsible for keeping all excavations free from water, whatever the source or cause may be, and shall properly deal with and dispose of water by use of sufficient temporary works, plant and appliances so as to ensure that the whole Works is executed in a satisfactory dry and safe manner, and costs for all dewatering operations shall be included in the price for civil works.

### **5.33.5 Excavation to be approved**

In no case shall broke stone for under drainage or concrete be placed in an excavation until the surface on which such materials are to be placed has been approved by the Employer.

The Contractor shall advise the Employer whenever the bottom of any excavation is ready for inspection or whenever it is necessary to cover up the work. In default of such notice the foundation shall on the order of the Employer be uncovered by the Contractor and reinstated without extra charge.

### **5.33.6 Disposal of Excavated Material**

All material excavated under this Contract shall be disposed of in accordance with the instructions

issued by the Employer. Selected material required for back-filling shall be removed to a tip found by the Contractor and the Contractor shall be responsible for ensuring that the required amount of spoil is set aside.

#### **5.33.7 Other Services**

Where trenches pass near or across other services, the Contractor shall take every precaution against damaging such services. These services shall be properly supported in the trench until back-filling is complete and the back-filling shall be thoroughly compacted under and around such services.

#### **5.33.8 Backfilling**

Back-filling shall be carried out either with selected spoil as set aside, or with imported selected spoil, or other material to the approval of the Employer. No back-filling shall be done until all the formwork has been removed together with pieces of timber, cement bags, vegetation and or other rubbish.

All back-filling shall be compacted in layers not exceeding 150 mm thick and shall be sprayed with water to bring the moisture content to the optimum for dense compaction.

Compaction shall be to approved standard.

### **5.34 Concrete, Formwork and Reinforcement**

#### **5.34.1 Material**

##### **5.34.1.1 Aggregates**

- a) Shall conform to BS 882.
- b) Shall be heaped separately on hard, self-draining surfaces.
- c) Normal size of coarse aggregate shall be 20 mm.

##### **5.34.1.2 Water**

Shall be fit to drink

##### **5.34.1.3 Reinforcement**

Shall conform to BS 4449.

##### **5.34.1.4 Reinforced Concrete**

Shall be designed to BS 8110, Foundation BS 8004

##### **5.34.1.5 Steel**

Shall be designed to BS 5950

##### **5.34.1.6 Cement**

Shall

- a) Conform to BS 12.
- b) Be either normal Portland or P.C. 15.
- c) Be used within 6 weeks of manufacture.

- d) Be stored in a manner to exclude any moisture.
- e) Be stored in a manner to ensure use of the earliest consignment.
- f) Different types of cement from different manufacturers shall not be mixed for a single cast or structural element.

Additives shall not be used

### **5.34.2 Before concreting**

#### **5.34.2.1 Design Mixes**

Not less than 2 weeks before the start of concrete work, the Contractor shall submit to the Employer for his approval a statement of proposed mix proportions for the various grades required in the project. (Note: the grade is the characteristic strength or the cube strength below which not more than 5% of the result may be expected to fall when tested at 28 days).

The statement shall include proportions of cement, fine and coarse aggregate, and water, the maximum and minimum slump and the target strength for each grade.

A certificate by recognized laboratory that the proposed mix will meet the requirements must accompany the statement.

The proportions stated may not later be altered without the written approval of the Employer.

Cost of mix designs to be borne by the Contractor.

#### **5.34.2.2 Formwork**

Formwork shall be sufficient to leave the concrete finishes specified on drawings and to be within the tolerances specified in the following table and to provide an acceptable surface for applied finished, where required.

Line and Level	1 mm per meter not exceeding 5 mm
Pockets, Sleeves etc.	+/- 5 mm
Bases	+/- 50 mm

The concrete shall have a smooth finish free of projections, voids, etc. The type of ties to be used shall be such that the required finish is achieved and does not become marred by subsequent corrosion. Ties to be set out to definite pattern to the Employer's or the Employer's approval. Rubbing down is allowed only after the Employer's approval of the surface to be treated.

#### **5.34.2.3 Reinforcement**

Shall not be heated or re-bent without the Employer's permission.

Shall be free from any material likely to impair bond or initiate corrosion.

Shall be bent and fixed according to the Employer's approved bending schedules.

Shall be tied with soft iron wire.

Shall be supported to maintain the following minimum cover during concreting.

- a) The greater of the diameter of the bar or 40 mm for external un-plastered face.
- b) The greater diameter of the bar or 15 mm for internal face.

Shall be inspected by the Employer.

#### **5.34.2.4 Construction Joints**

Shall be avoided, if possible, but if inevitable shall be pre-planned in consultation with the Employer and temporary stop ends inserted. Before placing of concrete against a construction joint, the formed face shall be hacked down to expose the coarse aggregate, kept continuously wet for 24 hours. Vertical faces should be covered with cement/water slurry and horizontal faces should be covered with 15 mm layer of cement/sand grout. New concrete should then be placed immediately.

#### **5.34.2.5 Camber**

To formwork shall not be at the expense of the overall depth of the concrete.

#### **5.34.2.6 Weather**

The expected temperatures in Turkana, Marsabit, and Samburu regions are more than 30 degrees Celsius. The contractor shall adopt use of membranes for curing, to manage the desired moisture and temperature conditions and hydrate the cement to avoid concrete cracking.

#### **5.34.2.7 Batching**

Shall

- a) Be by mass in accurately calibrated scales or be volume in soundly constructed gauge boxes making due allowance for bulking of the fine aggregate.
- b) Be in proportion to whole sacks of cement.

#### **5.34.2.8 Mixing**

Shall

- a) Be in a machine in good condition, large enough to carry the whole mix, controlled by a competent experienced operator.
- b) Be for sufficient time to ensure complete mixing of the ingredients.

#### **5.34.2.9 Placing**

Shall

- a) Be under the control of a competent, experienced overseer.
- b) Be in a manner to prevent separation of the ingredients.
- c) Be a continuous process until the pour is complete.

#### **5.34.2.10 Compaction**

- a) Shall be by immersion (poker) vibrator in the hands of experienced operators.
- b) Concrete shall not be moved by vibrator.



c) Shall be sufficient to remove all air pockets and honey-combing and to ensure complete dense concrete cover to all reinforcement.

#### **5.34.2.11 Testing**

a) Making of concrete cubes by Contractor under Employer's supervision. Contractor shall arrange for transport of cubes to approved testing laboratories. Cubes to be in sets of 3.

#### **5.34.2.12 Curing**

a) Shall commence early on the morning following the placing of the concrete.

b) Shall be effected by keeping the concrete in a permanently wet state.

c) Membranes shall be used due to expected high temperatures.

d) Shall continue for a minimum of fourteen (14) days or such longer time as may be required by the Employer.

#### **5.34.2.13 Stripping of Formwork**

a) To soffits shall not be struck until 7 days after placing of concrete (but see below for (props)).

b) To vertical faces shall not be struck until 14 days after placing concrete.

c) Props to soffits shall not be struck until 14 days after placing concrete.

d) Shall not be stripped without the Employer's approval who has the power to vary the above items.

#### **5.34.2.14 Patching**

a) To defective work shall not be undertaken before the item has been shown to the Employer.

b) Is a sign of poor workmanship. The Employer shall have the right to reject the complete element if an unreasonable amount of patching has to be done, or if patching will spoil the appearance of the finished concrete.

#### **5.34.2.16 Records**

Are to be kept by the Contractor, showing date and time of each concrete pour, the weather conditions, the temperature, the number of the cubes which represent the concrete, the slump and any other items which the Contractor and/or the Employer consider relevant. These records are to be made available for the Employer's inspection when required.

### **5.35 Foundations**

The contractor shall construct reinforced concrete structural foundations for the Equipment Enclosure as well as for the Solar Equipment as required. These shall be designed to relevant standards and reviewed by the Employer before implementation.

### **5.36 Cable Ducts and Conduits.**

**5.36.1** The Contractor is responsible for all civil engineering works required for the cable runs between the Solar field site and the control room and/buildings, in buried heavy gauge installation

ducts of minimum 150mm to connect cables from the solar panels and equipment to the Control room and/office as required. Manholes for inspections shall be provided at approved intervals.

**5.36.2** Where the cable trench is crossing roads, the ducts shall be constructed in such way that they will be able to withstand the weight imposed on them.

**5.36.3** The contractor shall appropriately mark the cable route.

**5.36.4** Cable entries into buildings/control room and road crossings shall be through 150 mm diameter heavy gauge ducts.

**5.36.5** Two (2) lines of 150 mm diameter heavy gauge of spare ducts shall be provided.

**5.36.6** After installation of cables the ducts shall be sealed with duct sealing compound where required. Cable entries into building/control room shall be sealed to prevent the entry of dust, vermin water, etc., using suitable materials

**5.36.7** The cable system design including manholes shall be subject to employer's approval.

### **5.37 Builder's Work**

#### **5.37.1 Setting out Walling**

The Contractor shall provide proper setting out rods and set out all work on the same for courses, openings, heights, etc. and shall build the walls and piers, etc. to the widths, depths and heights indicated on the drawings and as directed and approved by the Employer.

#### **5.37.2 Materials**

##### **5.37.2.1 Cement**

Cement shall be as described in concrete Works, Part 5.34.1.6

##### **5.37.2.2 Fine Aggregates**

Fine aggregates for concrete blocks shall be as described for fine aggregate in Concrete Works.

##### **5.37.2.3 Coarse Aggregate**

Coarse aggregate for concrete blocks shall be good, hard, clean aggregates from an approved quarry. It shall be free from all de-composted materials and shall be graded up to 7 mm, and all as described for coarse aggregate, Concrete Works.

##### **5.37.2.4 Machine cut stone.**

This shall be to approval of employer and meet minimum required specifications.

##### **5.37.2.5 Concrete Blocks.**

Concrete blocks for walling shall be provided by the Contractor complying with B.S. 6073, and made in approved block manufacturing machines.

Minimum thickness of blocks in external walls shall be 150 mm, and in internal walls the thickness shall be minimum 100 mm.

Samples of the proposed block types shall be approved by the Employer before any walling work is commenced.

Blocks shall be cast under sheds in suitable block manufacturing machines either power driven or hand operated. The form shall be of steel, and accurately made to size to give the required shape and squareness of block. The concrete shall be vibrated during casting to achieve a dense and uniform concrete. The material shall contain only sufficient water to obtain full chemical reaction of the cement and to give proper workability of the constituents.

The ratio of combined aggregate to cement shall not exceed 3:1. The Contractor shall present his proposal for mix recipe supported by test results for the Employer's approval.

Concrete shall have minimum 28 days strength of 20 N/mm<sup>2</sup> in accordance with B.S. 1881. Mixing shall take place in mechanical mixers so as to thoroughly mix the constituents to a uniform consistency before casting.

On removal from the machine the blocks shall be carefully deposited on edge on boarding or a clean concrete floor under sheds so as to prevent drying out by the sun for 3 days. During this time blocks shall be kept constantly damp. The blocks may then be laid on edge in the open and kept damp by spraying or covering with wet hessian or by other means for a further 5 days. The blocks may then be stacked if required, but not more than one meter high, and in such a way as to prevent damage to the edges and corners.

No blocks may be used in building or be transported to site before having reached required 28 days strength criterion. All concrete blocks shall be of even texture and properly mixed ingredients and all portions of the block shall be properly set and hardened concrete.

Blocks shall be free from cracks or blemishes and shall be true to shape and size with clean sharp edges and corners and with corners truly square. Damaged blocks shall immediately be removed from the site. No dimension of a block shall deviate individually by more than 3 mm from the correct size. The average length, width and height of a sample of 15 blocks should neither be longer nor less than 2 mm than the correct size.

Dressed natural/foundation stone blocks at least 200mm width may be used as alternative to the concrete blocks.

#### **5.37.2.6 Cement Mortar**

The cement mortar is to be mixed in the proportions of 1 Cement, 4 Sand, and thoroughly incorporated with a sufficiency of water. Any cement mortar which has been left for more than one hour shall not be used in the Works.

#### **5.37.2.7 Building Walling**

All blockwork shall be laid in raking stretcher bond solidly bedded, jointed and flushed up in mortar.

Where wall faces are to be plastered the joints shall be raked out to form a key. The blocks shall be thoroughly wetted for at least 24 hours before laying. Walls shall be carried up evenly course by course. During laying an open joint not less than 15 mm wide shall be left between the ends of all concrete lintels, whether pre-cast or cast in-situ and the blocks adjacent to these ends. These open joints shall be left as long as possible during construction and not filled until plastering or other works render such filling necessary. All such joints shall be properly filled in before the completion of the work. External walls shall be reinforced with two 8 mm high yield steel bars in every third horizontal mortar joint. The building shall be designed as a framed structure.

Blockwork which is not to be rendered or plastered shall be finished with a fair face and the blocks shall be selected for even texture and unmarked faces, regular shape and square unbroken arises. The blockwork shall be pointed as the work proceeds with a neat joint. Where blockwork is to be rendered or plastered the joint shall be raked out 10 mm deep as the work proceeds to form an adequate key. Galvanized steel ties with fishtailed end cast into the concrete spaced at alternate courses and extending not less than 150 mm into the block joints. All mortar joints are not to exceed 15 mm or less than 12 mm.

#### **5.37.2.8 Lintels**

Concrete lintels shall be used for all openings and shall be reinforced and constructed as per approved structural designs for the gourd house.

### **5.38 Structural Steelworks**

**5.38.1** Structural steelwork shall be shop-fabricated from structural shapes of medium grade carbon steel in suitable lengths for easy transport and erection. The structural members shall be jointed or fixed on site by bolting or welding. Site welds should be minimized. Design shall comply with BS 5950.

**5.38.2** All workmanship and fabrication shall be in accordance with the best practice and shall generally comply with the requirements of B.S.4449. The greatest accuracy shall be observed to ensure that all parts fit together correctly on erection within the tolerances stated in this section. Steelworks shall include all materials, bolts and attachments, cleats, brackets, gussets, etc.

**5.38.3** Where required in the Contract, the Contractor shall design the steelwork to comply with the information given on the Contract Drawings. Loading and factors of safety shall comply with relevant codes and regulations. Shop drawings shall be prepared using welding symbols to B.S. 499 where appropriate. Design calculations and shop drawings must be submitted to the Employer for his approval prior to fabrication of members. The approval of shop drawings and calculations by the Employer shall not relieve the Contractor of the full responsibility for any discrepancies, errors,

omissions or failure arising therefrom.

**5.38.4** All steelwork shall be transported, handled, stored on Site and erected so that members are not damaged or subjected to excessive stresses. Fabrication and erection shall comply with B.S. 5950 Part 2.

**5.38.5** The contractor shall provide steel support structures to support all equipment and solar panels at a minimum of 1m clearance from the finished ground level, on the lower side of the elevated panels.

**5.38.6** The structures shall be galvanized to the required specification, with a minimum coating of 614mg/m<sup>2</sup>.

**5.38.7** The Mounting of the Solar panels shall be done on steel rails and frames and shall be designed to carry all the loadings and in accordance to provision of B.S 5950 and any other relevant BSI standards.

### **5.39 Roofing-Control Room, Office Building Guard House and VIP Latrine**

**5.39.1** Materials, accessories and fixings shall be ordered from an approved supplier and the Contractor shall as and when required by the Employer, submit and deliver samples of all materials for inspection and testing. Roof trusses shall be in steel.

**5.39.2** Roof sheeting shall be hot dip galvanized troughed mild steel sheeting and shall be of minimum thickness 0.5 mm. The sheeting shall have approved plastic coating on face side. Type and brand of such sheeting shall be proposed by the Contractor with his Tender together with supporting specifications.

