

Appendix Document 15

Appendix Document 15.3-1 SPECIFICATIONS FOR PV SYSTEM:
GENERAL REQUIREMENTS

The land of the Republic of Botswana with a total population of about 1,600,000 consists of 408 villages of various sizes in 9 districts that lie in the south central Africa.

The electrification in Botswana is about 21% (urban area) and 3 % (rural area). The Master Plan on PV Rural Electrification (refer to the eighth National Development Plan 1997-2002:NDP8) will focus on geographical PV deployment strategy, PV technology improvement, effective institutional structure and sustainable management system for further dissemination of PV systems in order to accelerate rural electrification. The Dissemination Project for PV rural electrification will be implemented in selected village as follows.

The " the Photovoltaic Dissemination Project for Master Plan Study on Photovoltaic Rural Electrification " is to include the construction of the PV system which will consist the two (2) systems. The PV system shall be designed to be solar home system (SHS) and battery charging system (BCS).

The PV system that includes its planned sites and relevant sites are as shown on Drawing(s) SR-3-5.

GR-01 SITE CONDITION

1. General Explanation of the Site

(1) PV system for villages

As shown on Drawing SR-3-1~SR-3-8, PV systems consists of about 200 No. of Solar Home System corresponding to 50Wp, and one (1) BCS in three (3) villages.

The scope of this Tender consists of the following:

(a) Solar Home System (SHS) (Equipment, materials, spare parts/ tools for maintenance and instruments)

Motlhabaneng: 23 sets of SHS 50Wp class, 6 sets of SHS 100Wp class, 1 sets of SHS 150Wp class and 3 sets of SHS 250Wp(150Wp+100Wp) class, with pre-paid system.

Kudumatse: 39 sets of SHS 50Wp class, 7 sets of SHS 100Wp class, 1 sets of SHS 150Wp class, 1sets of SHS 200Wp(100Wp+100Wp) class 1sets of SHS 250Wp(150Wp+100Wp) class, with pre-paid system.

Lorolwana: 39 sets of SHS 50Wp class, 3 sets of SHS 100Wp class and 2 sets of SHS 150Wp class, with pre-paid system

Spare sets: 26 sets of SHS 50Wp class

Detail to be refered to “DOC. NO. : SR-3-7 of 7 Table and Drawings”

(b) Battery Charge System (BCS) (Equipment, materials, spare parts/ tools for maintenance and instruments)

The item is:

500Wp class PV Battery Charge System in Lorolwana village.

Detail to be refered to “DOC. NO. : SR-3-7 of 7 Table and Drawings”

(2) Transportation Condition

(a) Roads

The road from Gaborone to the site is in good condition without Lorolwana village.

(i) From Gaborone to Motlhabaneng

The road from Gabarone to Bobonong, extending about 490 km, is paved, with a double lanes, from Bobonong to Motlhabaneng, extending about 90 km, is unpaved, with a single lane contour and slope.

(ii) From Gaborone to Kudumatse

The road from Gaborone to Tautswe, extending about 260 km, is paved, with a double lanes, from Tautswe to Kudumatse extending about 50 km, is unpaved, with a single lane contour and slope.

(iii) From Gaborone to Lorolwana

The road from Gaborone to Kanye, extending about 100 km, is paved, with a double lanes, from Kanye to Lorolwana extending about 80 km, is unpaved, with a single lane contour and slope.

2. Definition of the Site(s)

Motlhabaneng, Kudumatse and Lorolwana village shall be designated as the Site in the Contract.

3. Design Conditions

All the Equipment shall be designed and manufactured for satisfactory operation at the followings conditions:

(1) Altitude

No more than 1,000 meters.

(2) Meteorological Conditions

(a) Temperature Maximum ; 45°C
 Minimum ; -10°C

(b) Relative humidity: 75% (Average)

(c) Wind velocity: 10 minute average; 10m/s
 (Maximum instantaneous; 25 m/s)

(d) Precipitation: Annual average; 475 mm

(3) Salt Contamination

Unless otherwise specified, under the Contract, design for salt contamination of the insulators and bushings shall be applied the following conditions:

- (a) Outdoor equipment

0.03 ng/cm²

- (4) Seismic Condition

Foundation of switching terminal equipment: 0.2G horizontal

The information stated in this clause regarding the Site Condition is to be regarded merely as guidance. Therefore, the Contractor shall confirm all information even if they are given by the Owner.

All cost and damage resulting from any conclusions drawn, or decisions made, by the Contractor will be his responsibility.

GR-02 UNITS OF MEASUREMENT

- (1) All weights, measures and dimensions shall be given in the metric system and the following symbols shall be used for units of measurement in the drawings and documents submitted by the Contractor.

Mm	:	millimeter
Cm	:	centimeter
M	:	meter
Km	:	kilometer
cm ²	:	square centimeter
cm ³	:	cubic centimeter
Kg	:	kilogram
Kgf	:	kilogram force
kgf/cm ²	:	kilogram force per square centimeter
T	:	tonne (1,000 kilogram)
sec.	:	second
m/s	:	meter per second
A	:	ampere
V	:	volt
KV	:	kilovolt
KVA	:	kilovolt-ampere
MVA	:	megavolt-ampere
KW	:	kilowatt
MW	:	megawatt
KWh	:	kilowatt-hour
MWh	:	megawatt-hour

KVAR	:	kilovar
MVAR	:	megavar
kVARh	:	kilovar-hour
MVARh	:	megavar-hour
°C	:	degree Celsius
rpm	:	revolution per minute
Hz	:	hertz

- (2) The electrical symbols, mechanical symbols and device numbers to be used in the drawings shall be accorded with the attached Drawings.

GR-03 LANGUAGE

All drawings, documents, manuals and nameplates shall be written in English.

GR-04 REQUIREMENTS FOR DRAWINGS AND DOCUMENTS

- (1) The Contractor shall furnish to the Engineer all drawings and documents which are required for completion of the Work.
- (2) The Contractor shall send all drawings and documents by registered mail or equivalent method, and shall ensure delivery by the designated dates.
- (3) In order to make the Equipment conform to the requirements and intent mentioned in the Specification, the Engineer will have the right to require the Contractor to submit the drawings or documents, and make any changes, if they are regarded as necessary.
- (4) The design drawings specified in Clause SC-06 shall include arrangement drawings, installation drawings, schematic and back wiring diagrams to demonstrate that the Equipment will conform to all requirements and intent of the Specification. These drawings shall have enough data to achieve completely the installation connection and maintenance works of the Equipment. Therefore, all dimensions, materials, and others shall be indicated in the drawings.

One (1) complete set of the Engineer's and/or the Contractor's design drawings used for the Work shall be kept by the Contractor in good condition on the Site, apart from all other prints used in actual construction. This set shall be designated "Record Prints". A current, complete and accurate record of any and all differences between the Works as actually constructed and erected, and the design indicated on the drawings shall be recorded on the

"Record Prints". At the completion of the work, the Contract shall furnish a complete set of "As Built" drawings, which have been revised to conform to the "Record Prints".

- (5) The title of each drawing, the signature of the Contractor 's responsible engineer, the date prepared and the corresponding number of the Contract Drawings shall appear in the bottom right hand corner of each drawing. The size of drawings shall be as follows:

594 mm × 840 mm

420 mm × 594 mm

297 mm × 420 mm

210 mm × 297 mm

Transparent reproducible prints shall not be folded and shall be packaged so as to preclude any damage during shipment.

In addition another set of drawings should be submitted in digital format. For electrical circuit drawings AutoCAD 14 or 2000 should be used and for maps (if any) Arc View 3.2A or 8 should be used.

- (6) The installation drawings shall contain all necessary information to enable the installation and testing works of the Equipment. They shall show the assembling and disassembling instruction, foundation shape, cabling, piping, and all other instructions for installation work.
- (7) Back wiring diagrams shall show the internal connections of the Equipment and shall indicate the wire number, terminal number, etc.
- (8) The documents shall be submitted to the Engineer in accordance with the following list.

Item	Number of copy	Remarks
Drawing lists	5	Within fifteen (15) days after the verification of the Contract
Detailed design calculation sheets	5	Immediately on completion of design
Work schedule	5	Within fifteen (15) days after the verification of the Contract
Minutes of meeting	5	Within five (5) days after each meeting
Results of Factory Test	5	Upon completion of the tests
Plans for Field Test	5	Not later than ten (10) days before the tests
Results of Field Test	5	Upon completion of the tests
Manuals and catalogues	5	Not later than thirty (30) days before the Taking-Over
Monthly reports	7	Within the first ten (10) days of the next month

Drawing list, detailed design calculation sheets, Work schedule plan for factory tests plan for field tests shall be subject to and the approval of the Engineer.

Work schedule shall show key dates for design, manufacturing, Factory Test, shipment, internal transportation, installation and erection, field tests and commissioning of the equipment.

Regular meetings shall take place between the Engineer and Contractor for the purpose of progressing work during manufacture, installation and erection of Equipment.

Plans for tests and plans for field tests shall be made in accordance with the test items indicated in the Technical Specifications and they shall clearly show the test procedure, test condition, test circuit, instruction of testing equipment, etc.

Maintenance and operation manuals shall describe in detail the construction of the Equipment, check points at inspection and operation, cleaning, lubrication and adjustment for proper maintenance and operation. All important drawings and diagrams shall be reduced to 297 mm by 420 mm in size and incorporated into the maintenance and operation manual. All subsequent additions and changes to the manual and attached drawings shall be made when they become necessary as a result of testing and initial operating experience. The manual shall be adequately bound with hard cover and identifiable by the title of the Equipment and the Owner's Contract number.

Monthly reports shall state the actual situation and next month schedule of the various parts of the Work, including a report on purchasing, manufacturing, delivering, erecting and testing of the Equipment, together with details of any actual or predicted departures from programme. Colour photographs, which indicate the progress of the Works, shall be attached to the report with appropriate cross-references.

GR-05 APPROVAL PROCEDURE OF DRAWING AND DOCUMENTS

Prior to the fabrication of the Equipment at the factory the Contractor shall submit to the Engineer the drawings and technical documents for approval.

The approval procedure of drawings only is mentioned below, but the technical documents mentioned in Clause GR-04 (8) shall in principle also be treated in accordance with the following procedure.

