Master Plan Study for Utilization of Solar Energy

in the Federal Republic of Nigeria

Part-II, (1)
Technical Specification
of
Pilot Project in Jigawa State

October 2005

Japan International Cooperation Agency (JICA)

Preamble

In response to the request of the Government of the Federal Republic of Nigeria (hereinafter referred to as “Nigeria”), the Government of Japan decided to conduct Master Plan Study for Utilization of Solar Energy in the Federal Republic of Nigeria (Hereinafter referred to as “Study”) in accordance with the relevant laws and regulations in force in Japan and entrusted the Study to the Japan International Cooperation Agency (hereinafter referred to as “JICA”), the official agency responsible for the implementation of the technical cooperation programs in the Government of Japan.
JICA sent the Master Plan Study Team (hereinafter referred to as “Team”) to Nigeria and conduct the Study in close cooperation with the authorities concerned in Nigeria. The Study includes a Pilot Project (hereinafter referred to as “Project”) using Photovoltaic (PV) systems, which is implemented in one (1) village each in Jigawa state, Ondo state, and Imo state.

The scope of the Project in Jigawa state includes the procurement, installation, and maintenance of the PV systems consisting of one (1) Battery Charging Station (BCS), one (1) Public Facility, sixty (60) Solar Home Systems (SHS), and ten (10) Street Lightings. The Project will be completed in early March 2006 and will be monitored up to February 2007 to evaluate the sustainability of PV systems.

The specification defines the technical requirement of the PV systems including installation and maintenance. The terms and conditions of the contract are described in the separate volume of “General Conditions of Contract for the Pilot Project.”

Content

1 General Condition

1.1 Project Site

Garkon-Alli, Kiyawa L.G., Jigawa

The village locates in the north of Kiyawa L.G. and about 30 km away from Dutse, the state capital. The village with population of about 5,000 has not been electrified either by grid or by diesel generators.

1.2 Units of Physical Quantities

All the equipment, devices, and materials delivered by the Contractor shall be designed and manufactured in accordance with the international system of units (SI). No British and US measure is allowed to use in this contract. The Contractor shall use SI units and their symbols in all his drawings and documents submitted to the Purchaser.

1.3 Language

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

1.4 Design Conditions

All the equipment, devices, and materials delivered by the Contractor shall be designed and manufactured to meet the following ambient conditions:

- Altitude Not more than 1,000 m
- Temperature 5 °C (minimum), 45 °C (maximum)
- Wind Pressure 8.3 kN/m^2
- Average amount of insolation 5.24 kW/m^2-day
- Running no insolation days 3 days

1.5 Requirements for Drawings and Documents

- The Contractor shall submit to the Purchaser all drawings and documents required for the completion of the Project.
- The Contractor shall send all drawings and documents by registered mail or equivalent method, and ensure delivery of them to the Purchaser by due date.
- In order to conform the PV systems to the requirements and intent described in the specification, the Purchaser will have the right to require the Contractor to make changes in the drawings and documents, if necessary.
- The design drawings comprised of arrangement drawings, installation drawings, schematic circuit diagrams shall demonstrate that the PV systems will conform to all requirements and intent described in the specification. These drawings shall indicate necessary data—dimensions, materials, etc.—for the installation, operation and maintenance of the PV systems.

- The Contractor shall keep one (1) complete set of the design drawings in good condition on the site. This set shall be designated “Record Prints.” The Contractor shall record any and all differences between the actual construction and design on the “Record Prints.”
- The size of drawings shall be as follows:

  297 mm × 420 mm (A3)

  210 mm × 297 mm (A4)

  In the lower right-hand corner of each drawing, the Contractor shall indicate the title of the drawing, signature of the Contractor's responsible engineer, date prepared, and drawing number.
- The arrangement and installation drawings shall contain all necessary information—assembling and disassembling instruction, foundation shape, cabling, piping, etc.—for the installation and testing works of the PV systems.
- The schematic circuit diagrams shall show the connection of the components and shall indicate the wire number, terminal number, etc.
- The documents shall be submitted to the Purchaser in accordance with the following list.