**5.39.3** The sheets shall be laid with 200 mm end laps and double corrugation side laps away from the prevailing wind. The sheets shall be fixed to light gauge steel purlins with galvanized coach screws and seating washers.

**5.39.4** Holes for screws shall be carefully drilled in the ridges of the corrugations. Great care shall be exercised to avoid damage and disfiguration to the surface coating of the sheets.

Maximum load acting on the building shall be in accordance with local or regional standards.

### **5.40 Roof Drainage**

**5.40.1** Gutters and down pipes shall, unless otherwise shown on the drawings, be approved plastic coated steel or heavy gauge PVC of diameters 200 mm and 150 mm respectively.

**5.40.2** Joints shall be lapped 150 mm in the direction of the flow and soldered. Slip joints shall be provided to allow for expansion. All hangers, brackets, and fastenings should be of the same metal as the gutter or of compatible materials. Gutters and down pipes including supports shall be designed for a concentrated load of 100 kg. Screens or strainers shall be provided to prevent debris from clogging the down pipes.

## **5.41 Metalwork and Containerized Control Room Solutions.**

**5.41.1** Unless otherwise specified, metalwork shall be carried out in accordance with the provision of B.S. 5950 and other relevant BSI standards.

**5.41.2** All steel shall unless otherwise specified, be hot dip galvanized. The minimum galvanized coating shall be 614mg/m<sup>2</sup>.

**5.41.3** For the case of containerized control room, the material shall be in good condition, Durable and environmentally friendly. The containers shall be fitted with insulations for temperature regulations, as an addition to Air conditioners installed for temperature control to specification, due to sensitivity of the equipment to high temperature conditions. Rejected containers due to poor Quality, shall be replaced at the contractor's expense. The container shall be painted with the first coat of red Oxide primer and then consequently painted with Zinc Chromate, anti-rust primer to approved layers and the final coat of paint shall be in accordance to the employer's approved company color codes.

**5.41.4** Prior to fabrication the Contractor shall submit shop drawings for the Employer's approval.

## **5.42 Metal Doors**

### **5.42.1 General**

Metal doors shall be supplied by approved manufacturers.

All doors shall be painted as specified under Painting and Decorating. All locks shall be master-keyed with three master keys supplied in addition to three regular keys for each door or gate.

Doors shall be measured by the number of doors of specified dimensions. The rate shall include all supplies, site works, painting and hardware.

### **5.42.2 Doors**

Door frames shall be pressed steel frames made from minimum 2 mm thick steel sheeting and reinforced where door closers are fixed.

Thresholds shall be made from rolled steel sheeting approximately 100 mm wide and 12 mm high.

Placing of doors in accordance with control room and office building drawing.

Internal door frames are to be built to walls truly vertical and square with three ties per frame.

External door frames are to be built in to walls truly vertical and square with six ties per frame.

All door frames are to be from an approved manufacturer and illustrated in the Manufacturer's Catalogue.

Door frames are to be complete with 100 mm, loose pin steel hinges welded in position and adjustable striking plate.

Door frames and similar components shall be fixed with countersunk screws or bolts with heads set

into the frames.

Doors wider than 800 mm shall have three 100 mm hinges. Other doors may have two hinges except where specified or detailed otherwise.

Door stops shall be fitted by screwed fixings where necessary.

#### **5.43 Aluminium or Steel Windows**

Unless otherwise indicated windows shall consist of aluminium sub frame with clear glass. Windows shall be from an approved supplier and the details thereof shall be approved by the Employer. Windows shall be operable and provided with corrosion resistant metal insect screens or as directed by the Employer.

Frames shall generally be built-in during construction of the walls and securely fixed.

Placing of windows in accordance with approved control room and office building drawings.

Windows are to be built in to walls truly vertical square with six ties per frame.

All aluminium or steel windows are to be from an approved manufacturer and illustrated in the Manufacturer's Catalogue.

Windows are to be fitted complete with casement fastening, stays etc.

All windows shall have approved burglar bars, and approved means of opening/locking.

#### **5.44 Door and Window Furniture**

Ironmongery shall be strongly made, well finished and of good quality. Ironmongery for windows and doors shall be galvanized or other approved manufacture for external use. Samples of all items shall be submitted to the Employer for approval before they are used for the Works.

All doors shall be lockable. External doors shall have approved security locks.

Three keys for each lock, clearly labelled, shall be placed in a key cabinet in the control room and all ironmongery shall be cleaned, oiled, adjusted and left in perfect working order.

Emergency doors shall be provided accordingly as per the safety requirements.

#### **5.45 Control room, Guard House, VIP Latrine and office building**

The specifications of the finishing should be read in conjunction to section 5.2 and 5.3 for the containerized control room and office.

**Table 18: Schedule of Materials and Finish**

ROOM	FLOOR	WALLS	CEILING	REMARKS/NOTES
Control room/ Office building	Wood tiles/ Ceramic	Cladding with approved	Cladding with approved	Subject to employer's approval

	tiles/steel	material	material	
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NOTES:

Sheets for ceilings: prefabricated/manufactured color and type in according to approval of the employer.

Control room and office building: External/internal color in accordance with approval of the employer.

**5.45.1 Plaster and Floor Coverings**

Materials

Cement and water to be as before described. The sand to be screened through a sieve of 10 to 15 and meshes to 1 cm and to be washed if directed.

**5.45.2 Mixing**

All materials for mixing are to be used in proper gauge boxes and they are to be strike measured and not tamped down in boxes. Proper non-absorbent stages are to be used for mixing and storing mortar.

No foreign matter must be mixed with the mortar.

The materials are to be mixed dry before adding water through a fine hose spray. No cement mortar which has taken its initial set will be allowed to be used.

**5.45.3 Plaster Thickness**

Unless otherwise specified all wall plasters should not be less than 13 mm thick and not more than 19 mm thick.

**5.45.4 Cement Plaster**

Cement plaster for external use to be composed of one part cement to four parts sand and for internal use to be one part cement to five parts sand.

**5.45.5 Form Key**

Rake out joints and roughen if necessary to form key for plaster.

For concrete surfaces, hack and apply 1:1 cement sand slush to form key. Continuously wet for 7 days and then apply plaster.

All brickwork and concrete works should be brushed down to remove dust and any other loose material.

**5.45.6 Wetting**

All internal and external brick or concrete surfaces are to be wetted well before plastering.

All cement plaster must be kept wet for at least 7 days.

**5.45.7 Repairing Defects**

All defective plaster, cracks, hollows, etc., are to be cut out to a rectangular shape, the edges undercut to form a dovetail key and to be made good to finish flush with the edge of the surrounding



plasterwork.

All patches will be to the approval of the Employer and if the defects cannot be made good satisfactorily then the whole surface is to be removed and re-plastered at the Contractor's expense.

#### **5.45.8 Glazing and Painting**

##### **5.45.8.1 Glass**

All glass is to be of approved manufacture, free from bubbles, waviness, scratches or other imperfections and is to be well bedded, puttied and back puttied and secured with glazing pins or clips in steel sashes or with sprigs in wood sashes.

All glass shall be carefully cut to the required sizes so that all panes of figured or textured glass are uniform in appearance with the pattern parallel to the edges and wired glass shall be so cut that the wires are parallel to the edges.

The window glass for control room shall be shatterproof type.

##### **5.45.8.2 Putty**

Putty for glazing to steel sashes is to be of approved proprietary brand. Rebates are to be thoroughly back puttied before glazing and all putty is to be carefully trimmed and cleaned off so that back putty finishes level with the top of sections internally, external putty covers sight lines exactly and finished straight and true. Rough surfaces to putty will not be allowed and any defective putty will be cut out and replaced at the Contractor's expense.

Rebates of wood sashes are to be given one coat of priming immediately before glazing.

##### **5.45.8.3 Mirrors**

Glass mirrors are to be of the thickness specified, of selected quality glass, silvered on back, with protective sealing coat and arrised edges, unless otherwise described.

Generally

Allow for removing and replacing all cracked, broken or defective glass and leave thoroughly clean and perfect at completion.

#### **5.45.9 Materials for Decoration**

All paints, primers, varnishes, emulsions, stopping, etc., to be of approved manufacture.

The contractor is to use proprietary ready mixed paints obtained from an approved supplier.

When a coat of proprietary paint is applied, the manufacturer's priming and previous coats suitable for the particular type are to be used.

All materials must be brought on to the site in unopened tins, and no dilution or adulteration will be permitted, unless approved by the Employer.

##### **5.45.10 Emulsion Paint**

Emulsion paint shall be PVA (Polyvinyl Acetate) alkali-resisting formulated with high washability

and capable of resisting a 8000 scrub test. The first coat to be specially formulated base coat for direct application to the specified surface.

#### **5.45.11 Fillers**

Higher grade cellulose fillers are to be used internally and premixed filler to be used externally.

#### **5.45.12 High Gloss Paints**

Primers for application to bare metal to be red oxide primer for iron and steel. For galvanized metal to be an approved zinc chromate or galvanized iron primer. For application on wood or plaster etc., to be an approved alkali primer.

#### **5.45.13 Finish enamels**

Finish enamels to be synthetic enamel high-capacity paint with high coverage and high gloss finish unless otherwise described.

#### **5.45.14 Workmanship**

All surfaces are to be free from moisture, dust, grease and dirt and rubbed down smooth according to approved practice.

All plaster to be free from efflorescence and treated with one coat of petrifying liquid, approved sealer or alkali primer if required. Hard wall plaster to be glass papered before decorating.

Rectifying defects to decorated surfaces due to dampness, efflorescence, chemical reaction, etc., will be to the Contractor's account, as these surfaces must be checked and the appropriate precautions taken before applying the decoration.

Metalwork must be scraped free of rust, primed as described and finished as later specified.

Galvanized sheet iron, pipes, etc., are to be cleaned down to remove manufacturer's ammoniated dichromate protective covering, primed as described and finished as later specified.

Coated pipes are to be cleaned down, stopped and primed with one coat of aluminium primer and finished as later specified.

All metal to have the specified number of coats in addition to the priming coat.

Every coat of paint must be a good covering coat and must dry hard and be well rubbed down to a smooth surface before the next coat is applied, otherwise the Contractor will be required to apply extra coats at his own expense.

Each coat of paint to be of a distinctive color: sample colors are to be prepared for the final coat which is to be an approved color scheme and must not be applied without the permission of the Employer. After undercoats are on, the painter shall check all work and grain fill as necessary with filler as described.

NOTE:

a) All paints specified are to be obtained from an approved manufacturer and used in strict accordance

with their instructions. Their representative will check the paints being used and the method of application and will advise accordingly.

b) This section of the work to be carried out by an approved firm of decorators who must allow for the very best finish possible and of the highest quality obtainable.

c) The prices must allow for the removal and refitting of all beads, fittings, fastenings, ironmongery, etc., removed for decoration purposes to be carried out by skilled tradesmen of the appropriate trade.

#### **5.46 Control Room and Office Building Sizes.**

The sizes are as specified in clause 5.2 and 5.3 of this document.

#### **5.47 Ironmongery and Metalwork**

##### **5.47.1 General**

All ironmongery shall be of the best respective types required and no alternative articles will be accepted unless approved. Articles described as brass must be solid brass and not brass finish. Chromium plated articles must be plated satin finish on solid brass or other approved metal.

Where items for ironmongery are required to be fitted to steel door frames, etc., the Contractor must ensure that the Manufacture makes provisions for the correct fitting or lock striking plates, hinges, cleat holes, bolt keeps, etc.

##### **5.47.2 Locks and Keys**

Locks are to be two levers unless otherwise described. All locks are to be provided with two keys which must be handed over to the owner on completion of the Works with identification labels attached.

##### **5.47.3 Steel**

Steelwork for general building construction is to be of approved manufacture complying generally with the appropriate British Standards and free from all defects, oil, dirt, loose rust, scale or other deleterious matter.

#### **5.48 Electrical Installation**

**5.48.1** The contractor shall supply, install, test and commission the complete electrical services within the Control room both outdoor and indoor, office building both outdoor and indoor, Guard house, VIP latrine and SPGP outdoor security lighting/perimeter lighting.

**5.48.2** The complete electrical installation shall comply with all local standards and rates and shall be as per KPLC requirements/specifications.

##### **5.48.3 Lighting**

- a. Luminaries shall be fluorescent lamps except for the toilets and outdoor lighting. SPGP and/Perimeter Outdoor lighting to use flood lights subject to employer's approval.
- b. All luminaries shall be supplied, installed and tested by the electrical sub-contractor.
- c. Outdoor lighting shall be controlled from an automatic photo cell.
- d. Lighting control switches shall be flush pattern with white finished plates.

**5.48.4** The outdoor SPGP flood lights/perimeter security lighting to be achieve the recommended luminaries and mounted on concrete poles.

**5.48.5** Socket outlets to be mounted at 300 mm above floor level in the office, guard house and control room.

**5.48.6** Conduit cast into the building structure shall be of the heavy-duty PVC type. PVC conduits shall not be fixed to the surface of the structure.

### **5.49 AC Installation**

The contractor to supply the ACs in the control room. The Contractor shall supply and install a minimum of two number AC units, including wiring and all necessary accessories. The number of ACs and its capacity shall be determined by calculations and design will be based on the equipment manufacturers ratings adopted and the rooms requirement (Including Lithium-Ion Batteries) and subject to approval by the employer.

### **5.50 Fire Safety Facilities**

**5.50.1** Portable fire extinguishers shall be provided under this Contract. Portable, wall mounted, hand held extinguishers shall be 6kg pressurized control discharge Bromochlorodifluoromethane (BCF) units in the office and control room. The number of units within the Control room and office shall be a minimum of 3 Number.

**5.50.2** A minimum of 1 No. 13 kg pressurized control discharge BCF units shall be provided in the SPGP area.

**5.50.3** The body of the extinguisher shall be seamless, welded and brazed as appropriate.

**5.50.4** The extinguisher shall be capable of being released by means of a lever-operated valve provided with a safety pin.

**5.50.5** Extinguishers shall be capable of controlled partial discharge.

**5.50.6** The type shall be of that recharge unit that is locally available.

**5.50.7** The extinguishers shall be wall mounted and attached and located in a manner affording quick release from the supporting bracket. They shall be installed so that the top of the extinguisher is not more than 1.5meters above the floor. In no case shall the clearance between the bottom of the extinguisher and the floor be less than 0.1 meter. The extinguishers shall be positioned so that the

instructions for operation face outwards.

**5.50.8** BESS to be housed in one room in the control room. The battery room shall have an automated fire detection, prevention and suppression system fitted with a suitable dry aerosol agent to put-out Lithium-Ion battery fires. The system shall include smoke detectors, horn strobes and other components required to enable it function properly and suppress fires while preventing unintended release. Suitable Fire protection and suppression system shall be designed for BESS in line with IEC or international requirements/specifications regulation as applicable and system requirement considering project site.

**5.50.9** The fire safety design shall be subject to approval by the employer. The contractor shall train the local staff on use of the installed system.

## **6. LAND OF SPGP**

### **6.1 Land Identification and acquisition**

**6.1.1** Land acquisition for setting up the generation station is the Employer's responsibility in liaison with the Ministry of Energy and Petroleum. Land areas for setting up of SPGP for all mini-grids sites have been identified and gazetted. The locational/geographical details of these sites including coordinates has been provided in Appendix 1.

**6.1.2** Site development, fencing, security and other applicable civil work for execution of the Mini-Grid is in the scope of Contractor.