- (1) The Engineer will review the submitted drawings within 15 days after receipt, or within 15 days after receipt of all information needed for such review, whichever is the later.
- (2) After the Engineer has reviewed the drawings, one (1) copy will be returned to the Contractor marked "Approved", "Exceptions as Noted" or "Not Acceptable" as appropriate.

The Contractor shall make all revisions or new drawings as necessary if the returned copy is marked with "Exception as Noted" or "Not Acceptable", and he shall submit the modified/new drawings to the Engineer for approval.

The modified/new drawings shall be subjected to the same procedure as described in (1) and (2) above.

- (3) The Contractor shall prepare and submit final drawings only after each drawing previously submitted has been returned and marked "Approved"

Any drawings being resubmitted for approval, in either revised or new format, shall refer to the modification contained and the date thereof.

- (4) The approval procedure shall be carried out in accordance with the following schedule unless otherwise mentioned.

Item	Number of copy	Remarks
Drawing for approval	5	Immediately on completion of design, but not more than thirty (30) days after the verification of the Contract
Modified/new drawings for approval	5	Within fifteen (15) days after received copy marked "Exceptions as Noted" or "Not Acceptable"
Final drawings	3	Within thirty (30) days after receiving copy marked "Approved"
Final drawings (reproducible transparencies)	1	within thirty (30) days after receiving copy marked "Approved"

- (5) The Contractor may proceed with the work covered by the drawings marked "Approved" upon its return. He may also proceed with the work covered by the drawing marked "Exceptions as Noted", if he performs the work in accordance with the Engineer's notes or comments.

The Contractor shall not begin any work covered by the drawings marked "Not Acceptable", until the modified/new drawings are marked "Approved" or "Exceptions as Noted" as they are returned to him.

If the Contractor proceeds with the work without approval of the Engineer, he shall make the necessary changes at his own expense in accordance with the drawings marked "Approved".

- (6) Approval by the Engineer of the drawings shall not relieve the Contractor from his obligation to satisfy the requirements of the Specifications or to carry out the responsibility of marking corrections on his drawings.

GR-06 MATERIALS

- (1) All materials used in the construction of the Equipment shall be new and of first-class commercial quality as normally used for this type of equipment, considering strength, durability and other performance besides those purposes. Any defect and imperfection will not be acceptable.
- (2) It is feared that materials to be used for the construction work might be eroded and/or corroded due to the saline weather condition peculiar to the tropical weather in Botswana.

The Contractor shall exercise his greatest care to the selection of materials. In due condition of the above situation in order to avoid erosion and/or corrosion which might occur on these materials.

Should the selection of such materials be impossible, the Contractor shall take proper countermeasures against such erosion and/or corrosion as an alternative thereto. For this purpose, he shall paint and galvanize the materials in accordance with the provisions of Clauses "GR 9" and "GR-10".

- (3) Metal materials shall comply with the latest specification of Cord of Botswana, IEEE and IEC standards.

All screws, nuts, bolts and other threaded parts shall conform to ISO standards.

All piping materials such as pipes, flanges fittings and others shall conform to relevant standards Botswana Bureau of Standards, IEEE and IEC.

- (4) Electrical materials shall comply with the latest specification of BOTSWANA STANDARD BOS 2-1, IEEE and IEC standards.
- (5) Details of grade and standard specification of the material used shall be submitted to the Engineer for approval.

GR-07 DESIGN STRESS

- (1) Ample factors of safety shall be adopted throughout the design, and special attention shall be paid to all parts which are subject to stress or shock.
- (2) The normally allowable unit compressive and tensile stress under any operating conditions shall not exceed 50% of the yield point or 33% of the ultimate tensile strength of the material, whichever is the smaller.

Components necessarily subjected to higher stress levels shall be subject to approval by the Engineer.

GR-08 WELDING

- (1) The welding shall be done by arc welding and tested and inspected in accordance with appropriate standards to ensure that the work shall be free from pinholes, cracks and all other defects.
- (2) The Engineer shall have the right to relieve any welding operator or welder if his work appears to be questionable.

The Contractor shall submit to the Engineer for approval the welding method, such as edge shape cutting, pre-heating, welding procedure, materials of welding rods, area and methods of non destructive tests and measurement of the deformation.

- (3) The edges of the plates to be welded shall be accurately cut to size and shall have exact dimensions and shape to allow thorough fusion and complete penetration. The edges shall be properly formed to accommodate the various welding conditions and positions.

Prior to welding, all welding surfaces and adjacent areas of the materials shall be thoroughly cleaned to ensure freedom from any rust, grease and other foreign contaminants.

All welding rods used shall be of the approved type appropriate for each application.

GR-09 PAINTING

- (1) The Contractor shall carry out the painting at his factory for all the Equipment except for the Equipment mentioned in Paragraph (4), of this Clause.

The detailed color schedule for the equipment will be decided by Munsell's color notation after verification of the Contract and subject to approval by the Engineer.

Paint quality and method of application shall conform to appropriate standards and be able to withstand during long period of commercial operation without deterioration.

- (2) One (1) coat of priming paint shall be applied to the Equipment to prevent rusting. After the primer, one (1) application of under coat paint followed two (2) coats of synthetic resin finishing paint shall be applied. The under coat paint shall be selected to suit the finishing paint.

Prior to application of the paint, all surfaces of the Equipment to be painted shall be cleaned and rendered free from any grease, oil, rust, dirt and other contaminants.

Each coat of paint shall be free from runs, sags and missed areas, and shall be allowed to dry or harden thoroughly before the succeeding coat is applied. Painted surfaces shall be protected from abrasion or other damage at all times.

- (3) Cubicles, control boards, switch boxes, motors, pumps, tanks and other factory-finished standard products shall be finished with spray painting at the factory after the priming painting.

The exterior surface of cubicles, control boards and switch boxes shall be coated with non-glossy paint.

- (4) All mating surfaces of materials and components, finished by machining, and also metal surfaces to be welded on Site shall remain free of paint.

However, all finished surfaces of ferrous metals shall be coated with a rust inhibitor suitable for preserving these surfaces during transportation and temporary storage at the Site.

The Contractor shall be responsible for making good all paint work defects, before the issue of the Taking-Over Certificate.

GR-10 GALVANIZING

Unless specifically mentioned to the contrary, all iron and steel be fully galvanized after fabrication is completed.

Unless otherwise specified in the Tender documents, all galvanizing shall be done by the hot dip process, and the minimum quantity of zinc coating shall be 350 grams/m² for bolts and nuts, 550 grams/m² for other parts except wires.

Zinc coating shall be as uniform, clean smooth and free from any all spangles.

GR-11 WIRING

- (1) The Contractor shall supply all Equipment only after he has completed the back wiring of the control and power circuit, and such wiring shall be of adequate design, neat, and tested to approved standards to ensure freedom from electrical fault.

- (2) The boundary line between the back wiring and outside wiring shall be at the terminal blocks which shall be located in suitable positions inside of each control board, terminal cabinet, switch box or other specified Equipment.

Therefore, all cables for the wiring, which are to be connected to the outgoing cables, shall be routed to the terminal blocks and connected.

- (3) The field connection work shall be minimum, and all materials and parts necessary to complete the assembly shall be supplied along with the Equipment.
- (4) The Contractor shall adopt the most suitable cable and wire with due consideration for the ambient temperature, electrical and physical characteristics as detailed below.
 - (a) Conductor size shall be adequate for the load required, voltage drop, short circuit current, and diversity factor for individual circuit application.
 - (b) Unless otherwise specified, the following cable and wire shall be used.

The outgoing cable shall comprise 240 V grade polyvinyl chloride insulated and sheathed control cable with copper strands (CVV type), or equivalent. The wiring shall comprise 240 V grade polyvinyl chloride insulated wire with copper strands (IV type), or equivalent. The Conductor size shall not be less than the followings.

5.5 mm² for PV – Controller – Battery
2.5 mm² for Controller – Fixtures

The low voltage power cable shall comprise 240 V cross-linked polyethylene insulated cable (CV type), or equivalent.

- (c) Any diversion from the above specification shall only be permitted with the approval of the Engineer.

GR-16 PACKING

Unless otherwise specified under the Contract, all Equipment and materials shall be packed according to the methods described hereinafter.

All the Equipment shall be carefully packed so as to withstand long time transport. The electrical equipment shall be completely protected against rust and moisture for transport and storage in humid tropical climate.

The finishing surface of the Equipment and portions embedded in concrete shall be protected by

rust preventive means.

The packages of parts to be used for the installation shall be separated in each destination and indicated clearly on them.

The spare parts shall be packed and crated firmly to withstand storage for a long time, and those in need of rust preventive treatment shall be so treated.

The spare parts shall be packed separately from other articles. Packages of spare parts shall have notation on them which clearly indicates that the contents are spare parts and shall be accompanied by a list of contents which sets forth directions for storing.

GR-17 INLAND TRANSPORTATION

- (1) The Contractor shall arrange and carry out under his own responsibility and supervision the inland transport to the installation sites.
- (2) The Contractor shall, at his own convenience, gather all necessary information and arrange for all necessary provision in order to obtain accurate information about unloading at port and inland transport facilities as well as all prevailing local conditions, particularly the safe load bearing capacity of roads and bridges. The Contractor shall bear every and all expenses related herewith.
- (3) The Contractor shall use every reasonable means and care to prevent any of the roads or bridges on the route to the Site from being damaged or injured by any traffic of the Contractor and in particular shall select, choose and use vehicles and restrict and distribute loads so that any such extraordinary traffic that will inevitably arise from the moving of Contractor's equipment and material from and to the Site shall be limited as far as reasonably possible and so that no damage or injury may be occasioned to such roads and bridges.
- (4) If during the carrying out of the work or at any time thereafter, the Contractor should receive any claim arising out of the execution of the works in respect of damage or injury to roads, bridges, jetties, and sea structure, he shall immediately report the same to the Engineer and thereafter he shall negotiate the settlement of any payment of all sums due in respect of such claim and in respect of all claims, demands, proceedings, damages, costs, charges and expenses in relation thereto.

GR-18 TESTS

The tests shall include, but not limited to, following tests.

(1) Factory Test

Unless otherwise approved, the factory tests shall be conducted in the presence of the Engineer.

(2) Field Test

(a) After completion of individual adjustment and tests of each equipment during installation and upon all the Equipment being ready for operation, the Contractor shall carry out the field tests of the items to be required in the Specifications in the presence of the Owner and the Engineer.