Item	Number of copies	Remarks
Drawing lists with target date of submission	5	Within fifteen (15) days after the contract
List of equipment and materials	5	Within fifteen (15) days after the contract
Detailed design calculation sheets	5	Immediately on completion of design
Work schedule	5	Within fifteen (15) days after the contract
List of suppliers and country of origin for each equipment	5	Within fifteen (15) days after the contract
System design drawings	5	Within fifteen (15) days after the contract
List of spare parts	5	Within fifteen (15) days after the contract
Plates and/or Stickers for National Flag of Japan	5	Within thirty (30) days after the contract
Notice and procedures of factory tests	5	Not later than ten (10) days before the tests
Result of factory tests	5	On completion of the tests
Notice and procedures of field tests	5	Not later than ten (10) days before the tests
Result of field tests	5	On completion of the tests
Installation completion report with photographs	5	Within ten (10) days after the completion
As-built drawings	5	At the completion of the installation work
Operation and maintenance manuals	7	Not later than thirty (30) days before the taking-over
Result of maintenance work	7	On completion of the maintenance work
Minutes of meeting	5	Within five (5) days after each meeting

All the above drawings shall be subject to approval of the Purchaser. The work schedule shall show key dates for design, manufacturing, factory tests, shipment, inland transportation, installation and erection, field tests, and completion of the PV systems. The factory and field tests shall be conducted in accordance with the test items described in the specifications, and the results shall clearly show the test procedure, test condition, test circuit, instruction of testing equipment, etc. The completion report shall contain the records, check lists, and photographs, which clearly indicate that the Contractor have installed and erected the PV systems in consistency with the specification. The operation and maintenance manuals shall describe in detail the assembling and disassembling method, operating instruction, and inspection procedure and check list of each component.

1.6 Approval Procedure of Drawing and Documents

Prior to the fabrication of the components at a factory, the Contractor shall submit the drawings and technical documents for approval to the Purchaser. The Contractor shall conform to the following procedures for the approval from the Purchaser.

- The Purchaser will review the drawings for approval within 15 days after receipt.
- After the review of the drawings, the Purchaser will mark “Approved,” “Approved on Condition,” or “Not Acceptable” as appropriate in the drawings and return one (1) copy of the drawings to the Contractor.
- The Contractor shall make all revisions or new drawings if the returned copy is marked with “Approved on Condition” or “Not Acceptable,” and shall submit the revised or new drawings to the Purchaser for approval. The revised or new drawings shall be subjected to the same procedure as described above.
- The Contractor shall prepare and submit final drawings only after each drawing previously submitted has been returned and marked “Approved.”
- The approval procedure shall be carried out in accordance with the following schedule unless otherwise noted.

Item	Number of copies	Remarks
Drawing for approval	5	Immediately on completion of design, not more than thirty (30) days after the contract
Revised or new drawings for approval	5	Within fifteen (15) days after received copy marked “Approved on Condition” or “Not Acceptable”
Final drawings	5	Within fifteen (15) days after receiving copy marked “Approved”

- The Contractor may proceed with the work covered by the drawings marked “Approved.” He may also proceed with the work covered by the drawing marked “Approved on Condition” as far as he

performs the work in accordance with the Purchaser's notes or comments. The Contractor shall not proceed with any work covered by the drawings marked "Not Acceptable" until he received the revised or new drawings marked "Approved" or "Approved on Condition." If the Contractor proceeds with the work without the approval from the Purchaser, he shall make the necessary changes at his own expense in accordance with the drawings marked "Approved."

- The approval of the drawings from the Purchaser shall not relieve the Contractor of his obligation to satisfy the requirements of the specification or to carry out the responsibility of making corrections on his drawings.

1.7 Normative References

The PV systems shall be installed in accordance with Electrical Installation Regulations of Nigeria. All the equipment, devices, and materials delivered by the Contractor shall be designed, manufactured, and tested in accordance with IEC standards and/or other major international standards. Especially, PV module shall comply with the latest edition of the following references.

- IEC 61215 Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval
- IEC 60904-1 Photovoltaic devices. Part 1: Measurement of photovoltaic (PV) current-voltage characteristics
- IEC 60904-3 Photovoltaic devices. Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data

2 General Specification

2.1 Materials

All materials delivered by the Contractor shall be new and of first-class quality regarding strength, durability and other performances. Any defect and imperfection will not be acceptable.

2.2 Design Stress

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.

2.3 Welding

The welding shall be done by arc welding and be tested and inspected in accordance with appropriate standards to ensure that the work is free from pinholes, cracks and all other defects.

2.4 Painting

A quality and method of painting shall conform to appropriate standards, and the painting shall last long period of commercial operation without deterioration.