## **7. POWER DISTRIBUTION NETWORK AND POWER SUPPLY TO CONSUMERS**

### **7.1 Scope**

**7.1.1** The bidder's scope includes design, supply, installation and commissioning of 11kV (for applicable Medium Voltage mini-grids), 415V and 240V Power Distribution Network (PDN) as detailed in Table 2 to table 7 above and shall be developed as per REREC requirements/specifications and technical standards.

**7.1.2** The line lengths and transformer sizes provided by the employer are estimated and may therefore vary during final survey and design work by the contractor. Transformers shall conform to standard sizes recognized by REREC as per REREC requirements/specifications and technical standards.

**7.1.3** Design work shall incorporate all necessary survey work, Customer premises picking, georeferencing, obtaining & filling customer information as prescribed in a customer information template and updating of REREC geospatial platform and KPLC Facility Data Base (FDB) to ensure all additional network is appropriately digitized. At project completion, "As Built Drawings" shall be used to permanently update the database.

**7.1.4** Design work shall include the following:

**7.1.4.1** Power line way leaves acquisition complete with signing way leaves consents with land owners (in liaison with REREC wayleaves staff) or other statutory bodies authorized to sign such consents. Design and subsequent construction shall follow all wayleaves procedures and requirements of REREC to avoid conflicts with land owners.

**7.1.4.2** Sensitizing all targeted customers and advising them to carry out their internal wiring without delay and ensuring wiring is done by electricians registered with Energy and Petroleum Authority (EPRA). Where a customer is unable to do electrical installation, the contractor will install a ready board and earthing, test the installation and issue EPRA wiring certificate.

**7.1.4.3** Issuing necessary KPLC applications forms to targeted customers and assisting customers to fill them.

**7.1.4.4** Collecting the application/supply forms together with other customer data (copy of PIN certificate, Copy of ID, Sketch etc.) and submitting the same to KPLC as part of design outcomes. The contractor shall also be responsible for creation and contracting of the customers in KPLC systems (InCMS and DCS)

**7.1.5** Designs shall be approved by the employer and four (4) physical files be availed to help in supervision. Soft copies of the designs shall also be submitted to the employer.

**7.1.6** Each design file shall bear REREC's SAP Reference No & KPLC's Design & Construction

System (DCS) reference number and full costing into a Capital Works Authority (CWA) job to facilitate online tracking and eventual commissioning in FDB and final capitalization into assets.

**7.1.7** The contractor shall be expected to be informed by the outcome of the design process in quantities to buy for certain materials that are difficult to predict. Of special interests are materials that will be highly influenced by how well project sensitization is done at design stage such as; Ready boards, Metallic meter boards at customer premises (for unprepared customers), earthing materials at customer meter board point etc. For bidding purposes, bidders may assume a span length of 100m for Medium Voltage network (11kV) and 40m for Low Voltage network.

**7.1.8** Employer to supply the following goods: Single Phase Pre-Paid Meters and MCBs for customer metering. Installation of the meter and MCBs to be done by contractor.

## **7.2 11kV Power Distribution Network for MV Mini-grids**

The 11kV (MV) Power Distribution Network (PDN) shall include design, supply, installation and commissioning of;

**7.2.1** 0.415/11 kV Step-up Transformers.

**7.2.2** 11/0.415 kV Step-down Transformers.

**7.2.3** Double Pole mounted transformer (Overhead) Substation along with all associated equipment, materials along with protection and complete interconnections and earthing etc.

**7.2.4** 11 kV Circuit breaker, 11 kV Isolators, CT, PT, DO Switch, Earthing Switch etc as per KPLC requirements/specifications.

**7.2.5** 11 kV Overhead lines, All Aluminum Conductors (75sq mm) , Conductors clamps, other all associated hard wares.

**7.2.6** Insulators and Fittings: Insulators, Insulators string fittings and Hardware's for 11 kV overhead lines & Substation.

**7.2.7** Concrete Poles (11 and 12m in length)

**7.2.8** Bus bars fittings for 11 kV Substation.

**7.2.9** Earthing wire/strips and earthing clamps, earthing rods and all associated material for earthing of 11 kV systems as per requirements/specifications of REREC.

**7.2.10** Lightning protection.

**7.2.11** Fuses and other protection systems.

**7.2.12** Stay wires with insulators and associated material and clamps etc

**7.2.13** Danger plates, phase plates, circuit plates, number plates, anti-climbing devices and other safety requirements

**7.2.14** Any other material required as per REREC requirements/specifications for the turnkey mini-



Grid completeness.

**7.2.15** O&M for satisfactory working of PDN and maintaining reliable supply of power to Consumers for 7 years from date of commissioning of SPGP & PDN.

**7.2.16** The bill of quantities for 11kV overhead lines will include but not limited to the following:

- Poles or other line support structures and associated materials (including pole caps, barbed wire, danger/hatari plates, pole number plates, binding wire, insulators, cross-arms, universal clamps, tie-straps)
- Conductors and accessories (Note: All connections shall comprise compression joints as specified in respective terminations/connections specification).
- Stays and stay blocks.
- Provision for isolation mechanism at point of Tee-off.

**7.2.17** The bill of quantities for 11kV substations will include but not limited to the following:

- Steel support structures and associated materials.
- Transformer protection equipment (surge arrestor, appropriate expulsion fuses, LV Moulded Case Circuit Breakers with enclosers).
- MV & LV earthing: Appropriate earthing mechanism to achieve recommended earth values  $\leq 20\Omega$  and  $10\Omega$  for MV and LV respectively. The earthing shall be done using copper clad earth rods. (For Poles without provision of earth mechanism, it is recommended that 25mm<sup>2</sup> GSW shall be used and connected to the earth rods using bimetallic clamps).

NOTE: The LV earthing (on each LV circuit) is shall be done at the first LV pole from the substation.

- Complete substation wiring (using 50mm<sup>2</sup> Aluminum conductor PVC soft drawn)
- Mount transformers at 17ft above the ground and carry out vandal – proofing through welding as specified in the associated drawing for substation structure erection

### **7.3 240 Volts Lines & Service Connections to Consumers for Respective Mini Grids**

The 240V (LV) Power Distribution Network (PDN) shall include design, supply, installation and commissioning of;

**7.3.1** 240 Volts, Single Phase Service lines as per requirements/specifications of REREC

**7.3.2** Single phase meters in accordance with REREC requirements/specifications for every connection of household, domestic, commercial, schools, and other single-phase consumers. (Customer meters to be provided by KPLC)

**7.3.3** 2 Core Cables, 10 Sqmm Aluminium concentric, for making single phase connections to

consumers as per requirements/specifications of REREC.

**7.3.4** 240 Volts, single phase circuit line as per survey requirements.

**7.3.5** Conductors and its fittings (100 Sqmm bare All Aluminum, 50 Sqmm bare All Aluminum)

**7.3.6** Fuse/ MCCB/MCB Protection

**7.3.7** Earthing and lightning Protection

**7.3.8** 1.1 kV class aluminum armored cables and clamps,

**7.3.9** Stay wires with insulators and associated material and clamps etc.

**7.3.10** Concrete poles (10m in length).

**7.3.11** Earthing wire, earthing clamps and earthing rods and associated material for earthing.

**7.3.12** Danger plates, phase plates, circuit plates, number plates, anti-climbing devices and other safety requirements

**7.2.13** Any other material required as per REREC requirements/specifications for the turnkey mini-Grid completeness.

**7.3.14** O&M for Satisfactory working of PDN and maintaining reliable supply of power to Consumers for 5 years from the date of commissioning of SPGP & PDN.

#### **7.4 415 Volts Lines & Service Connections to Consumers for Respective Mini Grids**

The 415V (LV) Power Distribution Network (PDN) shall include design, supply, installation and commissioning of;

**7.4.1** 415 Volts, 3 $\phi$  (Three Phase) Service Lines as per Requirements/specifications of REREC

**7.4.2** Three phase meters in accordance with KPLC standards, for every connection of household, domestic, commercial, schools, or other three-phase consumers.

**7.4.3** 4 Core Cables, 25 Sqmm Aluminium concentric, as per requirements/specifications of REREC.

**7.4.4** 415 Volts, 3 phase circuit line as per survey requirements.

**7.4.5** All Conductors and its fittings (100 Sqmm bare All Aluminium, 50 Sqmm bare All Aluminium)

**7.4.6** Relay / Fuse/ MCCB/MCB Protection

**7.4.7** Earthing and lightning protection

**7.4.8** Earthing wire, earthing clamps, earthing rods and associated material for earthing.

**7.4.9** Surge arresters, Lightning protection.

**7.4.10** Stay wires with insulators and associated material and clamps etc

**7.4.11** Concrete poles (10m in length).

**7.4.12** Danger plates, phase plates, circuit plates, number plates, anti-climbing devices and other safety requirements.

**7.4.13** Any other material required as per REREC requirements/specifications for the turnkey mini-

Grid completeness.

**7.4.14** O&M for satisfactory working of PDN and maintaining reliable supply of power to consumers for 5 years from date of commissioning of SPGP & PDN.

**7.4.15** The bill of quantities for Low Voltage (LV) overhead lines will include but not limited to the following :

- Poles or other line support structures and associated materials.
- 50mm<sup>2</sup> AA conductors (PVC insulated for phase conductors and bare for neutral conductors) and accessories. (All connections shall comprise compression joints as specified in respective terminations/connections specification).
- Protective Multiple Earthing(PME) at every 4th and terminal pole. Earth values must be  $\leq 10\Omega$ . The earthing shall be done using copper clad earth rods. (For Poles without provision of earth mechanism, it is recommended that 25mm<sup>2</sup> GSW shall be used and connected to the earth rods using bimetallic clamps).
- Stays and stay blocks.

**7.4.16** The bill of quantities for Service cable installations shall include but not limited to the following:

- Cables and accessories (including angle iron, insulator shackles, D-irons, cable termination on both sides, ready boards and single phase metallic meter boards (where necessary for customer's whose premises are not ready at the time of connection), provision for earthing materials at the customer premise).
- Pole mounted meter boxes and associated accessories (including mounting brackets).
- Prepaid meters (these shall be provided by KPLC)
- Miniature Circuit Breakers (MCBs; these shall be provided by KPLC)

**Notes:**

Earth loop impedance not exceeding  $0.001\Omega$  shall be achieved and the statutory wiring documents shall be issued by the contractor hence taking responsibility for customer premise internal wiring soundness

Prepaid meters and MCBs installation inside the pole mounted meter box, associated terminations and sealing of the meter shall be done by the contractor

**7.5 Reliable Supply of Power to Consumers (for 7 years distribution network O&M period)**

**7.5.1** Contractor's responsibility is to maintain;

- a) PDN system (11kV, 415V, 240V network) including the service connection up to 3 phase

or single-phase meters at compound of consumers and

b) Reliable Supply of Power to consumers after their getting connections during the period of distribution network O&M of 5 years from date of commissioning of SPGP & PDN.

**7.5.2** The following shall be required;

**7.5.2.1** The Mini-Grid shall serve electricity to households for 24/7 Hours basis.

**7.5.2.2** The contractor shall ensure supply to lighting loads for community facilities (health facilities, schools, administrative offices) and streetlights as per their requirement.

**7.5.2.3** Operation and Maintenance for 7 years period from the date of Commissioning of the respective Mini-Grid.

**7.5.2.4** Day to day maintenance of LV and MV line of PDN and removal of operational difficulty in supply of power to consumers and replacement of faulty material, equipment of PDN (within Maintenance charges to be paid to operator).

**7.5.2.5** Spares and consumables/replacement during 7 years of O&M period shall be to Contractor's account as per Requirements/specifications followed in KPLC to maintain 24/7 hours supply requirement of consumers. One-year spares of PDN should be readily available with Contractor. Stock position of spares / consumable spares shall be reviewed and recouped every quarterly basis so that requisite stock is always available and consumer service does not suffer.

**7.5.2.6** Connections to consumers/customers:

- a) All consumers to be connected by contractor to power
- b) All consumers/customers connected from the mini grids will be KPLC customers.
- c) KPLC will charge the consumers at the prevailing tariff for the respective category of consumers of Kenya.

## **7.6 Detailed Work of 11kV, 415 V & 240 V service lines of PDN including Service connections of Mini-Grids**

**7.6.1** Detailed survey, profiling, soil resistivity measurement, geo-technical investigation and check survey as applicable to 11kV, 415V and 240 V Distribution lines to finalize the actual line lengths.

**7.6.2** Supply of concrete poles for MV and LV lines based on detailed survey and accessories like phase plates, circuit plates, number plates, danger plates, anti-climbing devices as per REREC requirements/specifications.

**7.6.3** Supply of insulators, All aluminum and other conductors, earth wire, hardware fittings for conductor & earth wire and other line accessories.

**7.6.4** Supply of all other materials / equipment as per PDN requirements detailed above.

**7.6.5** Erection of Poles, fixing of insulator and other fittings, stringing of conductor and earth wires

along with all necessary line accessories and earthing as per REREC requirements/specifications.

**7.6.6** Testing and commissioning of erected lines.

**7.6.7** Way leaves acquisition and settlement of right of way problem with land owners while erection of distribution line network (11kV, 415V, 240V lines) along the route lengths from power plant to consumers. Payment of compensation if any will be done in consultation with the employer.

**7.6.8** Coordination with Local Authorities where necessary.

**7.6.9** Other material/items/ equipment not specified above but required to complete the work as turnkey Mini-Grid.

**7.6.10** Satisfactory working of PDN for O&M period from date of commissioning of SPGP & PDN with timely removal of faults in the system.

## **7.7 Design & Planning Requirements/specifications of REREC for Power Distribution Network Including Service Connections**

**7.7.1** Power Distribution Network (PDN) including Service Line connections shall be developed to supply electricity to consumers from SPGP. The Power Distribution Network including Service Line connections will be developed strictly as per requirements/specifications and technical standards of KPLC. Supply of materials, erection & construction of PDN shall also be as per the General Technical Standards of KPLC. For ready reference of the Bidder, the PDN design standards details provided below. The contractor shall submit the route plan and design of PDN for approval to REREC so that PDN qualifies to Grid standard of REREC. Thereafter the contractor will execute the PDN as per approved design.

**7.7.2** Distribution Standard & Guidelines Manual-Design Module

**7.7.2.1** The contractor is to design and plan the PDN based on the Grid Standards including following aspects.

- a) Safety – Basics of Electrical Safety
- b) Site Visit
- c) Conductors and Cables
- d) Under Ground System
- e) System Analysis and Technical Reports
- f) Design Calculations
- g) Line Clearances
- h) The Way leaves Process
- i) Design Formations & Fittings
- j) Secondary Sub-Station Designs

- k) Earthing
- l) Construction Units
- m) Primary Sub-Station Designs
- n) Underground Power Systems Design
- o) DCSs/SAP/FDB Systems
- p) Engineer Registration Process

**7.7.2.2 Pole mounted fuse carriers to be installed at the off-takes and tee-off in the LV network, with appropriately sized protection fuses.**

## **7.8 Detailed Equipment/ Material Technical Specifications of Power Distribution Network**

- REREC specifications are given below for various PDN items and attached in Appendix 3. All items including transformers shall conform to standard sizes as per REREC requirements/specifications.
- All items including transformers shall conform to standard sizes as per REREC requirements/specifications.
- The Specifications cover the specific requirements for design, manufacture, work testing, delivery, transport, installation, site testing of 11kV overhead distribution MV lines and low voltage lines. Design and manufacture of all the line hardware shall be in accordance with the attached specifications and drawings for the following Items:

### **7.8.1 Step up transformers (420/11000V)**

The technical Specification for step-up transformers of various sizes shall comply with KPLC standard specification document no. **KP1/6C.1/13/TSP/10/001-02** and **KP1/13D/TSP/10/001-03** (Appendix 3).