(b) In the event the tests do not satisfy the requirements of the Specifications or any defects attributable to the Contractor are found in the test, the Contractor shall promptly repair, replace, adjust or make good, and retest the Equipment at his own expenses to an extent satisfactory to the Engineer by the date designated by the Engineer.

(3) Through the field tests, the Contractor shall train the operation and maintenance personnel who are designated by the EAD and/or Engineer at Site.

GR-19 OTHER GENERAL REQUIREMENTS

(1) All Equipment shall be new and durable to withstand long-term usage, and shall meet the requirements for which it has been designed.

(2) The design of all Equipment shall facilitate ease erection, disassembling, inspection and maintenance work.

(3) Conductors shall not be joined by soldering except for inevitable positions. If there are some inevitable positions, they shall be indicated on the drawings for approval.

(4) Parts of Equipment which require inspection and/or replacement shall be fastened with bolts and nuts instead of built-in bolts.

PART-1 PHOTOVOLTAIC SYSTEM

SR-M-01 MATERIALS FOR INSTALLATION

1. General

- (1) This specification shall cover major materials which will be used for the construction work of the Photovoltaic system. The price shall include any and all costs to be incurred in the performance of a series of work from the arrangement of materials to the delivery to respective work places of such materials after unloading thereof at the Contractor's temporary storage-yard(s).
- (2) The contractor shall prepare a list of major materials, which gives the technical features and drawings of configurations and sizes of the said major materials. The contractor shall submit to the Engineer for approval three (3) copies of such list within thirty (30) days after the verification of the Contract. The Contractor shall not use any of the major materials without obtaining such approval from the Engineer.
- (3) The Contractor shall confirm factory tests of the major materials thereby preparing lists of the records of such tests. These lists shall be attached to the documents and drawings will be submitted to the Engineer during the preparatory work for the respective construction work, using the said major materials.

The Photovoltaic (PV) system shall comply with the requirements of "Botswana Standards BOS 2-1:1999" and following standards of the latest edition.

IEC 60891	Procedures for temperature and irradiance corrections to measured I-V characteristics of crystalline silicon photovoltaic devices
IEC 60904-1	Photovoltaic devices. Part 1: Measurement of photovoltaic current-voltage characteristics,
IEC 60904-2	Photovoltaic devices. Part 2: Requirements for reference solar cells
IEC 60904-3 (1989)	Photovoltaic devices, Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data
IEC 60904-5	Photovoltaic devices - Part 5: Determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open-circuit voltage method
IEC 60904-6	Photovoltaic devices - Part 6: Requirements for reference solar modules
IEC 60904-7	Photovoltaic devices - Part 7: Computation of spectral mismatch error introduced in the testing of a photovoltaic device
IEC 60904-8	Photovoltaic devices - Part 8: Measurement of spectral response of

	a photovoltaic (PV) device
IEC 60904-9	Photovoltaic devices - Part 9: Solar simulator performance requirements
IEC 60904-10	Photovoltaic devices - Part 10: Methods of linearity measurement of the latest edition.
IEC 61173	Overvoltage protection for photovoltaic (PV) power generating systems Guide
IEC 61194	Characteristic parameters of stand-alone photovoltaic (PV) systems
IEC 61215 (1993)	Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval
IEC 61277	Terrestrial photovoltaic (PV) power generating systems - General and guide
IEC 61683	Photovoltaic systems - Power conditioners - Procedure for measuring efficiency
IEC 61701	Salt mist corrosion testing of photovoltaic (PV) modules
IEC 61702	Rating of direct-coupled photovoltaic (PV) pumping system
IEC 61721	Susceptibility of a photovoltaic (PV) module to accidental impact damage (resistance to impact test)
IEC 61724	Photovoltaic system performance monitoring - Guidelines for measurement, data exchange and analysis
IEC 61725	Analytical expression for daily solar profiles
IEC 61727	Photovoltaic (PV) systems - Characteristics of the utility interface
IEC 61829	Crystalline silicon photovoltaic (PV) array - On-site measurement of I-V characteristics
IEC 61836	Solar photovoltaic energy systems - Terms and symbols
IEC 62111	Specifications for the use of renewable energies in rural decentralized electrification
IEEE 1262	Recommended Practice for Qualification of Photovoltaic (PV) Modules

2. Solar Home System (S.H.S)

The system configuration shall refer to attachment [Doc No. SR-3-1 & -2].

(1) Photovoltaic module

The specification shall cover the technical requirements of the Photovoltaic module for the solar home system (SHS). The PV module shall be adapted the following specification with condition of solar irradiation of 1kW/m^2 at spectral distribution of AM 1.5 and cell temperature of 55 degree Celsius or higher.

(a) Properties

- (i). Min. out put (rated) power; more than 50 (W)
- (ii). Voltage (typical at load); more than 16 (V) Direct Current (DC)

(iii). Open-circuit voltage;	more than 21(V)
(iv). Short-circuit current;	more than 3 (A)
(v). Output warranty	90% of minimum rated power for ten years
(vi). Type of module	Crystalline or Semi-Crystalline silicone type

(b) Tests

The following tests shall be carried by the Contractor at Contractor's temporarily-Storage Site before installation in accordance with IEC61215.

(i) Appearance inspection:

The photovoltaic module shall be free from any harmful flaws and cracks the surface thereof shall be smooth.

(ii) Dimensions inspection:

The dimension of the photovoltaic module shall be as approved documents.

(iii) Electrical Inspection:

- ✓ Power voltage test; the voltage of the photovoltaic module shall be as "SR-M-01, 2. (1), (a), (iii) Open-circuit voltage".
- ✓ Performance Test; In accordance with IEC61215.(Manufacture shop test report may be applicable instead of site testing.)
- ✓ Insulation Test shall be done at site.

(iv) Hail Test:

The ability of the module to with stand hail shall be determined in accordance with IEC 61215.

(c) Packing

The photovoltaic module shall be packed in rigid crates or boxes that shall withstand, without damage, rough handling during transport.

(d) Marking

Each photovoltaic module shall be marked with the following indications in a legible and indelible manner. (The panel specification shall comply with the mounting on the panel. Certifications of specification shall also be supplied.)

- (i) Name or trademark (its abbreviation, if available) of manufacture
- (ii) Month and year of manufacture
- (iii)Place (Country) of manufacture
- (iv)Serial number of manufacture

(2) Controller (Solar charge controller)

The specification shall cover the technical requirements of the Controller for the Photovoltaic solar home system (SHS). The controller shall be solid-state type.

Detail specification of the controller shall be complied with PV module and Battery specification that is selected by the contractor.

The 5 (five) Mark-7 controllers made by BoTeC shall be included in a part of total controller number.

(a) Properties

- | | |
|-----------------------------------|---|
| (i) System voltage; | 12 (V) Direct Current (DC) |
| (ii) Maximum module current; | more than 6 (A) for 50W S.H.S. |
| (In put current from PV module) | more than 10 (A) for 100W S.H.S. |
| | more than 20 (A) for 150W or above S.H.S. |
| (iii)Maximum load current; | more than 6 (A) for 50W S.H.S. |
| (Out put current from controller) | more than 10 (A) for 100W S.H.S. |
| | more than 20 (A) for 150W or above S.H.S. |

Notes on (ii) and (iii): If the controller can be used by parallel connection to adapt to size of PV module, the contractor may offer the controller system, which is specified as for 50W S.H.S with technical specification that indicate the system combination.

- | | |
|---|--|
| (iv) Self consumption | Less than 25mA |
| (v) Outdoor exposure; | Outdoor exposure shall be required according to IEC 61215. |
| (vi) Required functions and features | |
| ✓ Auto load disconnection function at low voltage (adjustable) and auto re-connection function at set voltage (adjustable). | |
| ✓ Auto input (PV module) disconnection functions at battery over charging (adjustable) and auto re-connection function at set voltage (adjustable).
The over charging disconnection point shall be maintained within 1% over an ambient temperature range of 10 degree Celsius to 30 degree Celsius. | |
| ✓ The High Voltage Disconnection point (HVD) shall be provided and set in accordance with specification of PV module manufacture. | |
| ✓ The PV module connection circuit in controller shall have withstanding voltage of twice the nominal system voltage for a period of 5 minutes without any damage to controller. | |
| ✓ Temperature compensation function | |
| ✓ Prevents reverse current function | |
| ✓ Prevents reverse polarity function | |
| ✓ Constant voltage algorithm and low loss power consumption in system | |
| ✓ 25% Current overload: 5 min. | |
| ✓ Lightning protection. | |

The contractor shall recommend the setting value on mentioned above adjustable functions.

(vii) LED indication; LED for status information, battery charge level information & malfunction of controller.

(viii) PVC plate, which instruction manual and notes to consumer is indicated, shall be attached near the controller. Engineer will inform the detail contents of indication in plate.

(b) Tests

The following tests shall be carried by the Contractor at Contractor's temporarily-Storage in the Site before installation.

(i) Appearance inspection:

The Controller (Solar charge controller) shall be free from any harmful flows and cracks the surface thereof shall be smooth.

(ii) Electrical Inspection:

- ✓ Electrical operation test: After installation the controller, the display of the controller shall be working and indicating a charging condition of battery or batteries accurately. The contractor shall measure the controller voltage of all inputs and outputs. The result shall be submitted as a part of site test result.
- ✓ Performance Test; In accordance with IEC. (Manufacture shop test report may be applicable instead of site testing.)
- ✓ Insulation resistance test shall be done at site.

(c) Packing

The Controller (Solar charge controller) shall be packed in suitable crates or boxes that can withstand, without damage, rough handling during transport.

(d) Marking

Each controller shall be marked with the vendor standard indication and following indications in a legible and indelible manner. (Performance certifications of manufacture shall be submitted.)

- (i) Name or trademark (its abbreviation, if available) of manufacture
- (ii) Month and year of manufacture
- (iii) Place (Country) of manufacture
- (iv) Serial number of manufacture

(3) Battery

The specification shall cover the technical requirements of the battery for the Photovoltaic solar home system (SHS). The conventional starter battery shall not be acceptable for SHS.