2.5 Galvanizing

Galvanizing shall be done by means of hot dip process after the fabrication of members is completed, and the minimum quantity of zinc coating shall be 350 grams/m^2 for bolts and nuts, 550 grams/m^2 for other parts. Zinc coating shall be uniform, clean, and smooth.

2.6 Wiring

- The wiring shall be 600 V grade polyvinyl chloride (PVC) insulated cables with copper strands. The conductor size shall not be less than the followings:
  25 mm^2 for Main circuit in Battery Charging Station
  6 mm^2 for PV – Controller – Battery
  2.5 mm^2 for Controller – Lighting
  Unless otherwise noted, all equipment and devices for PV systems shall conform to the above size of cables.
- The cables comprise two (2) cores, which have color identification—red for positive electrode and black for negative electrode.
- The cable shall be connected and branched at terminal blocks, which clearly indicate the mark of the terminals. No connection of cables is allowed along the route.

2.7 Packing

- 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.
- The spare parts shall be packed and crated firmly to withstand storage for a long time. 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 describes directions about storing.

2.8 Inland Transportation

- The Contractor shall arrange, carry out, and supervise the inland transportation to the site on his own responsibility.
- The Contractor shall, for his own convenience, arrange for all necessary provision to obtain accurate information about unloading at port and inland transport facilities as well as all local conditions—particularly the safe load bearing capacity of roads and bridges. The Contractor shall bear all expenses relating to the transportation.
- The Contractor shall use every reasonable means and be careful 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. If any problem occurs, the Contractor shall be responsible for all the claims, costs, and charges hereof.

2.9 Installation

- The Contractor shall assign a site manager, who is duly empowered by the Contractor. The manager shall supervise the installation of the PV systems at the site and make decision on all matters arising during the construction.
- The Contractor shall organize skilful workers—crews who perform work under the supervision of the site manager—to install and erect the PV systems.
- The Contractor shall prepare all equipment, devices, tools, and materials needed for the installation, and shall keep them at the site on his own responsibility.
- Discussing with the User, the Purchaser and/or Engineer will direct the Contractor to install the system at the designated place.
- The Contractor shall be responsible to prevent any damage or burglary of equipment during installation of PV system.

2.10 Tests

- The factory tests shall be executed by the Contractor in accordance with the specification and normative references, and all the test results shall be submitted to the Purchaser.
- On completion of individual adjustment and tests of each PV system after installation, the Contractor shall carry out the field tests and Inspections of Goods required in the specifications in the presence of the Purchaser and/or Engineer.

- If the tests do not satisfy the requirements of the specifications or any defects attributed to the Contractor are found during the tests, the Contractor shall promptly repair, replace, adjust, and retest the PV system at his own expenses by the date designated by the Purchaser.

2.11 Plates and/or Stickers for National Flag of Japan

- The Contractor shall provide the plates and/or stickers of Japan's national flag as shown on Fig. 2-1.

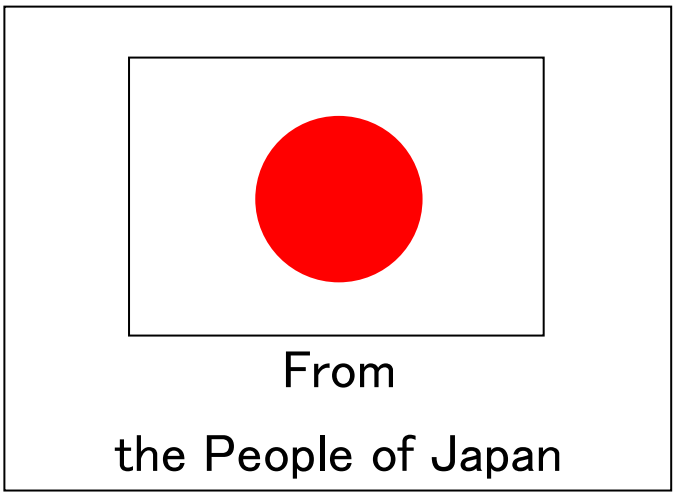


Fig. 2-1 Plates and/or Stickers for National Flag of Japan

- The plates and/or stickers shall be put on all major equipment to be provided for the project, except small equipment or parts on which it is too difficult to apply. The scope of application shall be instructed by the Purchaser. The details of the plates and/or stickers such as layout, description, materials, etc. shall be subject to the approval of the Purchaser.