### **7.8.2 Step down transformers (11000/420V)**

The technical Specification for pole mounted three phase transformers of various sizes shall comply with KPLC standard specification document no. **KP1/6C.1/13/TSP/10/001-02** (Appendix 3)

The technical Specification for pole mounted single phase transformers of various sizes shall comply with KPLC standard specification document no. **KP1/6C.1/13/TSP/10/001-01** (Appendix 3)

### **7.8.3 Concrete poles**

The technical Specification for Concrete poles without holes & without joints shall comply with KPLC standard specification document no. **KP1/6C/4/1/TSP/03/005-1** (Appendix 3)

### **7.8.4 Aluminium Conductors Steel Reinforced (75mm<sup>2</sup>)**

The technical specification for aluminum conductors steel reinforced (Bare & PVC Covered) shall comply with KPLC standard specification document no. **KP1/6C/13/TSP/06/022-2** (Appendix 3)

#### **7.8.5 All Aluminium Conductors (100mm<sup>2</sup>)**

The technical specification for All Aluminum conductors (Bare & PVC Covered) without laser marking on center standard shall comply KPLC standard specification document no. **KPLC1/3CB/TSP/06/020-2**

#### **7.8.6 All Aluminium Conductors (50mm<sup>2</sup>)**

The technical specification for All Aluminum conductors (Bare & PVC Covered) without laser marking on center standard shall comply with KPLC standard specification document no. **KPLC1/3CB/TSP/06/020-2**

#### **7.8.7 10mm<sup>2</sup> PVC Insulated Single Phase Concentric Aluminium Service Cables (Low Voltage)**

The technical specification for PVC insulated single phase concentric aluminum cables (Low Voltage) shall comply with KPLC standard specification document no. **KP1/3CB/TSP/05/004**

#### **7.8.8 25mm<sup>2</sup> 4C Aluminum cables**

The technical specification for Aluminium 4-Core PVC Insulated, Steel Wire Armoured cables shall comply with KPLC standard specification document no. **KP1/3CB/TSP/05/001**

#### **7.8.9 Low Voltage Insulators (Shackle Insulators)**

The technical specification for LV insulators (Shackle Insulators, LV) shall comply with KPLC standard specification document no. **KPLC1/3CB/TSP/04/011**

#### **7.8.10 11kV Suspension /Tension Composite Insulators**

The technical specification for 11kV composite insulators (Suspension/Tension Insulators) shall comply with KPLC standard specification document no. **KPLC1/3CB/TSP/04/017/1**

#### **7.8.11 11kV Pin Type Composite Insulators**

The technical specification for 11kV composite insulators (Pin type) shall comply with KPLC standard specification documents no. **KP1/6C.1/13/TSP/04/017/2 and KP1/3CB/TSP/04/017-3**

#### **7.8.12 Porcelain Stay Insulators**

The technical specification for porcelain stay insulators (LV, 11kV and 33kV) shall comply with KPLC standard specification document no. **KP1/13D/4/1/04/016**

#### **7.8.13 All Aluminum Conductors (Soft Drawn)**

The technical specification for all aluminum conductors (Soft Drawn) shall comply with KPLC standard specification document no. **KP1/6C/13/TSP/06/021**

#### **7.8.14 Overhead Line Fittings (For 10 to 300 mm<sup>2</sup> conductors)**

The technical specification for overhead line fitting for 10 to 300 mm square shall comply with KPLC standard specification document no. **KPLC1/6C.1/13 /TSP/06 /036-1**

#### **7.8.15 Steel Structures for Overhead Lines**

The technical specification for steel structures for overhead lines shall comply with KPLC standard

specification document no. **KP1/6C/13/TSP/03/003**

#### **7.8.16 11kV Surge Arresters**

The technical specification for Surge arresters (for 12kV and 36kV) shall comply with KPLC standard specification document no. **KP1/6C/4/1/TSP/11/036**

#### **7.8.17 Aluminum Binding Wire**

The technical specification for aluminum binding wire shall comply with KPLC standard specification document no. **KP1/6C/4/1/TSP/06/035**

#### **7.8.18 Stay Wires & Guy Grips**

The technical specification for stay wires & guy grips shall comply with KPLC standard specification document no. **KP1/6C.1/13/12/TSP/03/021**

#### **7.8.19 Fasteners and Washers for Overhead Lines**

The technical specification for fasteners and washers (Bolts, Nuts and Washers; Screws and Rawl Bolts), to be used in overhead lines, shall comply with KPLC standard specification documents no. **KP1/6C.1/13/TSP/02/003-1, KPLC1/3CB/TSP/02/001-2 and KP1/3CB/TSP/02/003-3**

#### **7.8.20 Multipurpose Overhead Line Clamps**

The technical specification for multipurpose overhead line clamps shall comply with KPLC standard specification document no. **KP1/3CB/TSP/02/004**

#### **7.8.21 11kV Expulsion Fuse**

The technical specification for 11kV expulsion fuse cut-out (drop out type) shall comply with KPLC standard specification document no. **KP1/6C/13/TSP/11/017**

#### **7.8.22 11kV Isolator, Solid Link**

The technical specification for 11kV Isolator, Solid Link shall comply with KPLC standard specification document no. **KP1/3CB/TSP/11/015**

#### **7.8.23 Low Voltage Cartridge fuses (Fuse links)**

The technical specification for LV cartridge fuses (Fuse links) shall comply with KPLC standard specification document no. **KP1/6C.1/13/TSP/11/022**

#### **7.8.24 Low Voltage Fuse Cut-Out**

Technical specification for LV fuse cut-out shall comply with KPLC standard specification document no. no. **KP1/6C.1/13/TSP/11/023**

#### **7.8.25 Stay Rods and Turnbuckles**

The technical specification for stay rods and turnbuckles shall comply with KPLC standard specification document no. **KP1/6C.1/13/TSP/03/022**

#### **7.8.26 Ready board (For Single-Phase Service Connections)**

The technical specification for ready boards (for Single-Phase Service Connections) shall comply



with KPLC standard specification document no. **KPLC1/3CB/TSP/14/052**

#### **7.8.27 Pole Mounted Enclosure**

The technical specification for ready boards (for metering equipment) shall comply with KPLC standard specification document no. **KPLC1/3CB/TSP/14/054**

#### **7.8.28 Street lights**

The technical specification for streetlights shall comply with KPLC standard specification document no. **KP1/6C/4/1/TSP/15/002**

#### **7.8.29 Pole Signs**

The technical specification for safety pole signs and accessories shall comply with KPLC standard specification document no. **KP1/6C/4/1/TSP/02/002**

#### **7.8.30 Earth rods and their connectors**

The technical specification for Earth rods and their connectors shall comply with KPLC standard specification document no. **KP1/3CB/TSP/06/031-1**

#### **7.8.31 Copper conductors for earthing (soft drawn)**

The technical specification for Copper conductors for earthing (soft drawn) shall comply with KPLC standard specification document no. **KP1/6C.1/13/TSP/06/026**

#### **7.8.32 Terminal Lugs (Compression Lugs) and Connectors**

The technical specification for Terminal Lugs (Compression Lugs) and Connectors shall comply with KPLC standard specification document no. **KP1/13D/4/1/TSP/05/029**

#### **7.8.33 Specification for PVC Insulated Wiring and Auxilliary Cables (For 10mm<sup>2</sup> Dropper Cable, Red and Black, for Single Phase Meters)**

The technical specification for Specification for PVC Insulated Wiring and Auxilliary Cables shall comply with KPLC standard specification document no. **KP1/6C.1/13/TSP/05/016**

#### **7.8.34 Stay Blocks & Hatari Slabs**

The technical specification for Stay Blocks & Hatari Slabs shall comply with KPLC standard specification document no. **KP1/6C/13/TSP/07/001**

#### **7.8.35 Current and Potential Transformer Connected Meters**

The technical specification for Current and Potential Transformer Connected Meters shall comply with KPLC standard specification document no. **KP1/6C/4/1/TSP/14/020**

#### **7.8.36 Single-Phase Static Meters for Active Energy**

The technical specification for Single-Phase Static Meters for Active Energy shall comply with KPLC standard specification document no. **TSP 14/11**

### **7.9 Metering system**

**7.9.1** The employer will provide approved metering and MCBs for customer metering upon request

by contractor, for every connection of household/commercial/community facility consumer.

**7.9.2** Customer meters installation shall be done by contractors and shall be as per KPLC requirements/specifications including the following;

**7.9.2.1** On site, meter boxes must be sealable as per KPLC standards/specifications.

**7.9.2.2** Customers` contracting data and installation certificates to be availed to KPLC.

**7.9.2.3** After meter installations, all meters and meter boxes must be sealed with serialized twist tights which conforms with KPLC standards.

**7.9.2.4** All installed meters must be communicated to KPLC for purposes of validation with their installed locations/meter boxes coordinates.

**7.9.2.5** Meter installation technician to fill and submit Installation Inspection Report (IIR).

**7.9.3** All PTs, CTs, meters and MCBs, must meet KPLC requirements/ specifications

## **7.10 Construction of PDN**

**7.10.1** Construction of various items of PDN should be carried out as per REREC/KPLC Construction Unit Manual.

**Table 19: PDN Items**

<b>Group no</b>	<b>Name</b>	<b>Description</b>
Group 02	Cross arms, Channels and Accessories	Cross arms, channels and accessories used in LV network
Group 03	LV insulators & accessories	LV insulator accessories and assemblies
Group 04	Conductors & Cables	Conductors & Cables for the network
Group 05	Transformers & LV substation Circuits	Units for the transformer and Corresponding LV circuits for
Group 07	MV Joints terminations and Connectors	Units for MV termination, connectors & straight through joints
Group 08	Substation structures	Units for the distribution substation structures & civil works
Group 09	Fuse links	Units for LV fuse links
Group 10	Installation accessories for LV overhead lines	Units for installation accessories of bare / PVC conductor for LV lines

Group 11	LV joints, terminations and Connectors	Units for LV joints, tap & terminal connections
Group 12	LV service fuse holders	Units of LV fuse holders
Group 13	Trenches	Units for underground trenches for MV & LV cables
Group 14	Earthing installations	Units for all earthing installations used in the distribution network
Group 15	Installation accessories for 11kV overhead lines	Units for installation accessories of bare conductor lines for 11kV

## **7.11 Route for PDN**

**7.11.1** The route for PDN shall be designed by contractor (winning bidder) during survey and design stage and shall then be approved by the employer. Tentative line lengths are given in Table 2 to table 7 and price schedule for tendering purpose. The bill of material shall be as per REREC standard requirements/specifications and site conditions.

## **7.12 Variation in Line Length in Actual**

**7.12.1** The Standard one km line length cost quoted by Bidder in Schedule of Prices shall be used for finalizing the difference in cost of less or more line length actually constructed vis-à-vis indicated in Schedule of Prices. Similarly, standard 3-phase and single-phase connection cost quoted by Bidder in Schedule of prices shall be used for finalizing the cost payable to the Contractor for single-phase or three-phase connections actually made by contractor.

## **8. O&M PERIOD FOR PDN AND ASSOCIATED CONSUMER CONNECTIONS**

### **8.1 Operation and Maintenance (O&M) Period**

**8.1.1** The time period for O&M shall be 7(seven) years from the Date of Commissioning of the PDN and Associated Service Lines and Consumer Connections.

**8.1.2** The Employer entrusts the total O&M activities of the PDN to the Contractor on turnkey basis for the 7 (seven) years O&M period as per Section IV, Schedule 6.

**8.1.3** During the term of contract of O&M period, the Contractor shall ensure the satisfactory operation of and readiness of the PDN and consumers connection service lines, distribution transformers, cables and all other equipment and material of PDN and service lines.

### **8.2 Operation and Maintenance of PDN & Associated Consumer Connections as per requirements/specifications of REREC/KPLC (7 years O&M Period)**

**8.2.1** The contractor shall be responsible for all the required activities for the successful running during the 7 years O&M period, optimum energy transfers from SPGP & maintenance of the PDN covering:

- i) Developing Operations and Maintenance manuals and maintenance schedules to be approved by the employer.
- ii) Deployment of engineering and supporting personnel and regulation of their Duties.
- iii) Successful maintaining the supply to Consumers and optimum utilization of energy generated from SPG.
- iv) Operation and Maintenance including supply and installation of all necessary replacement of equipment and materials.
- v) Monitoring controlling, troubleshooting maintaining of records & registers.
- vi) Supply and installation of all necessary replacement of following to ensure reliable and efficient supply to consumers.
- vii) All types of spares, consumables, equipment viz insulators, cables and conductors, jumpers, LA, isolator, CT, PTs, connectors, fitting accessories, poles, cable joints, lugs, clamps & other equipment and material etc.
- viii) Oil of transformer & Ct etc
- ix) Fuses, Switches, MCBs, service line cables, defective meters, material related to house hold connections up to Meter Box at consumers
- x) Conducting periodical checking, testing, over hauling and preventive action.
- xi) Daily general up keeping including of Distribution, maintaining of oil of transformer and checking of Neutral Earthing connection continuity and resistance measurement etc, checking

cutting of trees to maintain proper clearance between phases and phase to earth.

- xii) Submission of periodical reports to the Employer on the operating conditions of the Distribution lines.
- xiii) Taking care of the Security aspects of the PDN and lodging of reports etc in case of Theft /Sabotage etc.
- xiv) Insurance covering all risk (Fire & allied perils, earth quake, terrorists act, floods, storms and burglary).

**8.2.2** Operation part consists of deputing requisite manpower necessary to maintain PDN and supply to consumers. Operation procedures such as to up keep the Line and connection to consumers with safety precautions, monitoring of PDN etc. shall be carried out as per the REREC/KPLC Requirements/specifications /manufacturer's instructions (for transformer and other equipment) to have trouble free operation of the complete PDN system including service lines.

**8.2.3** The operator shall also note down failures, interruption in supply and tripping of different sections, reason for such tripping, duration of such interruption etc. The operator shall record monthly energy output, down time, etc.

### **8.3 Preventive Routine Maintenance of PDN and Consumer Connections as per Requirements/specifications of REREC/KPLC (7 years O&M Period)**

**8.3.1** The contractor shall carry out the periodical maintenance of Distribution lines, Insulators, jumper connections, joints, fuses etc. as given in the KPLC Manuals/ KPLC Requirements/specifications /manufacturer's service manual and perform at least minimum requirement.

**8.3.2** Regular periodic maintenance checkups of the LA, CT, isolators, breakers, etc. shall be carried out as a part of routine preventive maintenance as per respective equipment manufacturers service manuals.

**8.3.3** In order to meet the maintenance requirements stock of consumables are to be maintained as well as various recommended spares by the manufacturer.

**8.3.4** Particular care shall be taken for outdoor equipment to prevent corrosion. Cleaning of the junction boxes, cable joints, insulators etc. wherever required, shall be carried out at every six months interval.

**8.3.5** Resistance of the earthing system as well as individual earthing is to be measured and recorded at least once in six months. If the earth resistance is more than requirements/specifications, suitable action is to be taken to bring down the same.

**8.3.6** According to the recommendations stock of special tools and tackles shall be maintained for

cables, conductors' other major electrical equipment.

**8.3.7** A maintenance record register is to be maintained by the contractor to record the regular maintenance work carried out as well as any breakdown maintenance work carried out along with the date of maintenance, reasons for the breakdowns, steps have taken to attend the breakdown, duration of the breakdown etc.