(a) Properties

- (i). Normal Voltage; 12(V) DC

- (ii). Rated Capacity; more than 102Ah
- (iii). Battery Type; Deep Cycle
- (iv). Electrolyte type; Sulfuric acid-water
- (v). Seal type; Heat seal
- (vi). Maximum allowable depth of discharge; more than 50% (In case of within this discharge depth value, the standard life time shall be guaranteed.)
- (vii). Expected daily discharge depth (at normal condition /design base); more than 15%
- (viii). Life time (Cycle of discharge); more than 1200 cycle (at 15% discharge depth)
- (ix). Self discharge/month at 25 (degree Celsius); less than 4%
- (x). Floated voltage; 14.1 to 14.6 (V)
- (xi). Battery charge state indication; Visual indication shall be provided to show the battery state charge. Minimum acceptable shall be visual indication of batter High, Normal and Low. Battery Low indication shall operate at least 2.5% above disconnection point.

(b) Tests

The following tests shall be carried by the Contractor at Contractor's temporarily-Storage in the Site before installation.

- (i) Appearance inspection:
The battery shall be free from any harmful flows and cracks the surface thereof shall be smooth. No leakage of electrolyte.
- (ii) Electrical Inspection:
Power voltage test, the voltage of the battery shall be as "SR-M-01, 2. (3), (a), (i) Normal Voltage" or more than 12(V).

(c) Packing

The battery shall be packed in suitable crates or boxes that can withstand, without damage, rough handling during transport.

(d) Marking

Each battery shall be marked with the vendor standard indication and following indications in a legible and indelible manner. (Performance certifications of manufacture shall be submitted.)

- (i) Name or trademark (its abbreviation, if available) of manufacture

- (ii) Month and year of manufacture with latest full charging date
- (iii) Place (Country) of manufacture
- (iv) Serial number of manufacture
- (v) Basic specification (Ah, Voltage, Type, Cycle duty, etc.)

(4) Breaker and Fuse for battery and Breaker for PV system

The system shall be protected against damage due to accidental short circuit by use of fuses or circuit breakers. Consumer circuits shall have circuit breakers. Individual circuit from the battery shall have a maximum rated capacity of 25 Amperes where not otherwise specified. Each circuit shall be so designed that the peak demand does not exceed 80% of the rated capacity of the fuse or circuit breaker, and the rating is not more than 150% of the maximum rated load current.

(a) Properties

(i) Magnetic circuit breaker and Fuse; for 12VDC circuit protection

The contractor shall select suitable rated current in accordance with PV system and battery capacity.

Fuse shall be provided at all battery circuits to protect the battery from short circuit accident.

(b) Tests

The following tests shall be carried by the Contractor at Contractor's temporarily-Storage in the Site before installation.

(i) Appearance inspection:

The breaker and fuse for PV system shall be free from any harmful flaws and cracks the surface thereof shall be smooth.

(ii) Electrical Inspection:

Measurement of insulation resistance between each poles and earth. Measurement of contact resistance between primary and secondary terminal. The resistance of the breaker shall be measured before installation at the Site.

(c) Packing

The breaker for battery shall be packed in suitable crates or boxes that can withstand, without damage, rough handling during transport.

(d) Marking

Each breaker for battery shall be marked with the vendor standard indication and following indications in a legible and indelible manner.

(i) Name or trademark (its abbreviation, if available) of manufacture

- (ii) Place (Country) of manufacture
- (iii) Serial number of manufacture

(5) Switch

(a) Properties

Manual type “on-off” switch; For DC circuit or 250VAC standard type (min. rating 5A)
The contractor shall select suitable rated current in accordance with load capacity. The switches must be rated at twice (2 times) of their carrying current.

(b) Tests

The following tests shall be carried by the Contractor at Contractor’s temporarily-Storage in the Site before installation.

(i) Appearance inspection:

The switches shall be free from any harmful flaws and cracks the surface thereof shall be smooth.

(ii) Electrical Inspection:

Measurement of insulation resistance between energized parts and earth. Measurement of resistance between primary and secondary terminal. The inspection shall be executed before installation at the Site.

(c) Packing

The switch shall be packed in suitable crates or boxes that can withstand, without damage, rough handling during transport.

(d) Marking

Each switch shall be marked with the vendor standard indication and following indications in a legible and indelible manner.

- (i) Name or trademark (its abbreviation, if available) of manufacture
- (ii) Place (Country) of manufacture
- (iii) Serial number of manufacture

(6) Socket outlet and Plug

(a) Properties

The socket outlets shall be used that is designed for special 12VDC-2 pin plugs. It shall not be possible to reverse the polarity.

(b) Tests

The following tests shall be carried by the Contractor at Contractor’s temporarily-Storage in the Site before installation.

(i) Appearance inspection:

The breaker for battery shall be free from any harmful flows and cracks the surface thereof shall be smooth.

(c) Packing

The switch shall be packed in suitable crates or boxes that can withstand, without damage, rough handling during transport.

(d) Marking

Each switch shall be marked with the vendor standard indication and following indications in a legible and indelible manner.

- (i) Name or trademark (its abbreviation, if available) of manufacture
- (ii) Place (Country) of manufacture

(7) Pole with anchor and Support structure set for the module or panels(s) and Panel frame set (With Bolts/Screw, Washer and Nuts, U type banding set)

The support structure for panels shall be made of permanent materials, to be strong enough to withstand all climatic conditions (wind, heat, water) without deflection or vibrations and to be securely braced and fixed to the roof or the wall of building or the ground

(a) Properties

- (i) Pole and anchor; Steel Structure with painting as required in “GR-9 PAINTING” or equivalent material with rust prevention manner.
- (ii) Support structure and frame set; Steel with painting as required in “GR-9 PAINTING”, stainless steel, high strength aluminum alloy or non-corroding material for General Structure.
- (iii) Min. Dimension of Pole; more than 85 (mm) out of diameter x more than 3,000 (mm) length, more than 3 (mm) thickness

(b) Tests

The following tests shall be carried by the Contractor at Contractor’s temporarily-Storage in the Site before installation.

- (i) Appearance inspection:
The material shall be free from any harmful flows and cracks the surface thereof shall be smooth. Checking of any corrosion.
- (ii) Total assembling test:
The total assembling test(s) shall be conducted by the Contractor in order to confirm whether the Support structure set for the module or panels(s) can fulfil their complete functions in satisfactory combination with each other. Details of manner(s) and condition(s) of such tests shall be notified by the Engineer.

(8) Battery box

- (i). The Contractor shall furnish a compact case or box, which install the battery, controller, fuse switch, plug, breaker and other (pre-paid system equipment etc.).
- (ii). The box shall be made of any other non-metallic resistant to acid and shall be lockable with padlock and thermally insulated and made by non-corrosive material such as hard PVC case.

(9) Cable and wiring equipment

(a) Structure

The cable and wiring equipment shall withstand long time use in outdoors without deterioration of its mechanical and electrical properties. Minimum core size shall be 2.5 mm².

(b) Requirements

(i) Cable (PV to Controller);

Over head wiring

Type: PVC/PVC 300V or above

Under ground wiring

Type: PVC/SWA/PVC 300V or above

The core size shall be so designed by contractor that Max. Voltage drop between PV module and controller is less than 1.0V at rated PV module output.

(ii) Cable (Controller to Battery, battery box inside cabling);

Type: Flexible PVC 300V or above

The core size shall be so designed by contractor that Max. Voltage drop between controller and battery is less than 0.3V at rated battery charging current.

(iii) Cable (Controller to load such as switch/plug and lighting);

Type: Flexible PVC/PVC 300V or above.

The core size shall be so designed by contractor that Max. Voltage drop between controller and load is less than 1.0V at rated load current.

(c) Tests

The following tests shall be carried by the Contractor at Contractor's temporarily-Storage before installation.

(i) Electrical Inspection:

Measurement of insulation resistance, the insulation resistance of the cable shall be measured before installation at the site.

(d) Marking

Each cable shall be marked with the vendor standard indication and following indications in a legible and indelible manner.

(i) Name or trademark (its abbreviation, if available) of manufacture

- (ii) Place (Country) of manufacture,
- (iii) Month and year of manufacture

(10) Lighting (lamp) set

(a) Structure

The Lighting set shall withstand long time use in indoors without deterioration of its mechanical and electrical properties.

(b) Requirements

- (i) Compact Fluorescent Lamp 9W; Type: DC 12 (V) high efficiency type
The lighting fixture shall be with lamp guard cover that can be easily removed for cleaning and lamp changing. The system of ballast and inverter of fixture shall be designed with consideration of lamp lifetime as much as longer (more than 6 months).

(c) Tests

The following tests shall be carried by the Contractor at Contractor's temporarily-Storage before installation.

- (i) Electrical Inspection:
Measurement of resistance, the resistance of the lighting fixture shall be measuring before installation at the Site.

(d) Marking

Each cable shall be marked with the vendor standard indication and following indications in a legible and indelible manner.

- (i) Name or trademark (its abbreviation, if available) of manufacture
- (ii) Place (Country) of manufacture,
- (iii) Month and year of manufacture
- (iv) Serial number of manufacture

(11) Pre-paid system equipment and software

Pre-paid system for PV equipment shall mounted on SHS systems with software(s) furnished by the Contractor for Matlhabeneng, Kudumatse and Lorolwana. If any computer systems are required to operate and manage this system, contractor shall also provide those computer systems for each village.

(a) Properties

- (i) System voltage; 12 VDC
- (ii) Required functions and features
 - ✓ 30days pre-paid
 - ✓ Operated by magnetic card or token (for 30days)

As charge from user will a according to size of PV system (50, 100, 150W, etc) hence pre-paid equipment system should have variable cost mechanism i.e. to be programmed according to size of PV system.

If contractor has any recommendation and offer on this pre-paid system, contractor may offer it as alternative plan.

(iii) LED or LC-Display; On-off condition, credit remaining amount/days, malfunction alarm

Note: Vendor standard indication function may be applicable with owner approval, contractor shall clearly indicate the standard display and/or LED indication specification in tender documents.

(b) Tests

The following tests shall be carried by the Contractor at Contractor's temporarily-Storage in the Site before installation.

(i) Appearance inspection:

The pre-paid system controller shall be free from any harmful flows and cracks the surface thereof shall be smooth.

(ii) Electrical Inspection:

Electrical operation test, after installed the system, The system shall be working and indicating the operation condition as specified LC-display and/or LED.

(c) Packing

The pre-paid system shall be packed in suitable crates or boxes that can withstand, without damage, rough handling during transport.

(d) Marking

Each pre-paid system shall be marked with the vendor standard indication and following indications in a legible and indelible manner.