3 Technical Requirement of Components

3.1 BCS

A BCS consists of station components—PV module, battery charger, charge controller, storage battery, breaker, switch, outlet, lighting, and wiring—and household components—charge controller, storage battery, breaker, switch, outlet, lighting, and wiring. Since the BCS is operated at the system voltage of DC 12 V, all the equipment, devices, and materials for the system shall be suited for the above voltage.

3.1.1 Station Components

3.1.1.1 PV Module

3.1.1.1.1 Requirements

The module shall meet the following technical specification, and the electrical characteristics shall be measured under the standard test conditions—irradiance of 1,000 W/m^2, AM 1.5 spectrum, and cell temperature of 25°C—in accordance with IEC 60904-1 and 3.

- The module shall be either mono-crystalline or poly-crystalline type.
- The maximum power of the module shall be 55 W or more and shall not deteriorate by 10% in ten-year operation.
- The open circuit voltage shall be 20.5 V or more.
- The short circuit current shall be 3.4 A or more.
- The maximum power voltage shall be 16.5 V or more.
- The maximum power current shall be 3.15 A or more.
- The module shall be equipped with a bypass diode in the waterproof terminal box.

3.1.1.1.2 Markings

The module shall have a name plate on it at least the following information and specification:

- Name or trademark of manufacture
- Model and serial number
- Country of origin
- Maximum power, open circuit voltage, short circuit current, maximum power voltage, and maximum power current

3.1.1.2 Battery Charger

3.1.1.2.1 Requirements

The charger shall meet the following technical specification:

- The rated voltage of the charger shall be DC 12 V.
- The rated current of the charger shall be more than DC 20 A.
- The disconnection and reconnection voltages shall be adjustable at least in the following range:

  Low voltage of disconnection 11.1 V – 11.8 V

  Low voltage of reconnection 12.4 V – 12.8 V

High voltage of disconnection 13.7 V – 14.5 V

High voltage of reconnection 13.0 V – 13.8 V

- The charger clearly indicates the mode of operation by means of display or LED.
- The charger shall have protection against short circuit, overvoltage, deep discharge for the battery, and inverse connection of the polarity.
- The charger shall be equipped with terminal blocks to connect cables.

3.1.1.2.2 Markings

The charger shall have a name plate on it at least the following information and specification:

- Name or trademark of manufacture
- Model and serial number
- Country of origin
- Rated voltage and rated current

3.1.1.3 Charge Controller

3.1.1.3.1 Requirements

The controller shall meet the following technical specification:

- The rated voltage of the controller shall be DC 12 V.
- The rated PV input current of the controller shall be more than DC 4.5 A.
- The rated load current of the controller shall be more than DC 4.5 A.
- The disconnection and reconnection voltages shall be adjustable at least in the following range:

  Low voltage of disconnection 11.1 V – 11.8 V

  Low voltage of reconnection 12.4 V – 12.8 V

  High voltage of disconnection 13.7 V – 14.5 V

  High voltage of reconnection 13.0 V – 13.8 V
- The controller clearly indicates the mode of operation by means of display or LED.
- The controller shall have protection against short circuit, overvoltage, deep discharge for the battery, and inverse connection of the polarity.
- The controller shall be equipped with terminal blocks to connect cables.

3.1.1.3.2 Markings

The controller shall have a name plate on it at least the following information and specification:

- Name or trademark of manufacture
- Model and serial number
- Country of origin
- Rated voltage, rated PV input current, and rated load current

3.1.1.4 Storage Battery

3.1.1.4.1 Requirements

The battery shall meet the following technical specification:

- The battery shall be a valve regulated lead-acid battery, sealed type, and deep cycle use.
- The nominal voltage of the battery shall be DC 12 V.
- The rated capacity of the battery shall be more than 100 Ah/10 hr.
- The allowable depth of discharge shall be more than 50%.
- The battery clearly indicates the polarity—red for positive electrode and black for negative electrode.
- The battery shall be equipped with terminal covers to prevent the User from electric shock.
- The battery shall be shipped after it is fully charged.