**8.3.8** The Maintenance Schedules will be drawn such that some of the jobs other than breakdown, which may require comparatively long stoppage of the PDN Network, shall be carried out preferably during the low insolation periods.

**8.3.9** The Contractor shall deploy enough manpower to carryout work

i) As per operation and maintenance manuals/KPLC requirements/specifications/manufacturer's service manual and

ii) As specified in preventive maintenance schedules to be approved by the Employer.

**8.3.10** The Contractor will attend to any breakdown jobs immediately for repair/replacement /adjustments and complete at the earliest working round the clock. During breakdowns (not attributable to normal wear and tear) at O&M period,

**8.3.11** The Contractor shall promptly report and record accidents, if any, to KPLC showing the circumstances under which it happened and the extent of damage and or injury caused as per OSHA and KPLC requirements.

**8.3.12** The Contractor shall comply with the provision of all relevant acts of Central or Concerned County /State Governments including payment of Wages Act, Minimum Wages Act, Employer's Liability Act, Workmen's Compensation Act, Industrial Dispute Act, Maturity Benefit Act, Employees State Insurance Act, Contract Labor (Regulations & Abolishment) Act, Energy Act of 2019, Grid Code, Metering Code, or any modification thereof or any other law relating whereto and rules made there under from time to time.

**8.3.13** The contractor shall at his own expense provide all amenities to his workmen as per applicable laws and rules.

**8.3.14** The Contractor shall ensure that all safety measures are taken while working on PDN Network to avoid any accident to his or his sub-contractor workmen.

**8.3.15** The Contractor is fully responsible for defects and equipment failure during the 10 years O&M period.

**8.3.16** If any jobs covered in O&M Scope are not carried out by the contractor during the O&M period, pro-rata deduction will be made based on the quantum of work from the O&M contract bills.

**8.3.17** Preventive and Routine Maintenance of all the components of the PDN of respective Mini-Grid(s) equipment shall be carried out by the Contractor as recommended by the

manufacture/supplier of the component/sub system/KPLC requirements/specifications, but at least once in every three months.

**8.3.18** Preventive Maintenance shall include checking of all electrical connections, upkeep of the lighting systems, distribution lines etc. wherever required or any other activity that may be required for proper functioning of the PDN and Associated Service Lines and Consumer Connections

**8.3.19** The contractor shall ensure that the staff specified in Volume I Section IV Clause 2.5 are available whenever required to operate and maintain each lot.

**8.4 Breakdown/Corrective Maintenance of PDN and Consumer Connections as per Requirements/specifications of KPLC/REREC**

**8.4.1** During the term of the Contract (7 years O&M Period), the Contractor shall ensure that the following requirements are met for maintaining the regular supplies to consumers:

- a) Ensure electricity supply as per KPLC Requirements/specifications.
- b) Scheduled outages to be conveyed in advance to the consumer as per KPLC requirements/standards.
- c) The following key performance indicators shall apply for both generation (SPGP) and distribution (PDN):

**Table 20: Key Performance Indicators for Both SPGP and PDN.**

	<b>O&amp;M Key Performance Indicator</b>	<b>Expected value</b>	<b>How to measure</b>
1	Minimum uptime of the SPGP (Plant Availability) throughout the quarter per site.	90%	The Plant Availability (PA) <sup>2</sup> will be calculated as a percentage to represent the time that the power plant is available to provide energy.
2	Quarterly MTTR – Mean Time to Repair power loss/breakdown of the SPGP per lot.	2 days	This will be the average time taken by the bidder to carry out repairs. <sup>1</sup>

<sup>2</sup> Source of data is logs, records and reports referred to in clause 2.3.3

3	Medium voltage breakdowns per quarter	6	This will be the number of sustained breakdowns on the medium voltage (MV) power lines per quarter
4	Low voltage incidences per quarter	20	This will be the total number of low voltage incidences per quarter

**8.4.2** Applicable penalties for failure to meet the above KPIs shall be as per O&M contract (O&M PCC, Volume 1)

### **8.5 Annual Fee for O&M of PDN and Consumer Connections**

**8.5.1** The Annual fee payable for Operation and Maintenance of PDN and all Associated Service line and Consumer connections during 7 years of O&M period shall be per respective Schedule of Prices in section IV. This includes supply and installation of all necessary replacement equipment and materials, spares & consumable spares and all services detailed foregoing clauses of ERTS. All preventive/routine maintenance and breakdown/corrective maintenance required for ensuring maximum uptime of the PDN and all associated service line and Consumer connections of Mini-Grid shall have to be performed by the Contractor without any cost liability to be incurred by the Employer except that of annual fee.

**8.5.2** Bidder is to note that the Employer will pay Annual fee only quarterly as per the respective price schedule.

### **8.6 Grievance Redress during O&M Period**

#### **8.6.1 Complaints Register**

**8.6.1.1** The Contractor shall maintain a public relations office at its Site office and easily accessible to the users/beneficiaries of the Mini-Grid(s), where it shall keep a register (the “Complaint Register”) open to public access at all times for recording of complaints by any person (the “Complainant”). Information relating to the availability of and access to the Complaint Register shall be prominently displayed by the Contractor at appropriate places so as to bring it to the attention of all users/beneficiaries of the Mini-Grid(s).

**8.6.1.2** The Complaint Register shall be securely bound, and each page thereof shall be duly numbered. It shall have appropriate columns including the complaint number, date, name and address of the Complainant, substance of the complaint and the action taken by the Contractor. Immediately after a complaint is registered, the Contractor shall give a receipt to the Complainant stating the date and complaint number.



**8.6.1.3** Without prejudice to the provisions of the foregoing clauses, the Employer may, in consultation with the Employer, specify the procedure for making complaints in electronic form and for responses there to.

## **8.7 Redress of Complaints during O&M Period**

**8.7.1** The Contractor shall inspect the Complaint Register every day and take prompt and reasonable action for Redress of each complaint. The action taken shall be briefly noted in the Complaint Register.

**8.7.2** Within 7 (seven) days of the close of each month, the Contractor shall send to the Employer a copy of each of the pages of the Complaint Register on which any entry has been recorded during the course of such month, and upon perusal thereof, the Employer may, in its discretion, advise the Contractor to take such further action as the Employer may deem appropriate for a fair and just redress of any grievance.

**8.7.3** The Contractor shall consider such advice and inform the Employer of its decision thereon, and if the Employer is of the opinion that the Complainant is entitled to further relief, it may refer the matter to the competent forum for its disposal under the Consumer Protection Act, 1986, and advise the Complainant to pursue the complaint at his own risk and cost.

## 9. PERSONNEL DURING O&M PERIOD

9.1 The Contractor shall ensure that he has adequately trained and experienced manpower for carrying out O&M of the SPGP stand-alone system.

9.2 The Contractor shall deploy the following personnel to meet all the requirements of the O&M activities of the plant in each lot. The Contractor shall ensure that such personnel are available for duty at all times during the O&M period:

**Table 21: O&M Personnel**

<b>Item No.</b>	<b>Position/ specialization</b>	<b>Relevant academic qualifications</b>	<b>Number of Personnel per Lot</b>	<b>Minimum General work experience (years)</b>	<b>Minimum Specific work experience (years)</b>
1.	O&M Project Manager	Degree in Electrical or Mechanical Engineering or Renewable Engineering	1	5	3
2.	O&M Engineer	Degree in Electrical Engineering	1	5	3
3.	Technician	Diploma in Electrical Engineering	1	5	3
4.	Artisan/ Craftsmen	Certificate in Electrical/Renewable Engineering	5	5	3
5.	Environmental , Social, Health and Safety (ESHS) Specialist	Environmental/Social/Health/Safety Degree or other relevant Degree	1	5	3

### 9.3 Non-key Staff

Cleaning Staff: - Contractor may keep Cleaning staff persons on contract to clean modules (on regular basis as needed), cleaning building, wash room and other equipment.

Security personnel – as may be required

**9.4 NOTE:**

The outlined number of staff above are the minimum required to execute the O&M contract. It is therefore upon the bidder to judge and come up with the adequate number of any additional staff that may be required for effective implementation of the O&M Contract.

**9.5** The Contractor shall ensure that the manpower for carrying out O&M of the Mini-Grids are adequately trained. The man power can also go for training along with KPLC staff at KPLC Training Centre time to time on permission from KPLC.

## **10. SAFETY AND APPLICABLE LAWS**

### **10.1 Safety of contractor staff**

**10.1.1** The safety of the Contractor's staff is the responsibility of the Contractor itself. The scope of supply includes supply of adequate and appropriate Personal Protective Equipment (PPE) and all other safety items at each site.

### **10.2 Safety in O&M period**

**10.2.1** During O&M Period the replacement of worn out or damaged PPEs shall be the responsibility of the contractor. The site engineer of the Contractor shall take adequate steps to ensure the proper use of the safety equipment by Contractor's staff at all times. The contractor shall be responsible for any accident/incidents that may occur at any site.

### **10.3 Applicable safety regulations**

All works shall be executed in accordance with the requirement of the;

- a) Occupational Safety and Health Act (OSHA)
- b) Factories Act and rules
- c) Energy Act 2019
- d) KPLC safety rules and other and other applicable acts and rules or codes.

## **11. STATUTORY ACTS**

### **11.1 Clearances**

**11.1.1** All legal formalities/clearances are to be obtained prior to commencement of work by the Contractor regarding the execution of the Mini-Grid.

### **11.2 Applicable laws**

**11.2.1** The Contractor shall comply with the all the Acts, rules and regulations, laws and by-laws framed by the County or the Government of the Republic of Kenya. The Employer shall have no liabilities in this regard.

### **11.3 Key Obligations of Contractor**

**11.3.1** The Contractor shall be responsible for implementation of the Mini-Grid and 7 year O&M throughout the Term of the Contracts, subject to the provisions of the Contract, in accordance with the following. It should be clearly understood that in the event of inconsistency between two or more of the following, the order of priority as between them shall be the order in which they are placed, with 'applicable Law' being the first:

- a) Applicable Law.
- b) The Terms and Conditions of the Contract.
- c) Technical specifications and
- d) Any Approvals and Permits.

**11.3.2** The records maintained during the O&M period shall be available from time to time to the Employer.

## **12. SUPERVISION OF CONSTRUCTION AND COMMISSIONING WORKS**

### **12.1 Completion Time**

**12.1.1** All mini-grids in Lots 1 to 6 shall be completed within Twelve (12) months from the Effective Date as described in the Contract Agreement for Supply and Installation.

No time extension will be provided.

### **12.2 Custodian of The Mini-Grid**

**12.2.1** The Contractor shall be the custodian of the Mini-Grid at all times during the term of the Contracts-S&I and O&M- (unless transferred whole or part of the Mini-Grid to the KPLC /Any agency nominated by KPLC or Government of the Republic of Kenya) and shall be responsible for any theft, loss and damage of assets, etc. related to the Mini-Grid. All the recoveries pertaining to any loss of asset due to above reasons shall be on account of Contractor only.

### **12.3 Supervision of Construction and Commissioning**

**12.3.1** Gantt chart/ Time schedule to REREC; The Contractor shall submit to REREC, a detailed time schedule in MS Project consisting of adequate number of activities covering various key phases of the SPGP such as design, installation, testing and field erection activities within one (1) month from the date of signing of the Contract for approval.

**12.3.2** The contractor to submit Plan for Sequence of construction, to follow the guideline as follows:

- Preliminary Design (Topographical Survey, Geotechnical Investigations, Approval of Statutory Documents, Civil and electrical Works Methodology, Standard Operating Procedures, Quality Management Plan)
- Design Stage (Relevant Standards and Specifications, Drawings and Designs, Revision of Drawings, Statutory Approvals/Requirement)
- Works Program, Reporting System, Security plan.
- Closure (As-built drawings)

**12.3.3** The Contractor shall implement the SPGP after Notice to Proceed (NTP) from Employer via formal project communication means. The details shall include location of the SPGP, approximate capacity, approximate circuit length of the PDN, approximate number and type of consumers, etc.

**12.3.4** The Contractor shall generate and supply electricity to consumers in the areas identified in the ICB, conforming to technical standards and all safety measures.

**12.3.5** The Contractor shall be required to submit regular monthly progress reports of the SPGP and PDN to the Employer. Inability of the Contractor to furnish such progress reports shall be treated as a breach of Contract. For the purpose of information sharing, the format of such progress report shall

be mutually agreed between the Contractor, and the Employer after the Effective Date.

**12.3.6** The Contractor shall provide advance notice of at least 15 (Fifteen) days, to the Employer, of its intent of commissioning the SPGP. The Employer shall not delay the commissioning of the SPGP and shall be required to inspect the SPGP and PDN within 15 (Fifteen) days period and advise the Contractor for any further measures to be taken prior to the commissioning of the SPGP and PDN.

**12.3.7** The Contractor shall, during the Construction & Installation period, & O&M period, ensure compliance of all statutory and mandatory requirements, including all labor law requirements and shall be responsible for observance of all applicable acts and rules. The Contractor shall keep the Employer indemnified against any liabilities that may arise on this account. The contractor shall also be required to meet the class registration requirements for Energy and Petroleum Regulatory Authority (EPRA) and National Construction Authority (NCA).

**12.3.8** The Contractor shall be required to maintain copies of all insurance covers for inspection by the Employer at any time during the Term of the Contract.

**12.3.9** The Contractor is deemed to have visited the Site and familiarized itself fully. Non-familiarity with the Site conditions will not be acceptable for any type of extra claims or for not carrying out the Construction and Installation of SPGP and PDN in strict conformity with the ERTS or for any delay in date of Commissioning.

**12.3.10** The Contractor shall, during the Construction and Installation, be guided by and fully adhere to the ERTS. Non-adherence to the ERTS may lead to forfeiture of Performance Security or delay in certification of commissioning of the SPGP and PDN of respective Mini-Grid for which the Contractor shall be solely responsible and shall have no claim towards the Employer in this regard.

**12.3.11** Failure to meet the timelines as specified above shall cause the Employer to claim liquidated damages from the Contractor.

**12.3.12** The employer shall appoint a supervision consultant to oversee the construction and commissioning works of the SPGP and PDN.

## **12.4 Additional Capacity**

**12.4.1** After meeting the minimum capacity requirement as set out in the Contract in contractor, the Employer will be free to integrate the additional generation system (number of plants, capacity of each plant) in existing system in case load demand increases in future years to come.

## **12.5 Interconnection with State Grid**

**12.5.1** Initially, the Mini-Grid shall work standalone in un-electrified areas and will not be interconnected with the Grid. However, there is a potential that a few years later whenever State/National Grid is expanded in that area then these Mini-grids shall be allowed to interconnect

with the Distribution Licensee's system following the technical and commercial standards for interconnection with the National Grid. Therefore the mini-grids need to be designed and constructed in a manner to be grid connection ready including meeting required grid codes.



## **13. QUALITY ISSUES**

### **13.1 Inspections and tests during manufacture**

**13.1.1** As far as practicable, quality of material, workmanship and performance of all items of the equipment furnished under the present Contract shall be inspected at the places of manufacture by the Contractor's QC inspectors and the inspectors representing the Employer and the Engineer before shipment.

**13.1.2** Equipment shall wherever practical be subject to tests on completion in the Manufacturer's Works to prove that the reliability, operation and performance conforming to the requirements of this Specification and the provisions of the appropriate standards.