(i) Name or trademark (its abbreviation, if available) of manufacture

(ii) Month and year of manufacture

(iii) Place (Country) of manufacture

(iv) Serial number of manufacture

(12) Inverter (for 150Wp and above SHS)

Inverter system shall be provided for 150Wp and above SHS. The system shall be solid-state type.

(a) Properties

- | | |
|---------------------|---|
| (i) System voltage; | In put 12 VDC
Output 230VAC $\pm 5\%$ (50Hz $\pm 2.5\%$, Sine or Quasi- sine wave, 1-phase) |
| (ii) Rated out put; | 150VA for 150W S.H.S. |

200VA for 200W S.H.S.

250VA for 250W S.H.S.

(iii) Required functions and features

- ✓ Auto load disconnection function at 125% over loads (adjustable) and manual re-connection function.
- ✓ Prevents reserve current function
- ✓ Constant voltage algorithm and low loss power consumption in system
- ✓ Short circuit protection
- ✓ Operation Efficiency (at rated loads) more than 85%

The contractor shall recommend the setting value on mentioned above adjustable functions.

(iv) LED and LC-Display; LC display for tension and currents (output), LED for status information, input voltage level information & malfunction of system.

Note: Vendor standard indication function may be applicable with owner approval, contractor shall clearly indicate the standard display and LED indication specification in bidder documents.

(b) Tests

The following tests shall be carried by the Contractor at Contractor's temporarily-Storage in the Site before installation.

(i) Appearance inspection:

The inverter system shall be free from any harmful flows and cracks the surface thereof shall be smooth.

(ii) Electrical Inspection:

- ✓ Electrical operation test, after installed the inverter, The display of the inverter shall be working and indicating tension and currents (output) by LC-display and status information and input voltage level information by LED etc.
- ✓ Output voltage and frequency measurement at no-load and loads condition.
- ✓ Performance test; Voltage regulation test, Efficiency test, Output voltage wave form test, Output frequency test, Electromagnetic interference test and Full load test shall be performed by contractor. (Manufacture shop test report may be applicable instead of site testing.)

(c) Packing

The inverter shall be packed in suitable crates or boxes that can withstand, without damage, rough handling during transport.

(d) Marking

Each inverter shall be marked with the vendor standard indication and following

indications in a legible and indelible manner.

- (i) Name or trademark (its abbreviation, if available) of manufacture
- (ii) Month and year of manufacture
- (iii) Place (Country) of manufacture
- (iv) Serial number of manufacture

(13) 220VAC Circuit equipment (Cable, Socket outlet and Lighting)

220VAC circuit connected secondary side of inverter system shall be provided in accordance with IEE requirements and following specification.

(a) Socket outlet and Plug

The socket outlets shall be used standard 220VAC types. A label on each socket shall be added to show the maximum power available from that socket. The earth leakage breaker shall be provided for socket circuit or as main circuit breaker of inverter main output.

(b) Cable and wiring equipment

The cable and wiring equipment shall conform to IEE regulations and shall withstand long time use in outdoors without deterioration of its mechanical and electrical properties. Safety earthing system shall be provided in accordance with IEE regulations.

(i) Cable requirements: min. core size 2.5mm²

Cable (Inverter to load such as switch/plug and lighting);

Type: Surfex PVC/PVC 600V or above.

The core size shall be so designed by contractor that Max. Voltage drop between controller and load is less than 5.0V at rated load current.

(c) Lighting (lamp) set

The Lighting set shall withstand long time use in indoors without deterioration of its mechanical and electrical properties.

(i) Requirements

Compact Fluorescent Lamp 11W; Type: 220VAC high efficiency type

The lighting fixture shall be with lamp guard cover that can be easily removed for cleaning and lamp changing. The system of ballast and inverter of fixture shall be designed with consideration of lamp lifetime as much as longer (more than 6 months).

(d) Tests, packing and markings

The requirements of tests, packing and markings shall be as "SR-M-01 (3),(6) and (9)".

(14) Lightning protection system shall be provided in accordance with requirements in the "Botswana Standard BOS 2-12:1999". The equipment provision and construction works shall also be contractor's scope.

3. Battery Charging System

The system configuration shall be referred to attached drawings. The system shall be applied for Lorolwana only.

(1) Photovoltaic panel

The specification shall cover the technical requirements of the Photovoltaic panel for the Battery Charging System (BCS). The PV module shall be adapted the following specification with condition of solar irradiation of 1kW/m^2 at spectral distribution of AM 1.5 and cell temperature of 55 degree Celsius or higher.

(a) Properties

- (i). Minimum out put power; 500 (W) (50Wp×10)
- (ii). Number of module; 10 nos. and 10nos. as spare (Total 20nos.)
- (iii). The other technical requirements of PV module shall refer to “2. Solar Home System (1) Photovoltaic module”.
- (iv). Type of module Crystalline or Semi-Crystalline silicone type (10nos.)
Amorphous-Si type (10 nos.)

Amorphous-Si type shall be applicable for BCS only. The contractor shall strictly follow the below specification. If vendor cannot offer the Amorphous-Si type module, which is meet to the specification, the Crystalline or Semi-Crystalline silicone type may be applicable instead of Amorphous-Si type.

- Dimension: Less than $1000\text{mm} \times 1000\text{mm}$
- Thickness: Less than 40mm
- Weight: Less than 14 kg
- Output warranty (90% of minimum rated power for ten years)
- Submission of the certification on output warranty by official authority

Initial installation shall be done by Amorphous-Si type. Owner may request the replacement from Amorphous-Si type to Crystalline or Semi-Crystalline silicone type, which is provided as spare module, within the 1 year after taking over the system. This works shall also be included in contractor’s scope.

(b) Tests, Packing and Marking

The test, packing and marking requirements of PV module refer to “2. Solar Home System (1) Photovoltaic module”

(2) Controller (Solar charge controller)

The specification shall cover the technical requirements of the Controller for the Battery Charging System (BCS).

(a) Properties

- (i) System voltage; 12 (V) Direct Current (DC)
- (ii) Maximum module current; more than 6 (A) for Battery box mounted
(In put current from PV module) more than 20 (A) for BCS Loads
- (iii) Maximum load current; more than 6 (A) for Battery box mounted
more than 20 (A) for BCS Loads
- (iv) Other requirements shall refer to “2. Solar Home System (2) Controller”

(b) Tests, Packing and Marking

The test, packing and marking requirements of PV module refer to “2. Solar Home System (2) Controller”

(3) Battery

The specification shall cover the technical requirements of the battery for the Battery Charging System (BCS). The conventional starter battery shall not be acceptable for BCS. The contractor shall also provide 2 battery box racks, which 20 battery boxes can be installed in 1 rack. (Total storage number of Battery box = 40 (=20 x 2). The material requirement of battery rack shall refer to “2. Solar Home System (8) Pole with anchor and Support structure set for the module or panels(s) and Panel frame set ”

(a) Properties

- (i). Normal Voltage; 12(V) DC
- (ii). Rated Capacity; more than 102Ah for BCS Loads
more than 45Ah for Battery Box.
- (iii) All batteries shall be protected by FUSE.
- (iv) Other requirements shall refer to “2. Solar Home System (3) Battery”

(b) Tests, Packing and Marking

The test, packing and marking requirements of PV module refer to “2. Solar Home System (3) Battery”

(4) Breaker and Fuse for battery and Breaker for PV system

- (i). The system shall be protected against damage due to accidental short circuit by use of fuses or circuit breakers. Consumer circuits for BCS loads shall have circuit breakers. Individual circuit from the battery shall have a maximum rated capacity of 25 Amperes where not otherwise specified. Each circuit shall be so designed that the peak demand does not exceed 80% of the rated capacity of the fuse or circuit breaker.
- (ii). Also, breaker for battery charging in distribution boards shall be provided as indicated in attached configuration.

(iii). The contractor shall also provide wall mounted type distribution boards, which is mentioned in attachment [Doc. No. SR-3-4].

(a) Properties

(i) Magnetic circuit breaker and Fuse; For 12VDC circuit protection

The contractor shall select suitable rated current in accordance with PV system and battery capacity.

(b) Tests, Packing and Marking

The test, packing and marking requirements of PV module refer to “2. Solar Home System (4) Breaker and Fuse for battery and Breaker for PV system”

(5) Switch, Socket outlet and Plug

The requirement on Switch, Socket outlet and Plug refer to “2. Solar Home System (5) and (6)”

(6) Pole with anchor and Support structure set for the module or panels(s) and Panel frame set
The requirement on Pole with anchor and Support structure set for the module or panels(s) and Panel frame set refers to “2. Solar Home System (8)”

The support structure shall be sized and designed as both Amorphous-Si type and Crystalline or Semi-Crystalline silicone type module easily be installed.

(7) Battery box

(i). The Contractor shall furnish a compact case or box, which install the battery, controller, fuse switch and DC 12V-socket outlet.

(ii).The box shall be lockable with padlock and made by non-corrosive material such as hard PVC case. The box shall have carrying handle.

(iii). PVC plate, which instruction manual and notes to consumer is indicated, shall be attached on the box. Engineer will inform the detail contents of indication in plate.

(8) Cable and wiring equipment

The requirement on Cable and wiring equipment refer to “2. Solar Home System (9)”

(9) Lighting (lamp) set

(a) Structure

The Lighting set shall withstand long time use in indoors without deterioration of its mechanical and electrical properties.

(b) Requirements

(i) Compact Fluorescent Lamp 9W; Type: DC 12 (V) high efficiency type

(ii) The lighting fixture shall be with lamp guard cover that can be easily removed for

cleaning and lamp changing. The system of ballast and inverter of fixture shall be designed with consideration of lamp lifetime as much as longer (more than 6 months).

(iii) The lighting fixture shall be portable type with 10m Flexible PVC/PVC cable and plug for DC 12V circuit.

(c) Tests, Packing and Marking

The test, packing and marking requirements of lighting refer to “2. Solar Home System (10) Lighting”

(10) Inverter (for BCS loads)

Inverter system shall be provided for BCS loads. The system shall be solid-state type.

(a) Properties

(i) System voltage; In put 12 VDC
Output 230VAC $\pm 5\%$ (50Hz $\pm 2.5\%$, Sine or Quasi -sine wave, 1-phase)

(ii) Rated out put; 150VA

(iii) Required functions and features

- ✓ Auto load disconnection function at 125% over loads (adjustable) and manual re-connection function.
- ✓ Prevents reserve current function
- ✓ Constant voltage algorithm and low loss power consumption in system
- ✓ Short circuit protection

The contractor shall recommend the setting value on mentioned above adjustable functions.