3.1.1.4.2 Markings

The battery shall have a name plate on it at least the following information and specification:

- Name or trademark of manufacture
- Model and serial number
- Country of origin
- Rated voltage and rated capacity

3.1.1.5 Others

3.1.1.5.1 Requirements

The other components shall meet the following technical specification:

- The rated current of the breaker for PV input circuit shall be more than 30 A.
- The rated current of the breaker for battery charging circuit shall be more than 20 A.
- The rated current of the breaker for lighting circuit shall be more than 10 A.
- The breaker shall be Molded Case Circuit Breaker (MCCB) and bipolar type.
- The switch shall be bipolar type.
- The outlet shall be special type for DC circuit use.
- The rated voltage of the lighting shall be DC 12 V.
- The rated input of the lighting shall be more than 13 W.
- The lighting shall be fluorescent lamp specially developed for DC circuit use.
- The cable between an outdoor and indoor junction box shall be double circuit with a conductor diameter of 25 mm^2.
- The digital multimeter shall have the function of measuring ohmic resistance and voltage.
- The radio shall be DC 12 V use with a DC plug, and the output shall be approximately 5 W.

3.1.1.5.2 Markings

The other components shall indicate the following information and specification on it, if any.

- Name or trademark of manufacture
- Model and serial number
- Country of origin
- Rated voltage and rated input

3.1.2 Household Components

3.1.2.1 Charge Controller

The requirement and marking is the same as described in 3.1.1.3.

3.1.2.2 Storage Battery

The requirement and marking is the same as described in 3.1.1.4 except the following points:

- The battery shall be a lead-acid battery, vented type, and trickle use.
- The rated capacity of the battery shall be more than 80 Ah/10 hr.
- The battery shall be dry-charged and be shipped with necessary electrolyte.

3.1.2.3 Others

The requirement and marking is the same as described in 3.1.1.5 except the following point:

- The rated input of the lighting shall be more than 9 W.
- The rated current of the breaker shall be more than 10 A.

3.2 Public Facility

A Public Facility consists of PV module, charge controller, storage battery, breaker, switch, outlet, lighting, and wiring. Since the facility is operated at the system voltage of DC 12 V, all the equipment, devices, and materials for the system shall be suited for the above voltage.

3.2.1 PV Module

The requirement and marking is the same as described in 3.1.1.1.

3.2.2 Charge Controller

The requirement and marking is the same as described in 3.1.1.3 except the following points:

- The rated PV input current of the controller shall be more than DC 20 A.
- The rated load current of the controller shall be more than DC 20 A.

3.2.3 Storage Battery

The requirement and marking is the same as described in 3.1.1.4 except the following point:

- The rated capacity of the battery shall be more than 350 Ah/10 hr.

3.2.4 Others

The requirement and marking is the same as described in 3.1.1.5 except the following points:

- The rated current of the breaker shall be more than 20 A.
- The rated input of the lighting shall be more than 11 W.
- The cable from an outdoor junction box to the battery shall be single circuit with a conductor diameter of 25 mm^2.

3.3 SHS

A SHS consists of PV module, charge controller, storage battery, breaker, switch, outlet, lighting, and wiring. Since the SHS is operated at the system voltage of DC 12 V, all the equipment, devices, and materials for the system shall be suited for the above voltage.

3.3.1 PV Module

The requirement and marking is the same as described in 3.1.1.1.

3.3.2 Charge Controller

The requirement and marking is the same as described in 3.1.1.3.

3.3.3 Storage Battery

The requirement and marking is the same as described in 3.1.1.4 except the following point:

- The rated capacity of the battery shall be more than 50 Ah/10 hr.

3.3.4 Others

The requirement and marking is the same as described in 3.1.1.5 except the following points:

- The rated current of the breaker shall be more than 10 A.
- The rated input of the lighting shall be more than 9 W.

3.4 Street Lighting

A Street Lighting consists of PV module, charge controller, storage battery, breaker, switch, outlet, lighting, and wiring. Since the lighting is operated at the system voltage of DC 12 V, all the equipment, devices, and materials for the system shall be suited for the above voltage.

3.4.1 PV Module

The requirement and marking is the same as described in 3.1.1.1.

3.4.2 Charge Controller

The requirement and marking is the same as described in 3.1.1.3 except the following point:

- The controller shall have the function of timer-control to switch on and off the load on a set time.

3.4.3 Storage Battery

The requirement and marking is the same as described in 3.1.1.4 except the following point:

- The rated capacity of the battery shall be more than 60 Ah/10 hr.

3.4.4 Others

The requirement and marking is the same as described in 3.1.1.5 except the following points:

- The rated current of the breaker shall be more than 10 A.
- The lighting shall be a fluorescent lamp and outdoor use, and its rated input shall be more than 25 W.
- All the cable shall be of a conductor diameter of 6 mm^2.