**13.1.3** Every facility is to be provided by the Contractor to enable the Employer and the Engineer to carry out the necessary inspection of the equipment components and the costs of all tests during manufacture and preparation of test records are to be borne by the Contractor.

**13.1.4** The Contractor shall on request submit for approval procedures describing the proposed test methods to be used. Type and layout of test facility, location of instrumentation, formula for calculation of results and correction to Site conditions, etc. shall be included where appropriate.

**13.1.5** All instruments and apparatus required for the inspection or used for the performance of tests shall be calibrated to an agreed standard at a laboratory of National standing. The cost of making such calibrations shall be borne by the Contractor in all cases. Records shall be available for examinations by the Employer/Engineer or his Representative.

**13.1.6** The passing of the inspection test will not, however, prejudice the right of the Employer/Engineer to reject the equipment components if they do not comply with the Specification when erected, or given complete satisfaction in service.

**13.1.7** Where the Contractor desires to use stock material, not manufactured specifically for the work, satisfactory evidence that such material conforms to the requirements of the Contract shall be submitted. In this case tests on these materials may be waived, but certificates are to be submitted. Arrangements shall be made for expediting the shop inspection by having all shop assemblies or pieces covering a single shipment ready at one time. Any packing work as well as transport to the Site of the equipment concerned shall not be started before the approval of the Employer/Engineer has been obtained and all QC certificates due at this time for the equipment concerned have been received and reviewed by the Employer/Engineer.

**13.1.8** The Test Objects and the tests to be carried out as detailed in the attached specifications for each item.

## **13.2 Packing**

**13.2.1** The Contractor shall prepare, pack, and load all materials and equipment for shipment in such a manner that they are protected from damage during shipment and shall be responsible for and make good any and all damage resulting from improper packing until final acceptance of the Works. Items subject to open storage for several months at the sites shall be suitably protected from weather damage. All electrical parts and mechanical parts subject to damage from moisture shall be packed together with an appropriate quantity of desiccant in hermetically sealed metal containers, plastic envelopes, or other appropriate containers, with all machined surfaces heavily coated with rust preventing compound.

**13.2.2** Each case, crate, bundle, or single item shall be marked clearly with the name of the installation for which it is intended. Each container shall be clearly marked and the contents identified for proper warehousing.

**13.2.3** The Contractor shall take all necessary precautions to ensure that all materials, which may be subject to deterioration in humid tropical conditions, are packed in such a manner as to prevent such deterioration.

**13.2.4** All parts shall be carefully boxed or otherwise suitably prepared for shipment to a tropical climate. All openings shall be tightly closed before shipment. Equipment that will be vulnerable to damage due to seawater or moisture during transportation or storage at the Site shall be protected by a suitable vapour barrier and, if considered necessary by the Engineer, by an internal atmosphere of inert gas or approved desiccant.

**13.2.5** All parts exceeding 100 kg gross weight shall be prepared for shipment so that slings for handling by crane may be readily attached while the parts are on railway cars or on-board ship. The Contractor shall paint or mark the weight of all pieces in excess of 5 tonnes

**13.2.6** The Contractor shall take necessary measures to avoid ingress of moisture during transportation, storage and installation.

**13.2.7** The Contractor shall bear the risk of loss or damage to material prior to and including offloading on the dock at the port of entry.

## **13.3 Markings**

**13.3.1** The major equipment shall have the following markings embossed, indented, or otherwise indelibly marked on them in the factory:

- i. Name and registered trademark of the manufacturer
- ii. Country of Origin
- iii. Year of Manufacture

iv. The words “PROPERTY OF REREC” at least 4mm high

### **13.4 Drum Handling Instructions**

The following instructions should be followed for handling conductor drums:

- Generally, conductor ends should be available for inspection and testing.
- During unloading operation drums must not be thrown or dropped from a height, from wagons, trucks and ships. A ramp or crane may be used for unloading operation. If neither is available a temporary ramp may be arranged.
- The drums should be rolled only the way arrow mark on the drum is shown. If it is rolled the other way the cable will start unwinding and will become loose.
- The drums should be stored on a firm surface, preferably on concrete surface. Storage of drums on a soft surface may result in drums sinking, making it extremely difficult to move the drums later.
- The drums should never be stored flat i.e. the flanges being kept horizontal to the ground. The cables should also never be wound from this position. Unwinding of cable from this position may result in the cable getting twisted which is not rectifiable.

If for some reason it is necessary to rewind the cable on a different drum, the barrel of the new drum should not be less than the existing drum.

### **13.5 Packing List**

**13.5.1** The contents of each shipping package shall be itemised on a detailed list showing the exact weight, extreme outside dimensions, length, width, and height of each container. If all containers are uniform in size and weight, the dimensions and weight of only one may be shown.

**13.5.2** One copy of the detailed packing list shall be enclosed in each package delivered. There shall also be enclosed in one package a master packing list summarizing and identifying each individual package which a part of the shipment is.

**13.5.3** The box number in which the master packing list is contained should be shown on each packing list. On barrels, bags, drums, or kegs where it is not feasible to place the packing list inside the container, all pertinent information is to be stenciled on the outside and this will thus constitute a packing list.

### **13.6 Submission of Drawings**

Drawings shall be submitted to the Employers for approval one (1) months prior to the date on which they will be required at the manufacturer's works, to ensure that the work is carried out in compliance with the program of Works.

The Engineer, for approval of all design calculations and drawings, requires a minimum period of 28 days.

Before commencing the manufacture, the Contractor shall submit to the Employers, for approval, four copies of prints of drawings in sufficient detail to show:

- The general arrangement and outline of dimensions of the parts to be supplied under the Contract;
- On detail drawings, the weights of components over one tonne to be shipped separately;
- The material specifications from which the various parts are to be made and their machined surface finished;
- The welding details and machining and assembly tolerances of all assemblies;
- The manner in which such parts are designed to function;
- Diagrams, performance curves and catalogue numbers of all electrical and mechanical equipment.

The Contractor shall submit to the Engineer, for approval, all drawings and technical documents as follows:

	Prints	Electronics copy (CD)
<b>For approval</b>		
Calculations and drawings	4	1
As-built drawings	2	1
Other documents	2	1
Supervision formats	2	1
Commissioning procedures	2	1
<b>For Final issue</b>		
Calculations and drawings	3	1
As-built drawings	3	1
Other documents	3	1
Supervision formats	3	1
Commissioning procedures	3	1

### 13.7 Site Installation and Commissioning

The Contractor shall ensure that all Site installation and commissioning controls, inspections and tests, are carried out in accordance with the planned program, and that data recorded are adequate to permit the Engineer to verify that the whole of the Contract Works are in full compliance with all Contract requirements.

### **13.8. Inspection and Testing**

The Contractor shall ensure that measures are established for all material and items that will provide the ability, at any point of manufacture, to determine that the manufacturer's planned inspections and tests up to that point have been carried out.

### **13.9. Measurement and Payment**

The quantities in the Schedule of Prices are estimated quantities, and they are not to be considered as limiting or extending the amount of work to be done by the Contractor.

The measured items in the Schedule of Prices are to be accepted as the full interpretation of the requirements of the Technical Specifications and Drawings

## **14. SPGP PERFORMANCE**

### **14.1 Demonstration of Performance Guarantee of SPGP**

**14.1.1** The Contractor ensures the Performance Guarantee of the installed equipment shall meet the ratings and performance requirements stipulated for various equipment covered in the ERTS/ Contract.

**14.1.2** The contractor shall demonstrate and achieve guaranteed values during the performance guarantee test period (one year), as per details given below, at site in the presence of the Employer for the complete system.

**14.1.3** The Contractor shall supervise and direct the operation during performance guarantee test and shall take complete responsibility in this regard. During performance guarantee test, the Contractor shall make available necessary experienced operating & maintenance personnel.

**14.1.4** The Contractor shall provide and install all measuring instruments with required calibration for checking the guaranteed generation during performance guarantee test.

### **14.2 Performance Measurement Procedure for SPGP**

**14.2.1** The Performance guarantee test of SPGP aims at the comparison of the actual PV plant energy production with the guaranteed value for a limited operation time of the PV plant of 30 consecutive days.

**14.2.2** After one-year correct operation of the plant and after receiving all the satisfactory results for one year there will be continuous monitoring of the performance for 30 days. This monitoring will be performed on the site under the supervision of the Employer / Employer's engineer.

**14.2.3** The final tests to prove the guaranteed performance parameters shall be conducted at site by the Contractor in presence of the Employer or his representative. The Performance Guarantee Tests (PG tests) shall be commenced immediately after Date of commissioning of plant. These tests shall be binding on both the parties to the contract to determine compliance of the equipment with the guaranteed performance parameters.

**14.2.4** The test will consist of guaranteeing the correct operation of each plant individually over 30 days, by the way of the efficiency rate (performance ratio) based on the reading of the energy produced and measured at Solar Meter and the average incident solar radiation.

**14.2.5 The Efficiency or performance ratio (PR)** of the PV Plant is calculated as follows (according to IEC 61724)

$$\text{Performance Ratio (PR)} = Y_A/Y_R [1 - \alpha * (T_{\text{Cell avg}} - T_{\text{Cell}})]$$

Where;

Y<sub>A</sub> = Final PV system yield (representing the number of hours that the system would need to operate at its rated output power P<sub>Nom</sub> to contribute the same energy to the grid as was monitored)

Or 
$$Y_A = E_{ac}/P_{Nom}$$

Y<sub>R</sub> = Reference yield (representing the number of hours during which the solar radiation would need to be at STC irradiance levels in order to contribute the same incident energy as was monitored)

Or 
$$Y_R = I_{R Site}/I_{R STC}$$

E<sub>ac</sub> = AC energy injected into the grid during a clearly specified amount of time (kWh)

P<sub>Nom</sub> = Installed nominal peak power of modules (Flash test rating at STC) (kWp)

I<sub>R Site</sub> = Irradiation on the module plane of array during a clearly specified amount of time (measured with a pyranometer installed on the array plane) (kWh/sq. m)

I<sub>R STC</sub> = Irradiance at STC (kW/ sq. m)

T<sub>cellavg</sub> = Average cell/ module temperature (oC)

T<sub>cell</sub> = STC cell/ module temperature (oC)

α = temperature coefficient of power (negative in sign) corresponds to the installed module (%/oC)

### 14.3 Plant Performance & CUF

- i) The plant performance will be evaluated through Performance ratio test as per IEC 61724 and Capacity Utilization Factor calculation as per the formulas and procedures mentioned above.
- ii) The minimum acceptable PR of the plant is 0.78.
- iii) As the PR of the Plant is dependent on the quality of plant equipment and optimum design of the plant, the bidders shall demonstrate the PR of 0.78 as per the procedure mentioned in Clause 14.2 above for Operational Acceptance of the plant.
- iv) The acceptance of the plant will be evaluated during commissioning by measuring PR for continuous 7 days. However, contractor must demonstrate the PR for a period of 30 days as per the PR test procedure specified above.

### 14.4 Monitoring System for PR Verification

14.4.1 The following instrumentation will be used to determine the SPGP Performance. This equipment shall be provided by bidder during PR verification test

- i) Solar Meter at the delivery point of ACDB.
- ii) Power Meter for each inverter for reference only.
- iii) One nos. calibrated pyranometer to determine irradiance on the plane of array (with a target

- measurement uncertainty of  $\pm 2$ ).
- iv) One nos. calibrated Pyranometer to determine irradiance on horizontal plane (with a target measurement uncertainty of  $\pm 2$ ).
  - v) Two nos. thermocouples to measure module temperature with a measurement uncertainty of  $\pm 1$  °C.
  - vi) Shielded ventilated thermocouple with a measurement accuracy of  $\pm 1$  °C.
  - vii) An anemometer mounted on a 10m mast to measure wind speed (without additional shadowing on modules).

## **14.5 Liquidated Damages / Compensation for Low Performance Ratio**

**14.5.1** During the O&M period of 7 years after the commissioning of the plant, the bidders need to maintain minimum 90% uptime of the plant to achieve the proposed CUF at the end of each year. Any repair, replacement, overhauling of DC area of SPGP etc., are to be performed during night times as far as possible so that no generation loss will be there in daytime.

**14.5.2** Bidders are expected to make their own study of solar profile and other related parameters of the area & make sound commercial judgment about the Performance ratio. It shall be the responsibility of the Bidder to access the corresponding solar insolation values and related factors of solar plant.

**14.5.3** Remedial Measures to Demonstrate Performance Guarantee after completion of each year of O& M Period.

In case of Bidder could not demonstrate the Performance Acceptance Test, the bidder will be allowed to relocate the solar modules and install at different places in the same land at their own cost ensuring guaranteed PR of plant. The entire cost dismantling and erection etc, will be borne by the bidder. To ensure PG of plant after first year from DoC of plant and every year thereafter, the bidder will be allowed to erect additional number of solar modules without extra cost to Employer.

### **14.5.4 Liquidated Damages / Compensation for Shortfall in Performance during the Performance Acceptance of Plant**

During the Performance Acceptance of plant, any shortfall in the Performance Ratio (PR) as determined through the PR Test Procedure specified above will attract imposition of liquidated damages. For every 0.01 shortfall in PR below 0.78 by the Contractor, a penalty of 1% of the Prices of Schedules 1, 2, 3, 4 & 5 for SPGP shall be levied and deducted from 5% balance amount.



### 14.5.5 Liquidated Damages/Compensation for Shortfall in Performance during the O&M period of Plant

During the O&M Period of SPGP, any shortfall in the Performance Ratio (PR) as determined through the PR Test Procedure specified above may attract imposition of penalty. For every 0.01 shortfall in PR below 0.78 by the Contractor, a penalty of 1% of the total Annual Fees of respective year (Schedule 6) shall be levied.

### 14.5.6 Key performance indicators and penalties during O&M period

14.5.6.1 The following key performance indicators shall apply for both generation (SPGP) and distribution (PDN) O&M:

**Table 22: Key Performance Indicators Shall Apply for Both Generation (SPGP) and Distribution (PDN) O&M**

	<b>O&amp;M Key Performance Indicator</b>	<b>Expected value</b>	<b>How to measure</b>
1	Minimum uptime of the SPGP (Plant Availability) throughout the quarter per site.	90%	The Plant Availability (PA) <sup>3</sup> will be calculated as a percentage to represent the time that the power plant is available to provide energy.
2	Quarterly MTTR – Mean Time to Repair power loss/breakdown of the SPGP per lot.	2 days	This will be the average time taken by the bidder to carry out repairs. <sup>1</sup>
3	Medium voltage breakdowns per quarter	6	This will be the number of sustained breakdowns on the medium voltage (MV) power lines per quarter
4	Low voltage incidences per quarter	20	This will be the total number of low voltage incidences per quarter

14.5.6.2 Applicable penalties for failure to meet the above KPIs shall be as per O&M contract (O&M PCC, Volume 1).

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<sup>3</sup> Source of data is logs, records and reports referred to in clause 2.3.3

## **15. ENVIRONMENTAL AND SOCIAL SAFEGUARDS**

### **15.1 Adherence to ESHS Laws and ESMF**

**15.1.1** The Contractor shall be responsible for adherence to the Environmental and Social Safeguards as provisioned in Kenyan Law.

**15.1.2** In addition to providing the electricity generation, connection and supply, the Contractor shall at all times are required to adhere to the Environmental and Social Management Framework (ESMF) and Environmental and Social Management Plan (ESMP). The KOSAP ESMF is available on the REREC website ([www.rerec.co.ke](http://www.rerec.co.ke)).