(iv) LED and LC-Display; LC display for tension and currents (output), LED for status information, input voltage level information & malfunction of system.

Note: Vendor standard indication function may be applicable with owner approval, contractor shall clearly indicate the standard display and LED indication specification in bidder documents.

(d) Tests, Packing and Marking

The test, packing and marking requirements of inverter system refer to “2. Solar Home System (11) Inverter system”

(11) 220VAC Circuit equipment (Cable, Socket outlet and Lighting)

The requirements on 220VAC Circuit equipment refer to “2. Solar Home System (13)”

(12) Lightning protection system shall be provided in accordance with requirements in the

“Botswana Standard BOS 2-12:1999”. The equipment provision and construction works shall also be contractor’s scope.

(13) Battery Charging House and office

The contractor shall provide the battery charging house and office as mentioned in attachment [Doc. No. SR-3-6]. 2 sets battery rack shall also provided in the house, that 20 battery boxes per 1 set could be mounted.

4. (Not applicable)

5. Monitoring System

Contractor shall design and furnish the following monitoring system to execute 2years monitoring of this PV system. The system shall be installed one set per each village. The installation place will be informed later. System configuration shall refer to attachment.

(1) PV system condition monitoring

- (a) Data logger 3 sets data logging system (with voltage resister and shunt resistor.)
Nos. of Input CH: 8
Input level: DC 0V to 100mV
Operation power: Battery (capable more than 7 months continuous sampling operation and 1 year data maintainable)
Sampling cycle: once / 30 min (settable: 1 min to 2 hr)
Output algorithm to PC: vendor standard
Continuous sampling term: more than 6months
Low loss power consumption
- (b) PC and software One set portable PC (Notebook type) and software for analysis of logging data shall be provided by contractor. Contractor shall also provide OS for the PC and the type of OS shall be “Windows”.
- (c) Pyranometer 3 nos.
Output level: DC 0V to 100mV
Max input: Irradiance 3kw/m²
- (d) Temperature meter 3 nos.
Output level: DC 0V to 100mV
Max input: 60 degree Celsius
- (e) Resister for voltage data input: 3sets 20k Ω , 50 Ω (Rated voltage: more than DC 30V)
- (f) Shunt resister for current data input: 3sets 5A/60mV (Max. current: more than 10A)
- (g) Accessories The contractor shall provide all necessary accessories for this data logging system. The detail of system construction and specification shall be designed by the contractor and submitted with bidder’s documents.
- (h) Box and cabling Box: The system shall be assembled in a metal box. The box shall be lockable and outdoor exposure wall mounted type.

Cabling: All cabling and wiring of this system shall be scope of contractor.

- (i) Location 1 point per 1 village. Detail will be informed by engineer later.

6. Maintenance tools

Contractor shall provide the following maintenance tools.

- (a) Portable Digital Multi Tester Function: Vdc/Vac/Iac/Idc/R measurement

- (b) Portable Battery Tester Required function shall be as follows.

- (i). Voltage level measurement and indication
- (ii). Remaining capacity measurement and indication
- (iii). Expected remaining life cycle measurement and indication

- (c) General tool
- Screwdriver sets (3 size / + and - sets)
 - Wire Cutter (2 size)
 - Prier (2 size)
 - Hammer (2 size)

7. Technical Document to be submitted

The following documents shall be submitted at mentioned stage at least with indicated documents in Commercial, General and Installation (SR-M-02) requirements and /or specification.

- (a) Tender stage as proposal documents

Note; If the following documents are missing in the contractor's proposal documents, the contractor may lose a right as bidder.

- (i) Catalogue and specification of all equipment
- (ii) PV module V-I characteristic curve (at 25 and 55degree Celsius)
- (iii) PV module output warranty certification (90% for 10 years, at least)
- (iv) Battery Life cycle – Discharge depth characteristic curve
- (v) Battery Self-discharge – Ambient temp. characteristic curve
- (vi) Controller and Inverter life cycle or standard MTBF rate.
- (vii) Lighting fixture out line drawing and circuit diagram.
Inverter and ballast system specification shall be clearly indicated in the drawing.
- (viii) Typical cable list for each system size
Cable type, size, length and voltage drop level shall be indicated in the list.
- (ix) Typical installation drawing for each system size
Cable route, equipment-fixing method and equipment layout shall be indicated in the drawings. Especially, PV module and module pole installation plan such as pole mounting, wall mounting and roof mounting shall be clearly indicated in the typical drawings.

(b) Detail design stage as approval documents

- (i) Catalogue, specification and characteristic data of all equipment**
- (ii) Cable list and voltage drop calculation sheet for all systems**
- (iii) Installation drawing for all system**
- (iv) System wiring diagram/ layout drawings for all system**
- (v) Vendor shop test report in accordance with IEC practice.**
- (vi) Other documents; The detail of contents will be informed by engineer in accordance with level, amount and quality of information from mentioned above documents.**

SR-M-02 INSTALLATION

1. General

This specification shall be applied to the construction work of the Photovoltaic system.

The construction work shall mean the following work but not necessarily limited thereto.

- (1) Site Survey
- (2) Preparation of Profile (Sketches of each Job)
- (3) Survey for Clearing
- (4) Preparation of Construction Plan

The concept and method of the construction work shall be as stated in 2. through 5. below. Unless otherwise specified in the same clauses, the technical design criteria shall conform to the stipulations given in the latest edition of the “IEC Standard” refer to “SR-M-01 MATERIALS FOR INSTALLATION 1. General (4)”.

2. Site Survey

The site survey shall mean and include the preliminary survey, profile (sketch of house and PV system size with village map), survey for determining the limits of area to trim, cut and/or remove trees, bushes and/or any other obstructs, (hereinafter called “survey for clearing”) and the preparation of a detailed construction plan to be worked out by the Contractor, but the work of the site survey stated in this clause is not limited thereto.

(1) Preliminary Survey

(a) Study on maps

The Contractor shall examine carefully the planned PV system on the map and shall have knowledge thereof before commencing the required work.

(2) Preparation of Profile (sketch of house and PV system size with village map)

The contractor shall prepare profile sheets giving the PV installation houses on the village layout map(s) and sketches of each house with system size in accordance with the format and manner as mentioned herein below.

(a) Items to be indicated on sheet

- (i) Name of village
- (ii) Name of house owner
- (iii) Lay out of PV system in the house with kind of PV system
- (iv) Existence of interfering tree(s) and bushes, etc. for PV panel
- (v) others

(b) Approval of sheets

Upon completion of the profile sheets, the Contractor shall submit three (3) copies of the said profile sheets to the Engineer for the approval of the lay out of PV system in the house with kind of PV system, existence of interfering tree(s) and bushes, etc. for PV panel and others as well as the PV system installation arrangement.

(3) Preparation of Construction Plan

The preparation work of the construction plan shall mean the compilation of the results of the site survey already performed by the Contractor.

In due and overall consideration of the site survey, survey for clearing, etc. already performed by the Contractor, he shall determine his work schedule, work implementation method and the quantities of the work required.

The Contractor shall select and determine the locations of his temporary facilities at site(s) as storage-yard(s), site office(s), camp(s), etc. and any other facilities indispensable for the performance of the Works under the Contract.

The Contractor shall submit the construction plan containing the final results of the site survey to the Engineer for approval.

The contractor shall not commence any subsequent work following the erection and setting of poles (array)/PV panels prior to the approval by the Engineer of the construction plan.

The Contractor shall propose a draft format and items to be incorporated in the construction plan in draft form to the Engineer for approval five (5) days at the latest prior to the preparation of the construction plan.

At least the following items shall be on and/or attached to the construction plan.

- (a) Construction work schedule
 - General schedule of the PV system
- (b) All drawings and relevant documents related to Profile (sketch of house and PV system size with village map) sheets.
- (c) Transportation schedule of materials, equipment and supplies
 - (i) Preparation for transportation
 - Marine and inland transportation schedule
 - Manner of and schedule for inland transportation and transportation routes
 - (ii) Plan for utilization of a storage-yard for storage of materials including site office and dormitory
 - Selection of the location of a storage-yard and space for storage of materials
 - Selection of the location of a site office and dormitory
- (d) Plan for setting and assembling of PV system(s)
 - (i) Work of poles (array)/PV panels setting
 - Detailed work schedule, work method, organization and mobilization of gangs
 - (ii) work of assembling for PV system equipment (controller, battery, breakers, fuses and

others)

- Detailed work schedule, work method, organization and mobilization of gangs

(e) House-wiring plan

(i) Detailed work schedule, house-wiring work, work method, organization and mobilization of gangs

(4) Preparation of a plan for the performance of the Site Survey

The plan for the performance of the site survey proposed by the Contractor shall include at least the following items:

- (a) Detailed schedule (time-table) for the performance of the necessary work
- (b) Full names of a person in charge and persons of each gang
- (c) Schedule for mobilization of each gang

3. Installation of Solar Home System (SHS)

The installation of SHS mean such work that will be conducted by the Contractor in accordance with the construction plan, profile sheets and plan but will not be limited thereto.

- (1) Erection and Setting of PV modules on poles
- (2) Setting and installation of PV system equipment
- (3) Contractor's equipment

The details and manner of the construction work from Item (1) through (4) enumerated hereinabove are as stated in 3-(1) through 3-(4).

(1) Erection and Setting of Poles with PV modules on poles

(a) Work item

The work shall consist of the items mentioned below.

- (i) Preparation for the work
- (ii) Digging and preparations for PV modules (panel) setting and pole erection
- (iii) PV modules (panel) setting and pole erection and confirmation thereof
- (iv) Back-filling and tamping of pole holes opened
- (v) Inspection

(b) Preparation for the work

The Contractor shall start the work after perusal of the construction plan prepared by the Contractor and approved by the Engineer, based on the site survey.

The Contractor shall also conduct all the necessary checking of the work; mobilization and deployment of man-power including labours, materials, instruments and tools, etc. before starting the work.

The Engineer will have the right to have the Contractor submit a written aforementioned checking report. On receiving instructions from the Engineer, the contractor shall submit to the Engineer;

one (1) copy of the report within two (2) days (including the day on which

the instructions are received).