4 Installation

4.1 BCS

4.1.1 Station Components

4.1.1.1 PV Module

The PV array—a set of PV modules—shall be installed and erected as follows:

- The tilt angle of the array shall be fixed on 15 degrees, and the array shall face due south.
- The PV array shall be set up on the ground beside BCS and are installed on galvanized steel frames bolted on a reinforced concrete foundation. The Contractor shall propose the design of the frames and foundation to the Purchaser for approval considering the design wind pressure.
- The steel frames shall be earthed using an earth rod, and the color of the earthling cable shall be green-and-yellow.
- The cables of the PV modules shall be led to an outdoor junction box and be connected to a bus bar in the box. And then, the cables shall be laid underground using flexible conduit and be led to an indoor junction box inside BCS.
- To keep the PV array from being robbed and damaged, the Contractor shall erect a fence around the array. The fence comprised of wire netting and barbed wire shall have a gate with a lock. The Contractor shall propose the design of the fence to the Purchaser for approval in consideration of preventing the array from being shaded by the fence in mid winter.

4.1.1.2 Battery Charger

The charger shall be installed as follows:

- The charger shall be installed in a junction box, which is firmly fixed on the interior wall of BCS.
- At the end of the cables for charging batteries, plugs shall be equipped to clip battery terminals. The plugs shall have color identification—red for positive electrode and black for negative electrode—to prevent the User from misunderstanding the polarity of the circuit.
- All cables are dragged into the junction box from the bottom.

4.1.1.3 Charge Controller

The controller shall be installed as follows:

- The controller shall be installed in the same junction box for the battery chargers.
- All cables are dragged into the junction box from the bottom.

4.1.1.4 Storage Battery

The battery shall be installed as follows:

- The battery shall be horizontally installed on the flat floor at a drafty place.
- The battery shall be stored in a battery box, which has a lid fitted with a lock and a hole backside for the purpose of air ventilation and wiring. The box shall be nonmetal and made from materials enduring acid solution.

- The cable shall be firmly bolted to the terminal at the specified torque.

4.1.1.5 Others

The other components shall be installed as follows:

- The breaker shall be installed in the same junction box for the battery chargers.
- The lighting will be fixed on the beam or ceiling of BCS.
- The cable of interior wiring shall be laid passing through the shortest distance, and shall be fixed on the wall and ceiling using cable clips.

4.1.2 Household Components

4.1.2.1 Charge Controller

The controller shall be installed as described in 4.1.1.3 except the following point:

- The controller shall be installed in a junction box, which is firmly fixed on the interior wall of the house.

4.1.2.2 Storage Battery

The battery shall be installed as described in 4.1.1.4. The Contractor shall be responsible for the initial charge of vented type batteries and follow the manufacturer's instructions to charge them. All batteries shall be put on seals and/or stickers indicating numbers or names to identify owners of batteries.

4.1.2.3 Others

The other components shall be installed as described in 4.1.1.5 except the following points:

- The switch shall be installed in each circuit for the lighting and be fixed on the interior wall.
- The lighting will be fixed on the beam or ceiling of the house.

4.2 Public Facility

4.2.1 PV Module

The PV array—a set of PV modules—shall be installed and erected as described in 4.1.1.1 except the following point:

- The cables of the PV modules shall be led to an outdoor junction box and be connected to a bus bar in the box. And then, the cables shall be laid underground using flexible conduit and be led to an indoor junction box inside the facility.

4.2.2 Charge Controller

The controller shall be installed as described in 4.1.2.1.

4.2.3 Storage Battery

The battery shall be installed as described in 4.1.1.4.

4.2.4 Others

The other components shall be as described in 4.1.2.3.

4.3 SHS

4.3.1 PV Module

The module shall be installed and erected as follows:

- The tilt angle of the module shall be fixed on 15 degrees, and the module shall face due south.
- The module shall be installed on the top of a galvanized steel pole, which is not less than 4 m in length. The Contractor will dig a hole approximately 1,000 mm in depth to erect the steel pole. The pole will be firmly fixed in the ground using gravel and concrete. The Contractor shall propose the way of installation to the Purchaser for approval considering the design wind pressure.
- The frame of the module shall be earthed using an earth rod, and the color of the earthling cable shall be green-and-yellow.
- The cable from the module will be led overhead and fixed on the exterior wall using a messenger wire. The Contractor will drill a hole on the wall with the User consent and lead the cable inside through the hole.
- The module shall be installed in the proper space to minimize the period of shade on it. Installation technicians would benefit using site control devices such as solar pathfinder.