### **15.2 Compliance to Environmental and Social Management Framework during Mini Grid Development**

**15.2.1** The Contractor shall ensure the following while constructing and developing the Mini-Grid.

- i) Acquisition of relevant permits from Local Authority for setting up the Mini-Grid,
- ii) Acquisition of requisite approvals from the Pollution Department/NEMA,
- iii) Acquisition of permission for Tree cutting (If applicable),
- iv) Approval for use of water requirement,
- v) Due diligence for waste management system or any pollution which may generate from the plant,
- vi) Due diligence for Ground water usage/availability of water/ Right of way/drainage,
- vii) Safe handling and management of E-waste (CFLs, LEDs, solar panels)
- viii) Compliance with Workers Right, Health and Safety requirements as per the applicable local laws and World Bank Group Environmental, Health, and Safety Guidelines(EHSG).

### **15.3 Precautions to be taken during Mini Grid Development**

The Contractor shall ensure that the following are avoided while construction, development and operations of the Mini-Grid.

#### **15.3.1 Phase I: Site Identification and Due Diligence**

The following activities shall be avoided:

- i) Clearing of natural forest or using its resources,
- ii) Any type of land acquisition resulting involuntary resettlements,
- iii) Land having physical or any other cultural significance to the local community,
- iv) Disputed land or have encroachments on them (informal settlers, non-titled entities),
- v) Lack of provision for advance notice and lack of due crop compensation for owners and

stakeholders.

- vi) Adverse impact to any indigenous people (if any) in the mini-grid area,
- vii) Non-conformity of the local laws for any change in the land use,
- viii) Lack of approvals from the Pollution Department/NEMA.

### **15.3.2 Phase II: Mini-Grid Implementation**

The contractor shall avoid the following during implementation

- i) Tree cutting without permission,
- ii) Use of Chemical Pesticides,
- iii) Non-compliance to Kenya Bureau of Standards (KEBS) requirements
- iv) Blockage of drainage and consequent flooding or erosion due to cross drainage structures such as new roads or water access,
- v) Lack of internal drainage system for the rain fall run off,
- vi) Lack of buy back arrangements during the procurement of batteries, solar panels, invertors, LEDs, cables, etc.,
- vii) Non-involvement of local labor.

### **15.3.3 Phase III: Mini-Grid Management and Operation**

During O&M period, contractor shall take the following precautions

- i) Avoid waste disposal or waste run off in the nearby fields during construction stage,
- ii) Have a water conservation plan,
- iii) Ensure arrangements for safe handling and management of e-waste (CFLs, LEDs, solar panels),
- iv) Avoid non-compliance with Workers Right, Health and Safety of the Workers and community at large.

## **15.4 Ground Water Uses /Right of Way**

15.4.1 The contractor shall be responsible for provisions for Ground water usage/availability of water/drainage and other approvals. In case of difficulty, REREC will provide recommendation letter to other Government departments on request of contractor.

15.4.2 The contractor shall be responsible for provisions Right of Way/wayleaves acquisitions and other approvals. In case of difficulty, REREC will provide recommendation letter to other Government departments on request of contractor.

## **16. ROLE OF REREC AS EMPLOYER**

**16.1** The Employer shall endeavor to provide reasonable assistance to the Contractor (Successful Bidder) in obtaining the required approvals and in addressing any key concern/issue pertaining to the involvement of any county government for timely completion of the Mini-Grid (s). Provided that, the Employer, at any time, during the term shall not be under any legal obligation to provide such assistance to the Contractor.

**16.2** REREC shall act as Employer through the phase of the contract that includes the supply, installation, and commissioning of the mini-grids i.e. the Solar Power Generation Plant with associated BESS and Diesel Generator (SPGP) and Power Distribution Network (PDN) while KPLC shall act as the employer during the phase of 7-year O&M period. KPLC as Employer will pay annual fees to the contractor for O&M works as quoted in Price Schedules for the O&M period on quarterly basis.

**16.3** Successful Bidder (Contractor) will be responsible for O&M of the

- i) Solar Power Generation Plant
- ii) Power Distribution Network
- iii) Service Connections and to maintain regular supply to consumers for 7 years of O&M contract period after commissioning of SPGP.

**16.4** The customers shall be billed on KPLC systems and payments shall be made to KPLC accounts during 7 years of O&M contract period.

**16.5** The energy supplied by SPGP shall be recorded by Joint Member Reading Team (comprised of contractor and client) every month at Metering Set located at plant termination Distribution Point and at DG metering Point.

**16.6** All customers connected from the Mini Grids will be KPLC customers. KPLC will charge a uniform tariff from these customers/consumers as per EPRA orders.

**16.7** Power Distribution Network includes the service cables and meters.

## **17. FACILITIES FOR THE EMPLOYER**

**17.1** The Contractor shall afford the Employer and his Representatives at a cost deemed to be covered by his Bid price, plant, labour, materials and apparatus as may be required in performing operations in connection with the execution, examination, inspection, and testing of the Works supply:

1. Office facilities including full services at a suitable location to be approved by the Employer. This shall be provided within the contractor's site office for the lot.
2. Transport services shall be provided on a 24 hours basis, 7 days a week including associated maintenance and repair costs for the vehicles (4X4) double cab provided.
3. Communication facilities for Site Works supervision.

**17.2** The facilities purchased shall include all local custom duties and charges. The contractor shall provide full/detailed specifications and supporting documents (catalogues, descriptions and technical documentation) with model/type and product for the evaluation of each item. If the specified type/model of items will not be available at the time of supply the contractor will supply the higher model of the concerned item in its range.

**17.3** Any equipment provided shall, unless specified to the contrary, become the property of the employer, and shall be required for use solely by the Employer and / Engineer's personnel and shall be handed over in good working order and condition upon completion of the Contract.

**17.4** The Contractor shall provide all necessary cleaning and maintenance services, including labor, and provide all the required consumable such as, but not limited to water, electricity, cleaning gear and washroom equipment etc.

### **17.5 Office facilities requirements**

The Contractor shall provide for the entire duration of the Contract for each lot, contractor's site office for the lot at a localized area as shall be approved by the Employer; fully furnished, complete with all electrical fittings, plumbing and sanitary systems, clean and provided with windows to give a sufficient supply of natural light and adequate security.

### **17.6 Transport**

The Contractor shall provide transport services for use by the employer in site supervision on a 24 hours basis, 7 days a week for the entire contract period with an experienced licensed driver who must be having a certificate of good conduct. The type of vehicle should be a 4X4 double cab suitable for off-road and site conditions.

## **18. GUARANTEED TECHNICAL PARTICULARS**

**18.1** Bidders are requested to submit for each Mini-Grid.

- i) Guaranteed Technical Particulars duly filled for equipment being offered.
- ii) The Technical Data sheets of Major equipment as listed in Bid Data sheet, Volume I.
- iii) Single line diagram of offered typical mini-grid layout including offered SPGP (generation) layout showing modules capacity, DCDB, inverters, Transformers, ACDB, BESS, DG, Metering DP outgoing line, etc.
- iv) General details of 1 km 11kV line.
- v) General details of 1 km 415 Volt line.
- vi) General details of 1 km 240 volts line.
- vii) Step up and step-down transformer details

Guaranteed Technical Particulars sheets are contained in Appendix 2.

## **19. END OF LIFE (EOL) PLAN FOR BATTERIES AND E-WASTE**

**19.1 End-of-Life (EOL)** plan for all batteries and other potentially hazardous e-waste at the end of its useful life.

**19.1.1** Bidder shall prepare and submit an EOL recycling and disposal plan for all batteries to be safely processed at a certified facility for the Lithium-Ion battery chemistry included in the proposal for each Lot. To the extent that the selected battery chemistry has some residual value as a result of the recycling process, this value can be considered as funds set aside to offset the handling and transport of materials at the end of their useful life

## **20. CODE OF CONDUCT (ESHS) AND IMPLEMENTATION STRATEGY**

**20.1** The Bidder shall submit its Code of Conduct that will apply to Contractor's and sub-contractor's Personnel (as defined in Sub-clause 1.1.2.7 of the GCC), to ensure compliance with its Environmental, Social, Health and Safety (ESHS) obligations under the contract.

**20.2** In addition, the Bidder shall detail how this Code of Conduct will be implemented. This will include: how it will be introduced into conditions of employment/engagement, what training will be provided, how the community shall be sensitized against having sexual relationships with the contractor/sub-contractor personnel, how it will be monitored and how the Contractor proposes to deal with any breaches.

**20.3** The Contractor shall be required to implement the agreed Code of Conduct.



## **21 COMMUNITY PROJECTS COMPENSATION IN KIND**

**21.1** The land acquired for the development of SPGP plant is to be compensated in kind through community projects to be implemented by the contractor.

**21.2** A provisional amount of Ksh. 1,000,000 per mini-grid site has been provided in the price schedule (Vol III) and shall be included in the bidder's price.

**21.3** The project and technical specifications for the project shall be provided by the employer.

## **22. SITE VISITS**

**22.1** The Bidders are advised to visit the sites of respective Lots before bidding to appreciate the site conditions including transportation of material/equipment. The interested Bidders should arrange the site visits of respective Mini Grids at their own as per Section II (BDS) so that they can get timely required clarifications. If any assistance is needed, then the bidder representative may contact the Employer as per clause ITB 7.4.

**22.2** The Contractor is deemed to have visited the sites and familiarized himself fully. Non-familiarity with the Site conditions will not be acceptable for any type of extra claims or for failure to carry out the Construction and Installation of mini-grids in strict conformity with the ERTS or for any delay in date of Commissioning.

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**APPENDIX 1 – LOCATIONAL DETAILS OF SITES**

**Table 23: Lot 1 (Parts of Turkana County – Turkana West & Turkana North Constituencies)**

No	COUNTY	CONSTITUENCY	PROJECT NAME	COORDINATES		APPROX AREA (HA)
				EASTINGS	NORTHINGS	
1	Turkana	Turkana North	Kaikor	768135.800	500236.430	1.30
				768248.460	500247.320	
				768266.590	500136.630	
				768153.900	500125.770	
2	Turkana	Turkana North	Kanakurdio	772761.990	42081.510*	0.60
				772847.060	420909.180	
				772920.150	420842.690	
				772835.080	420746.020	
3	Turkana	Turkana North	Kibish	813021.848	585088.861	0.90
				813081.989	585221.034	
				813160.283	585169.015	
				813093.980	585051.872	
4	Turkana	Turkana North	Kokuro	800852.340	516834.170	0.81
				800908.640	516802.950	
				800898.120	516854.040	
				800874.620	516900.870	
5	Turkana	Turkana West	Oropoi	650744.190	422093.230	0.66
				650848.690	422149.120	
				650863.250	422011.140	
				650802.810	421976.770	
				773094.040	458439.510	
				773214.610	458358.010	
6	Turkana	Turkana North	Nachukui	819378.290	450025.260	0.94
				819408.830	450112.010	
				819538.350	450069.970	
				819507.800	449983.220	

**Table 24: Lot 2 (Parts of Turkana County – Turkana Central, Turkana East, Turkana South & Loima Constituencies)**

LOT	COUNTY	CONSTITUENCY	PROJECT NAME	COORDINATES		APPROX AREA (HA)
				EASTINGS	NORTHINGS	
1	Turkana	Turkana Central	Kalokol	817466.991	390717.425	3.27
				817478.647	390791.716	
				817619.466	390748.016	
				817581.688	390674.974	
2	Turkana	Turkana South	Lochwaangiamatak	795045.590	287982.450	0.82
				795142.520	287983.540	
				795144.360	287907.200	
				795049.940	287899.490	
3	Turkana	Turkana East	Lomunyenakwan	192073.420	278376.170	0.86
				192125.040	278208.080	
				192014.240	278178.880	
				191967.470	278347.271	
4	Turkana	Loima	Lorengippi	721022.829	284847.075	0.61
				720945.109	284920.295	
				721084.809	284948.375	
				721133.199	284820.045	
5	Turkana	Turkana Central	Namukuse	825705.000	386831.000	0.87
				819408.000	386896.000	
				825887.000	386856.000	
				825869.000	386791.000	
6	Turkana	Turkana South	Naposimoru	816246.660	295542.337	0.74
				816212.900	295597.906	
				816107.711	295564.226	
				816119.811	295444.537	

**Table 25: Lot 3 (Parts of Marsabit County – Moyale and Saku Constituencies)**

No.	COUNTY	CONSTITUENCY	PROJECT NAME	COORDINATES		APPROX AREA (HA)
				EASTINGS	NORTHINGS	
1	Marsabit	Moyale	Dirdima	521546.340	370180.630	0.22
				521470.260	370297.480	
				521589.850	370283.940	
				521575.800	370168.620	
2	Marsabit	Moyale	El Bor	415236.120	385958.220	1.27
				415308.760	386011.290	
				415401.330	385883.620	
				415332.420	385831.150	
3	Marsabit	Saku	Kargi	342190.610	278027.490	1.23
				342309.590	278013.100	
				342296.110	277896.360	
				342170.460	277902.790	
4	Marsabit	Moyale	Bori	496828.000	388373.000	0.97
				496954.000	388495.000	
				497014.000	388401.000	
				496864.000	388327.000	
3	Marsabit	Moyale	Forolle	384723.000	411188.000	0.80
				384736.000	411315.000	
				384848.000	411305.000	
				384836.000	411174.000	

**Table 26: Lot 4 (Parts of Marsabit County – Laisamis and North Horr Constituencies)**

No.	COUNTY	CONSTITUENCY	PROJECT NAME	COORDINATES		APPROX AREA (HA)
				EASTINGS	NORTHINGS	
1	Marsabit	Laisamis	Gatab	269694.850	293144.790	0.71
				269639.340	293206.820	
				269582.550	293164.890	
				269608.010	293094.060	
2	Marsabit	North Horr	Bubisa	398993.000	298786.000	1.85
				399091.000	298922.000	
				399159.000	298878.000	
				399061.000	298739.000	
3	Marsabit	Moyale	El Gadhe	309624.820	367103.100	0.55
				309682.420	366992.420	
				309805.750	366974.510	
				309770.370	367082.950	
4	Marsabit	North Horr	Gas	258022.610	339229.390	0.69
				257930.340	339239.530	
				257883.550	339197.590	
				257985.770	339155.350	
5	Marsabit	Laisamis	South Horr	268832.940	233432.990	1.20
				268929.880	233527.980	
				268936.440	233440.590	
				268809.500	233374.400	

**Table 27: Lot 5 (Parts of Samburu County – Samburu West, Samburu East & Samburu North Constituencies)**

LOT	COUNTY	CONSTITUENCY	PROJECT NAME	COORDINATES		APPROX AREA (HA)
				EASTINGS	NORTHINGS	
1	Samburu	Samburu North	Latakweny	289412.000	171220.000	0.46
				289482.000	171260.000	
				289558.000	171131.000	
				289488.000	171090.000	
2	Samburu	Samburu West	Barsaloi	261391.720	148673.550	0.94
				261460.100	148748.110	
				261533.800	148680.510	
				261465.420	148605.960	
3	Samburu	Samburu North	Tuum	251188.285	237864.400	1.01
				251141.665	237945.218	
				251254.155	238010.316	
				251300.775	237929.498	
4	Samburu	Samburu East	Sereolipi	344421.030	125161.750	1.45
				344409.000	125282.000	
				344507.450	125320.810	
				344506.850	125182.730	

**Table 28: Lot 6 (Parts of Isiolo County (Isiolo North & Isiolo South Constituencies))**

No	COUNTY	CONSTITUENCY	PROJECT NAME	COORDINATES		APPROX AREA (HA)
				EASTINGS	NORTHINGS	
1	Isiolo	Isiolo North	Eras Ha Boru	482711.167	120015.181	1.14
				482829.579	120021.067	
				482831.377	119909.853	
				482715.318	119907.551	
2	Isiolo	Isiolo South	Garfasa	455040.351	103540.999	1.15
				455102.210	103622.167	
				455191.635	103549.775	
				455127.504	103469.166	
3	Isiolo	Isiolo North	Kipsing	304076.201	66978.252	0.72
				304169.550	66980.819	
				304172.068	66844.495	
				304079.305	66841.729	
4	Isiolo	Isiolo South	Bassa	496529.039	144968.415	0.96
				496637.946	144994.485	
				496658.407	144888.155	
				496544.007	144864.466	
5	Isiolo	Isiolo South	Malkadaka	477001.308	140221.165	0.67
				477103.774	140300.381	
				477169.181	140218.850	
				477065.809	140137.686	



## APPENDIX 2 - GUARANTEED TECHNICAL PARTICULARS (GTP)

(i) Bidder is to submit duly filled Guaranteed Technical Particulars (GTP) for each major equipment; duly completed and signed by the Manufacturer of the equipment and submitted together with relevant copies of the Manufacturer's Technical data sheet, catalogues, brochures, drawings, technical data & calculations, documentary evidence indicating manufacturer's supplies record, details of manufacturing capacity, the manufacturer's experience, copies of complete type test reports and accreditation certificate for the testing laboratory for tender evaluation, all in English language.