- (c) Digging and preparations for PV modules (panel) setting and pole erection
- (i) Pole hole depth; Dig a hole of 200mm diameter and 1,000mm depth at selected place
 - (ii) The Contractor shall start the digging work, upon confirmation of the exact positions checking if there exist any foreign matters under the ground.
 - (iii) After completion of the digging work, the Contractor shall set pole to be erected vertically.
 - (iv) After completion of setting poles on the positions, the Contractor shall confirm the direction of each pole and module (panel) vertically.
- (d) PV modules (panel) setting and pole erection and confirmation thereof
- (i) The Contractor shall install the PV modules (panel) with support structure sets on poles before they are set and erected, accordingly.
 - (ii) After completion of setting poles on the positions, the Contractor shall confirm the direction of each module (panel) direction.
 - Face to north (Recommendable range: ± 5 degrees from north)
 - Horizontally Angle (Recommendable range: ± 5 degrees from 25 degree).
- (e) Back-filling and tamping of pole holes opened
- Back-filling shall be conducted by means of tamping the earth at an interval of every about 25 cm each.
- (f) Inspection
- (i) Inspection by the Contractor

After completion of the work started in Item 3. -(1)-(c) through 3. - (1)- (e) the Contractor shall prepare a written report of such inspection. The report mentioned above shall include at least the following items of the work, if so required, together with photographs showing the progress of the work so that the Engineer may easily evaluate the quality of the work.

 - Name of village
 - Name of house owner
 - Depth of pole hole
 - Direction of poles and PV module (panel) degrees from north
 - Back-filling and tamping conditions
 - Completion date of the inspection by the Contractor
 - Others, if any
 - (ii) Inspection by the Engineer

The Engineer will have the right to instruct the Contractor to submit a written report of the inspection conducted by the Contractor himself.

The contractor shall submit to the Engineer one (1) copy of the report for approval

within two (2) days after receipt of instructions from the Engineer.

The Engineer will have the right to inspect the work of “erection and setting of poles with PV modules on poles” already performed by the Contractor in reference to the written report of such inspection conducted by the Contractor himself and submitted to the Engineer.

(iii) Failure in the inspection

Should the Engineer find any improper discrepancies or problems between “erection and setting of poles with PV modules on poles” actually conducted by the Contractor and the descriptions made in the written report of the inspection submitted to the Engineer, the Engineer will indicate such improper discrepancies or problems to the Contractor and instruct him to remove such improper discrepancies or problems of the erection and setting of poles with PV modules on poles at the expense of the Contractor.

On such occasion that the Contractor should have removed such improper discrepancies or problems, the Contractor shall submit again to the Engineer for approval another modified report in writing of the inspection conducted again by the Contractor himself.

The Engineer will have the right to instruct again to report of the inspection as many time as deemed necessary by himself at such time wherever the Engineer should deem it necessary to inspect at his own discretion, all on the account and at the expense of the Contractor, before the approval by the Engineer of the field test is made.

(g) Tender price schedule

The price schedule shall be filled out in consideration of the following items.

- (i) The unit price of the “erection and setting of poles with PV modules on poles” work shall consist of only the construction cost (labour cost, fuel and lubricant cost of machinery and tools, cost of materials except main materials, and cost of hire and rent of the machinery).
- (iii) The unit, in other words, shall not include such cost of poles proper, cost of transportation, cost Contractor’s Manager and Technical Personnel at Site and cost of hire and rent of the machinery during the transportation.

(2) Setting and installation of PV system equipment

(a) Work item

The work shall consist of the items mentioned below.

- (i) Preparation of drawings of Assembling and installation of PV system equipment
- (ii) Assembling and setting of PV system equipment
- (iii) Installation of cables
- (iv) Setting of lighting (lamp) sets

(v) Inspection

(b) Preparation of drawings of assembling and installation of PV system equipment

The Contractor shall submit to the Engineer for approval three (3) copies each of drawing of assembling and installation of PV system equipment work within fifteen (15) days after the Site Survey.

Should no approval be obtained from the Engineer regarding the said drawings, the Contractor shall not commence any setting and installation of PV system equipment work.

(c) Assembling and setting of PV system equipment

The Contractor shall install the PV system equipment (controller, battery with battery box, breakers, fuses, switches, plug(s) and other inc. pre-paid system equipment) based on the plan for setting and assembling of PV system(s).

The Contractor shall handle and/or treat PV system equipment with care they should be damaged.

(d) Installation of cables

The Contractor shall install the cable(s) from PV panel to controller, from controller to battery (ies), from controller to switch (es) and plug (s), from switch (es) and plug (s) to lighting set(s) based on the plan for setting and assembling of PV system(s).

(e) Setting of lighting (lamp) sets

The "Setting of lighting (lamp) sets" shall mean such work that lamp (s) and other equipment shall set in houses based on the house-wiring plan.

(f) Inspection

(i) Inspection by the Contractor

The Contractor shall prepare a written report of inspection.

The report mentioned above shall include at least the following items of the work

- Name of village
- Name of house owner
- Confirmation of lighting for each lamp
- Completion date of the inspection by the Contractor
- Others, if any

(g) Tender price schedule

The price schedule shall be filled out in consideration of the following items.

(h) The unit prices of the "Setting and installation of PV system equipment" work shall consist of only the construction cost (labour cost, fuel and lubricant cost of machinery and tools, cost of materials except main materials, and cost of hire and rent of the machinery).

4. Installation of Battery Charging System (BCS)

The installation of BCS mean such work that will be conducted by the Contractor in accordance with the construction plan, profile sheets and plan but will not be limited thereto.

- (1) Erection and Setting of PV Panel(s) on Array
- (2) Setting and installation of PV system equipment

The details and manner of the construction work from Item (1) through (4) enumerated hereinabove are as stated in 3-(1) through 3-(4).

- (1) Erection and Setting of array with PV panel on array

- (a) Work item

The work shall consist of the items mentioned below.

- (i) Preparation for the work
- (ii) Digging and preparations for PV panel setting and array erection
- (iii) PV panel setting and array erection and confirmation thereof
- (iv) Back-filling and tamping of arrays holes opened
- (v) Inspection

- (b) Preparation for the work

The Contractor shall start the work after perusal of the construction plan prepared by the Contractor and approved by the Engineer, based on the site survey.

The Contractor shall also conduct all the necessary checking of the work; mobilization and deployment of man-power including labours, materials, instruments and tools, etc. before starting the work.

The Engineer will have the right to have the Contractor submit a written checking report. On receiving instructions from the Engineer, the contractor shall submit to the Engineer;

one (1) copy of the report within two (2) days (including the day on which the instructions are received).

- (c) Digging and preparations for PV panels setting and array installation

- (i) Array's pole holes depth; Dig a hole of 200mm diameter and 1,000mm depth at selected place
- (ii) The Contractor shall start the digging work, upon confirmation of the exact positions checking if there exist any foreign matters under the ground.
- (iii) After completion of the digging work, the Contractor shall set array to be erected vertically.
- (iv) After completion of setting array on the positions, the Contractor shall confirm the direction of each pole and module (panel) vertically.

- (d) Array installation and PV module panels setting

- (i) The Contractor shall install the PV panels on array after installation of array.
- (ii) After completion of setting array on the positions, the Contractor shall confirm the direction of each panel direction. The recommendable range shall refer to "SR-M-2, 3-(1)-(d)-(ii).

(e) Back-filling and tamping of array's pole holes opened

Back-filling shall be conducted by means of tamping the earth at an interval of every about 25 cm each.

(f) Inspection

(iv) Inspection by the Contractor

After completion of the work started in Item 4. -(1)-(c) through 4. - (1)- (e) the Contractor shall prepare a written report of such inspection. The report mentioned above shall include at least the following items of the work, if so required, together with photographs showing the progress of the work so that the Engineer may easily evaluate the quality of the work.

- Name of village
- Depth of array's pole holes
- Direction of PV panel's degrees from north
- Back-filling and tamping conditions
- Completion date of the inspection by the Contractor
- Others, if any

(v) Inspection by the Engineer

The Engineer will have the right to instruct the Contractor to submit a written report of the inspection conducted by the Contractor himself.

The contractor shall submit to the Engineer one (1) copy of the report for approval within two (2) days after receipt of instructions from the Engineer.

The Engineer will have the right to inspect the work of "erection and setting of poles with PV modules on poles" already performed by the Contractor in reference to the written report of such inspection conducted by the Contractor himself and submitted to the Engineer.

(vi) Failure in the inspection

Should the Engineer find any improper discrepancies or problems between "erection and setting of poles with PV modules on poles" actually conducted by the Contractor and the descriptions made in the written report of the inspection submitted to the Engineer, the Engineer will indicate such improper discrepancies or problems to the Contractor and instruct him to remove such improper discrepancies or problems of the erection and setting of poles with PV modules on poles at the expense of the Contractor.

On such occasion that the Contractor should have removed such improper discrepancies or problems, the Contractor shall submit again to the Engineer for approval another modified report in writing of the inspection conducted again by the Contractor himself.

The Engineer will have the right to instruct again to report of the inspection as many time as deemed necessary by himself at such time wherever the Engineer should deem it necessary to inspect at his own discretion, all on the account and at the expense of the Contractor, before the approval by the Engineer of the field test is made.

(g) Tender price schedule

The price schedule shall be filled out in consideration of the following items.

- (i) The unit price of the “erection and setting of poles with PV modules on poles” work shall consist of only the construction cost (labour cost, fuel and lubricant cost of machinery and tools, cost of materials except main materials, and cost of hire and rent of the machinery).
- (iv) The unit, in other words, shall not include such cost of poles proper, cost of transportation, cost Contractor’s Manager and Technical Personnel at Site and cost of hire and rent of the machinery during the transportation.

(2) Setting and installation of PV system equipment

(a) Work item

The work shall consist of the items mentioned below.

- (i) Preparation of drawings of Assembling and installation of PV system equipment
- (ii) Assembling and setting of PV system equipment
- (iii) Installation of cables
- (iv) Setting of lighting (lamp) sets
- (v) Inspection

(b) Preparation of drawings of assembling and installation of PV system equipment

The Contractor shall submit to the Engineer for approval three (3) copies each of drawing of assembling and installation of PV system equipment work within fifteen (15) days after the Site Survey.