(ii) The technical specifications requirements in this document (Volume II) and in the Bidding Document Volume IV (Technical Specifications) shall guide the filling in of the GTPs.

(iii) Where there is more than one capacity/size of a major equipment (i.e. where a single unit may have multiple sizes ), a separate GTP is to be filled for each different capacity/size.

**Table 29: GTPS**

1) SOLAR PV MODULES			
No.	Description	REREC Requirement	Bidder's offer
1	PV Module manufacturer		<i>State</i>
	Origin country		<i>State</i>
2	Cell manufacturer		<i>State</i>
	Origin country		<i>State</i>
3	Module Manufacturer Tier / Ranking	Tier 1	<i>State</i>
4	Technology	Monocrystalline	<i>State</i>
5	Number of cells	Minimum 72 cells	<i>State</i>
6	Capacity of each module (Wp) (Capacity of single unit)		<i>State</i>
7	Module dimensions		<i>State</i>
8	Product warranty offered	Minimum 10 years	<i>State</i>
9	Performance warranty: Initial degradation (first year) (%)	A 25-year long-term performance warranty with a maximum linear decrease in peak	<i>State</i>

	Per year degradation (%)	power at STC of 2.5% in the first year, 0.6%/year in subsequent years. At year 25, the peak power shall be not less than 83%.	<i>State</i>
	Peak power at year 25 (%)		<i>State</i>
10	Module efficiency	Minimum 19.5%	<i>State</i>
11	Temperature coefficient of power (%/K or %/deg cell)		<i>State</i>
12	Applicable standards	As per Table 10 and clause 4.1	<i>State</i>
13	Model No. of offered product		<i>State</i>
14	Technical data sheet must be attached to bid (for the Model offered)		<i>Submit</i>
	Name of Manufacturer ..... Signature of Manufacturer .....		

<b>2) BATTERIES</b>			
<b>No.</b>	<b>Description</b>	<b>REREC requirement</b>	<b>Bidder's offer</b>
1	Product manufacturer		<i>State</i>
2	Origin country		<i>State</i>
3	Technology	Lithium ion	<i>State</i>
4	Depth of discharge (DOD) of battery	Minimum 80%	<i>State</i>
5	Nominal cell voltage (VDC)		<i>State</i>
6	Output of voltage of battery bank (system voltage)	48VDC	<i>State</i>
7	Capacity of each power pack battery (wh / Ah)		<i>State</i>
8	Operation temperature		<i>State</i>
9	Maximum charge/discharge Rate (C rating)	Must be at least C/4	<i>State</i>
10	Life time in number of cycles at the recommended DOD	Minimum 3,500 cycles	<i>State</i>
11	Calendar lifetime at recommended operating temperature		<i>State</i>
12	Product warranty in years	10 years minimum	<i>State</i>
13	Is there danger of explosive gas/fumes formation?		<i>State</i>
14	Protections provided		<i>State</i>
15	Minimum required/recommended charging time (Hrs.)		<i>State</i>
16	Minimum required/recommended discharging time (Hrs.)		<i>State</i>
17	Does the proposed design include a comprehensive Power Management System?		<i>State</i>
18	Applicable standards	As per clause 4.6	<i>State</i>
19	Model No. of offered product		<i>State</i>
20	Technical data sheet must be attached to bid (for the Model offered)		<i>Submit</i>
	Name of Manufacturer..... Signature of Manufacturer .....		

<b>3) PV INVERTERS</b>			
<b>No.</b>	<b>Description</b>	<b>REREC requirement</b>	<b>Bidder's offer</b>
1	Product manufacturer		<i>State</i>
2	Origin Country		<i>State</i>
3	MPPT Voltage range		<i>State</i>
4	No. of independent MPPT trackers		<i>State</i>
5	Capacity of Inverter (kW) (Capacity of single unit)		<i>State</i>
6	Type of inverters	String Inverters	<i>State</i>
7	Product warranty	Minimum 10 years	<i>State</i>
8	Efficiency	More than 95% at full load.	<i>State</i>
9	Total harmonic distortion	less than 3%	<i>State</i>
10	Power Factor Range		<i>State</i>
11	Protections provided	As per clause 4.5	<i>State</i>
12	Are the Inverters integrated with the power management system in the design?		<i>State</i>
13	Applicable standards	As per Table 10 and clause 4.5	<i>State</i>
14	Model No. of offered product		<i>State</i>
15	Technical data sheet must be attached to bid (for the Model offered)		<i>Submit</i>
	Name of Manufacturer..... Signature of Manufacturer .....		

<b>4) BATTERY INVERTERS</b>			
<b>No.</b>	<b>Description</b>	<b>REREC requirement</b>	<b>Bidder's offer</b>
1	Product manufacturer		<i>State</i>
2	Origin Country		<i>State</i>
3	DC input voltage	48VDC	<i>State</i>
4	Capacity of Inverter (kW) (Capacity of single unit)		<i>State</i>
5	Output waveform	Pure sinewave	<i>State</i>
6	Product warranty	Minimum 10 years	<i>State</i>
7	Efficiency	More than 95% at full load.	<i>State</i>
8	Total harmonic distortion	less than 3%	<i>State</i>
9	Power Factor Range	0.8 lagging to 0.8 leading	<i>State</i>
10	Protections provided	As per clause 4.5	<i>State</i>
11	Are the Inverters integrated with the power management system in the design?		<i>State</i>
12	Applicable standards	As per Table 10 and clause 4.7	<i>State</i>
13	Model No. of offered product		<i>State</i>
14	Technical data sheet must be attached to bid (for the Model offered )		<i>Submit</i>
	Name of Manufacturer..... Signature of Manufacturer .....		

<b>5) DIESEL GENERATOR</b>			
<b>No.</b>	<b>Description</b>	<b>REREC requirement</b>	<b>Bidder's offer</b>
1	Product manufacturer		<i>State</i>
2	Origin Country		<i>State</i>
3	Diesel Genset rated capacity (kVA)		<i>State</i>
4	Frequency (Hz)	50 Hz	<i>State</i>
5	Nominal Voltage (V)	415V	<i>State</i>
6	Rated RPM	1500	<i>State</i>
7	Oil change period (Hrs.)		<i>State</i>
8	Oil consumption (% of SEC)		<i>State</i>
9	Recommended oil grade		<i>State</i>
10	Low oil shutoff		<i>State</i>
11	Cooling System: Designed for max ambient temperature (°C)		<i>State</i>
12	Radiator system capacity		<i>State</i>
13	Fuel Type		<i>State</i>
14	Fuel consumption rate at % of nominal KWe load		<i>State</i>
	100% (L/kWinstalled)		<i>State</i>
	75% (L/kWinstalled)		<i>State</i>
	50% (L/kWinstalled)		<i>State</i>
	25% (L/kWinstalled)		<i>State</i>
15	Product Warranty (Years)	Minimum 2 years	<i>State</i>
16	Applicable standards		<i>State</i>
17	Engine Model & Type		<i>State</i>
18	Model No. of the Generator alternator		<i>State</i>
19	Technical data sheet must be attached to bid for the engine and generator alternator		<i>Submit</i>
	Name of Manufacturer..... Signature of Manufacturer .....		

	<b><u>GTPs FOR MAJOR ITEMS OF PDN:</u></b>	
	<b>6) TRANSFORMERS (STEP UP AND STEP-DOWN TRANSFORMERS)</b>	Refer to specification document KP1/13D/13/TSP/10/001-02 and KP1/13D/13/TSP/10/001-03 in Volume IV for the GTP
	<b>7) CONCRETE POLES (10M, 11M, 12M)</b>	Refer to specification document KP1/6C/4/1/TSP/03/005-1 in Volume IV for the GTP
	<b>8) CONDUCTORS (75 MM<sup>2</sup> ALUMINIUM CONDUCTOR STEEL REINFORCED (ACSR), 100 MM<sup>2</sup> BARE ALL ALUMINIUM CONDUCTOR, 50 MM<sup>2</sup> BARE ALL ALUMINIUM CONDUCTOR)</b>	Refer to specification document KP1/6C/13/TSP/06/022-2 and KPLC1/3CB/TSP/06/020-2 in Volume IV for the GTP
	<b>9) SERVICE CABLES (10 MM<sup>2</sup> SINGLE PHASE CONCENTRIC ALUMINIUM CABLES AND 25 MM<sup>2</sup> 4-CORE ALUMINIUM CABLES)</b>	Refer to specification document KP1/3CB/TSP/05/004 and KP1/3CB/TSP/05/001 in Volume IV for the GTP
	<b>10) LINE INSULATORS (11KV AND LV)</b>	Refer to specification document KPLC1/3CB/TSP/04/017/1, KPLC/3CB/TSP/04/017/2, KP1/3CB/TSP/04/017-3 and KPLC1/3CB/TSP/04/011 in Volume IV for the GTP

**APPENDIX 3 – CAPACITY FORMS TABLES**

**A - Lot 1 (Parts of Turkana County – Turkana West & Turkana North Constituencies)**

No.	Name of Mini-grid	PV Modules		Battery		PV Inverter		Battery Inverter Charger		Diesel Generator	
		REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer
		Minimum PV Capacity (kWp)	PV Capacity (KW)	Minimum Total Capacity (KWh)	Capacity (KWh)	Minimum Total Capacity requirement (KW)	Total Capacity (KW)	Minimum Total Capacity requirement (KW)	Total Capacity (KW)	Minimum Total Capacity requirement (KVA)	Total Capacity (KVA)
1	Kaikor	175		438		175		120		120	
2	Kanakurdio	75		188		75		60		60	
3	Kibish	120		300		120		82		82	
4	Kokuro	120		300		120		82		82	
5	Nachukui	120		300		120		82		82	
6	Oropoi	100		250		100		60		60	

Name of Bidder .....

Signature of Bidder .....



**B - Lot 2 (Parts of Turkana County – Turkana East, Turkana Central, Turkana South & Loima Constituencies)**

No.	Name of Mini-grid	PV Modules		Battery		PV Inverter		Battery Inverter Charger		Diesel Generator	
		REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer
		Minimum PV Capacity (kWp)	PV Capacity (KW)	Minimum Total Capacity (KWh)	Capacity (KWh)	Minimum Total Capacity requirement (KW)	Total Capacity (KW)	Minimum Total Capacity requirement (KW)	Total Capacity (KW)	Minimum Total Capacity requirement (KVA)	Total Capacity (KVA)
1	Kalokol	450		1125		450		320		320	
2	Lochwaangia matak	120		300		120		82		82	
3	Lomunyenakwan	120		300		120		82		82	
4	Lorengippi	75		188		75		60		60	
5	Namukuse	120		300		120		82		82	
6	Naposimoru	100		250		100		60		60	

Name of Bidder .....

Signature of Bidder .....

**C - Lot 3 (Parts of Marsabit County – Moyale and Saku Constituencies)**

No.	Name of Mini-grid	PV Modules		Battery		PV Inverter		Battery Inverter Charger		Diesel Generator	
		REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer
		Minimum PV Capacity (kWp)	PV Capacity (KW)	Minimum Total Capacity (KWh)	Capacity (KWh)	Minimum Total Capacity requirement (KW)	Total Capacity (KW)	Minimum Total Capacity requirement (KW)	Total Capacity (KW)	Minimum Total Capacity requirement (KVA)	Total Capacity (KVA)
1	Dirdima	30		75		30		25		25	
2	El Bor	175		438		175		130		130	
3	Kargi	160		400		160		130		130	
4	Bori	135		338		135		82		82	
5	Forolle	100		250		100		60		60	

Name of Bidder .....

Signature of Bidder .....

**D - Lot 4 (Parts of Marsabit County – North Horr and Laisamis Constituencies)**

N o .	Name of Mini-grid	PV Modules		Battery		PV Inverter		Battery Inverter Charger		Diesel Generator	
		REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer
		Minimum PV Capacity (kWp)	PV Capacity (KW)	Minimum Total Capacity (KWh)	Capacity (KWh)	Minimum Total Capacity requirement (KW)	Total Capacity (KW)	Minimum Total Capacity requirement (KW)	Total Capacity (KW)	Minimum Total Capacity requirement (KVA)	Total Capacity (KVA)
1	El Gadhe	75		188		75		50		50	
2	Bubisa	250		625		250		175		175	
3	Gatab	100		250		100		60		60	
4	Gas	100		250		100		60		60	
5	South Horr	160		400		160		130		130	

Name of Bidder .....

Signature of Bidder .....

**E - Lot 5 (Parts of Samburu County – Samburu North, Samburu East, Samburu West Constituencies)**

No.	Name of Mini-grid	PV Modules		Battery		PV Inverter		Battery Inverter Charger		Diesel Generator	
		REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer
		Minimum PV Capacity (kWp)	PV Capacity (KW)	Minimum Total Capacity (KWh)	Capacity (KWh)	Minimum Total Capacity requirement (KW)	Total Capacity (KW)	Minimum Total Capacity requirement (KW)	Total Capacity (KW)	Minimum Total Capacity requirement (KVA)	Total Capacity (KVA)
1	Latakweny	75		188		75		50		50	
2	Barsaloi	120		300		120		82		82	
3	Tuum	135		338		135		100		100	
4	Sereolipi	200		500		200		130		130	

Name of Bidder .....

Signature of Bidder .....

**F - Lot 6 (Parts of Isiolo County – Isiolo North and Isiolo South Constituencies)**

No.	Name of Mini-grid	PV Modules		Battery		PV Inverter		Battery Inverter Charger		Diesel Generator	
		REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer	REREC requirement	Bidder's offer
		Minimum PV Capacity (kWp)	PV Capacity (KW)	Minimum Total Capacity (KWh)	Capacity (KWh)	Minimum Total Capacity requirement (KW)	Total Capacity (KW)	Minimum Total Capacity requirement (KW)	Total Capacity (KW)	Minimum Total Capacity requirement (KVA)	Total Capacity (KVA)
1	Eras Ha Boru	160		400		160		100		100	
2	Garfasa	160		400		160		100		100	
3	Kipsing	100		250		100		60		60	
4	Bassa	135		338		135		82		82	
5	Malkadaka	100		250		100		60		60	

Name of Bidder .....

Signature of Bidder .....