Should no approval be obtained from the Engineer regarding the said drawings, the Contractor shall not commence any setting and installation of PV system equipment work.

(c) Assembling and setting of PV system equipment

The Contractor shall install the PV system equipment (controller, battery with battery box, breakers, fuses, switches, plug(s) and other inc. pre-paid system equipment) based on the plan for setting and assembling of PV system(s).

The Contractor shall handle and/or treat PV system equipment with care they should be damaged.

(d) Installation of cables

The Contractor shall install the cable(s) from PV panel to controller, from controller to

battery(ies), from controller to switch(es) and plug(s), from switch(es) and plug(s) to lighting set(s) based on the plan for setting and assembling of PV system(s).

(e) Setting of lighting (lamp) sets

The “Setting of lighting (lamp) sets” shall mean such work that lamp (s) and other equipment shall set in houses based on the house-wiring plan.

(f) Inspection

(i) Inspection by the Contractor

The Contractor shall prepare a written report of inspection.

The report mentioned above shall include at least the following items of the work

- Name of village
- Confirmation of charging voltage each battery
- Confirmation of lighting for each lamp
- Completion date of the inspection by the Contractor
- Others, if any

(ii) Tender price schedule

The price schedule shall be filled out in consideration of the following items.

(iii) The unit price of the “Setting and installation of PV system equipment” work shall consist of only the construction cost (labour cost, fuel and lubricant cost of machinery and tools, cost of materials except main materials, and cost of hire and rent of the machinery).

5. (Not Applicable)

6. Field Tests

The field test shall mean the inspection of completion of the PV system construction, “AS-BUILT DRAWINGS” and “RECORDS OF CONSTRUCTION” but not necessarily limited thereto.

(1) Plan for Inspection

(a) The Contractor shall prepare a plan for inspection covering all construction sections and submit five (5) copies of the same to the Engineer for approval within ten (10) days at the latest prior to the commencement of the Field Test.

The Contractor shall not commence any inspection before the approval by the Engineer thereof is granted.

(b) The plan for inspection shall include at least the following items:

(i) Application of inspection (name of construction, date of inspection, reason(s) of application and date of completion)

(ii) List of summary of inspection conducted by the Contractor himself.

The Engineer will notify the Contractor of the place(s) or section(s) to be inspected etc. on the day of such inspection or in advance. The Contractor shall not be allowed to refuse such instruction(s) given by the Engineer for any reason(s) whatsoever.

(2) Inspection Item

The completion inspection of the PV system shall be conducted by the Contractor in the presence of the Engineer in accordance with the inspection items selected by the Engineer at his option and discretion out of the Contract documents and any and all other relevant documents including drawings related to the Contract.

(3) Inspection of Completion of Construction Work

(a) The inspection of the completion of the construction work shall mean such inspection to be conducted to inspect if the overall construction should be performed perfectly and faithfully in accordance with the specifications and all other relevant documents (as-built drawings and records of construction) related to the Contract.

(b) The inspection shall consist of inspecting the supporting structures for PV system, equipment of PV system, house-wiring and other items in such manners as item-wise and/or section-wise.

(c) The inspection items shall correspond to those inspected by the Contractor himself, but shall not be limited thereto.

(d) The following items shall be added to those inspected by the Contractor himself:

(i) Direction, gradient, fixing and appearance test for the supporting structures for PV system

(ii) Lighting, insulation resistance of house-wiring and battery charging quantity test for PV system

(4) As-Built Drawings and Record of Construction of PV system

The As-built drawings and the records of construction shall be prepared at the time of inspection by the Contractor and submitted to the Engineer in one (1) original and five (5) duplicate copies. The As-built drawings and the records of construction shall be used as data for the inspection of completion of the construction. The list of such documents shall include at least the following items.

(a) Report of inspection conducted by the Contractor himself.

(b) List of setting PV system

(c) Profile (including sheet of each house with house owner's approval) of SV system in village

(5) Approval of Inspection

The Contractor shall submit to the Engineer for approval three (3) copies of a written request for approval of the inspection of the completion of the construction after the inspection has been completed.

The Engineer will approve the inspection of the completion of the construction, provided that the construction of the PV system could be deemed completely satisfactory in accordance with the terms and conditions of the specifications.

(6) The cost of the above mentioned Field Tests shall be quoted in the column of the costs of sub-clause 3 "Installation of Solar Home System (SHS)", clause 4 "Installation of Battery Charging System (BCS)" of this clause.

7. Contractor's Equipment

(1) General

The machinery and tools (special tools included) required for the construction of the transmission line shall be procured and made available by the Contractor himself because of the reason that procurement of the same shall be difficult in the place where the construction is to be conducted and shall be transported to the site by the Contractor himself for the performance of the construction work.

(2) Machinery and Tools

(a) One (1) unit of truck crane

The truck crane shall be used for construction of the temporary bridges and others and shall be of the following specification.

Maximum lifting capacity : 4.9 tons or more
(Hydraulic type, capacity : approx. 125 ps)

(b) Digger derrick

Type : To be selected by contractor, if necessary.
Maximum lifting capacity as the crane : To be selected by contractor, if necessary.

- (c) Other machinery and tools (Contractor shall confirm the detail specification of below tools by themselves and necessary and suitable tools for this construction shall be provided by contractor.)

- | | |
|--------------------------------|---|
| (i) Electrical tools | Tester, pliers, screwdriver, cutter knife et. |
| (ii) Tensioner or winch | 0.5 t |
| (iii) Com-along | : 0.5 t |
| (iv) Com-along | : 1.5 t |
| (v) Wire cutter | : S-16 |
| (vi) Other miscellaneous tools | |

(3) Tender Price Schedule

- (a) Hire and rent of machinery and tools under transportation (marine and inland transport) shall be indicated in Tender Price Schedule.

8. Contractor's Site Personnel

(1) Contractor's Manager

The Contractor's Manager at Site shall mean such a person who will administrate and supervise the overall execution of the work at Site, having the qualifications as mentioned below.

- (a) He shall be a representative of the Contractor duly empowered to make decisions binding on the Contract in respect of any and all matters which are likely to arise in connection with the execution of the Works at Site.
- (b) He shall have a proficient knowledge of the English language, both spoken and written, enough to negotiate and settle any and all matters which are likely to arise in connection with the execution of the Works at Site.
- (c) He shall have a versatile knowledge of respective callings required for the performance of the Works under the contract and shall be well-versed in the administration of the Contract and competent enough to supervise any and all matters related to the work at Site.

(2) Technical Personnel at Site

The "Technical Personnel" at the site stated herein means such persons as set forth in the provisions of GC-06 and SC-24 of the CONDITIONS OF CONTRACT whom the Contractor shall assign to the construction of the PV system in order to assist the

Contractor's Manager in the smooth performance of the work, mainly supervision of the same under the Contract. Such personnel shall have a competent capability of preparing a detailed construction plan, man-power mobilization and deployment plan, temporary facility construction plan, transportation plan, safety and accidents prevention plan in an elaborate manner. Each of the personnel shall be acquainted with respective callings or work related to the construction of PV system.

(a) Categories of Technical Personnel

The technical personnel will be classified into two (2) categories of the "Senior Technical Assistant" and "Technical Assistant" who shall be engaged in the respective work as mentioned below.

(i) Technical personnel for installation work except for site survey

- Senior technical assistant

He shall have the professional experience of the following number of years in the design, construction and operation and maintenance of PV system.

- In case of a graduate of senior high school;

More than five (5) years

- In case of a graduate of college or university;
(Four (4) years schooling)

More than two (2) years

(ii) Technical assistant

He shall have the professional experience of the following number of years in the design, construction and operation and maintenance of PV system.

- In case of a graduate of senior high school;

More than three (3) years

- In case of a graduate of college or university;
(four (4) years schooling)

More than one (1) years

- Licensed operator of construction equipment

With a body weight three (3) tons or more	Certificate issued to participants in a seminar on the skill
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Width a body weight of three (3) tons or less	Certificate issued to special training course of the skill
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(3) Contractor's Skilled Labours

The Contractor shall select his skilled labours (Electrical technician) to be assigned to the work under the Contract from among personnel directly employed by his Electrical Constructor. The Contractor shall also deploy those linemen effectively in due consideration of the kinds of their callings, number of years of experience and internal relations among the linemen of each gang. The Contractor shall clearly indicate in which grade and ranking each of the said linemen can be positioned in a gang in accordance with the table shown hereunder so that the engineer may readily evaluate the organization of the gang members and the degree of their skills.

The lineman shall have at least two (2) years experience of line-wiring and the number of years of any other categories of work such as house-wiring is counted as the number of years of his experience in this particular work under the Contract.

(4) Approval of qualifications of the Contractor's Site Personnel

- After selection of candidates of Site personnel whom the Contractor intends to assign to the Works under the Contract, he shall submit the curriculum vitae together with the following certificate(s) of each of such personnel to the Engineer for approval within fifteen (15) days after the Contract.
- Unless approved, the Contractor shall not assign any of his Site personnel to the work of the PV system set forth under the Contract.
- Documents or certificate evidencing the professional experience of each of the Site personnel.
- Certificate of "Identification" (ID) of each person of the Site personnel that he is duly in service with the Company.

Issued by the Social Insurance Office, Public Employment Security Office or any other government agency(ies)

- Photo copy of license or certificate
- One (1) colour photograph of each of the Site personnel. Technician

9. Technical Document to be submitted

The following documents shall be submitted at mentioned stage at least with indicated documents in Commercial, General and Equipment (SR-M-01) requirements and /or specification.

(a) Tender stage as proposal documents

Note; If the following documents are missing in the contractor's proposal documents, the contractor may lose a right as bidder.

- (i) Material stock and control plan at site
- (ii) Over all organization (Purchasing, Design and construction)
- (iii) Material shipping plan to site
- (iv) Installation typical diagram

SR-M-03 ATTACHMENT AS REFERENCE

SR-3-1 S.H.S (50 AND 100Wp) CONFIGURATION

SR-3-2 S.H.S (150Wp to 250Wp) CONFIGURATION

SR-3-3 BATTERY CHARGER SYSTEM CONFIGURATION

SR-3-4 MONITORING SYSTEM CONFIGURATION

SR-3-5 SITE(s) MAP

SR-3-6 BATTERY CHARGING HOUSE PLAN

SR-3-7 USER LIST/BQ LISTS

SR-3-8 USER HOUSE SKETCHES