4.3.2 Charge Controller

The controller shall be installed as described in 4.1.2.1.

4.3.3 Storage Battery

The battery shall be installed as described in 4.1.1.4.

4.3.4 Others

The other components shall be as described in 4.1.2.3.

4.4 Street Lighting

4.4.1 PV Module

The module shall be installed and erected as described in 4.3.1 except the following point:

- The cable from the module will be laid along the pole and be connected to the junction box for the charge controller.

4.4.2 Charge Controller

The controller shall be installed as described in 4.1.1.3 except the following point:

- The controller shall be installed in a junction box, which firmly fixed on the pole.

4.4.3 Storage Battery

The battery shall be installed as described in 4.1.1.4 except the following point:

- The battery shall be stored in a battery box, which is firmly fixed on the bottom of the pole and has a lid fitted with a lock. The box shall be metal and be earthed using the same earth rod for the module, and the color of the earthling cable shall be green-and-yellow.

4.4.4 Others

The other components shall be installed as described in 4.1.2.3 except the following point:

- The lighting shall be installed on the top of the pole, but it shall not prevent the PV module from being shaded.

5 Tests

For each component of the PV systems, the Contractor shall submit the result of factory tests to the Purchaser and carry out the field tests as follows:

5.1 PV Module

5.1.1 Factory Tests

- The PV module shall be free from any harmful flaw in its appearance.
- The dimension of the module shall be as designed.
- The maximum output of the module shall meet the technical requirement.

5.1.2 Field Tests

- The PV module shall be free from any harmful flaw in its appearance.
- The module shall be connected correctly in accordance with the approved drawings.
- The open circuit voltage of the module shall conform to the characteristic curve.
- The positive and negative electrode shall be absolutely insulated so as not to short-circuit.

5.2 Battery Charger

5.2.1 Factory Tests

- The charger shall be free from any harmful flaw in its appearance.
- The dimension of the charger shall be as designed.
- The function of the charger shall meet the technical requirement.

5.2.2 Field Tests

- The charger shall be free from any harmful flaw in its appearance.
- The charger shall be connected correctly in accordance with the approved drawings.
- The charger shall work correctly in accordance with the manual.
- The positive and negative electrode shall be absolutely insulated so as not to short-circuit.

5.3 Charge Controller

5.3.1 Factory Tests

- The controller shall be free from any harmful flaw in its appearance.
- The dimension of the controller shall be as designed.
- The function of the controller shall meet the technical requirement.

5.3.2 Field Tests

- The controller shall be free from any harmful flaw in its appearance.
- The controller shall be connected correctly in accordance with the approved drawings.

- The controller shall work correctly in accordance with the manual.
- The positive and negative electrode shall be absolutely insulated so as not to short-circuit.

5.4 Storage Battery

5.4.1 Factory Test

- The battery shall be free from any harmful flaw in its appearance.
- The dimension of the battery shall be as designed.
- The voltage and capacity of the battery shall meet the technical requirement.

5.4.2 Field Test

- The battery shall be free from any harmful flaw in its appearance.
- The battery shall be connected correctly in accordance with the approved drawings.
- The voltage of the battery shall meet the technical requirement.
- The positive and negative electrode shall be absolutely insulated so as not to short-circuit.

5.5 Others

5.5.1 Factory Test

- The other components shall be free from any harmful flaw in its appearance.
- The dimension of other components shall be as designed.

5.5.2 Field Test

- The other components shall be free from any harmful flaw in its appearance.
- The other components shall be connected correctly in accordance with the approved drawings.
- The positive and negative electrode shall be absolutely insulated so as not to short-circuit.

6 Training and Maintenance

6.1 Training

To facilitate the skills of the operation and maintenance crews assigned by the Purchaser, the Contractor has the following obligations:

- Throughout the installation and field tests of the PV systems, the Contractor shall show his engineering works to the Purchaser, Engineer, and crews.
- Not later than a week before the commencement of commercial operation of the PV systems, the Contractor shall organize the training course—at least for three (3) days—for the Purchaser Engineer, and crews. The course shall be held based on the operation and maintenance manuals for the PV systems.
- The Contractor shall arrange all the materials, tools, and equipment needed for the training at his own expense.

6.2 Maintenance

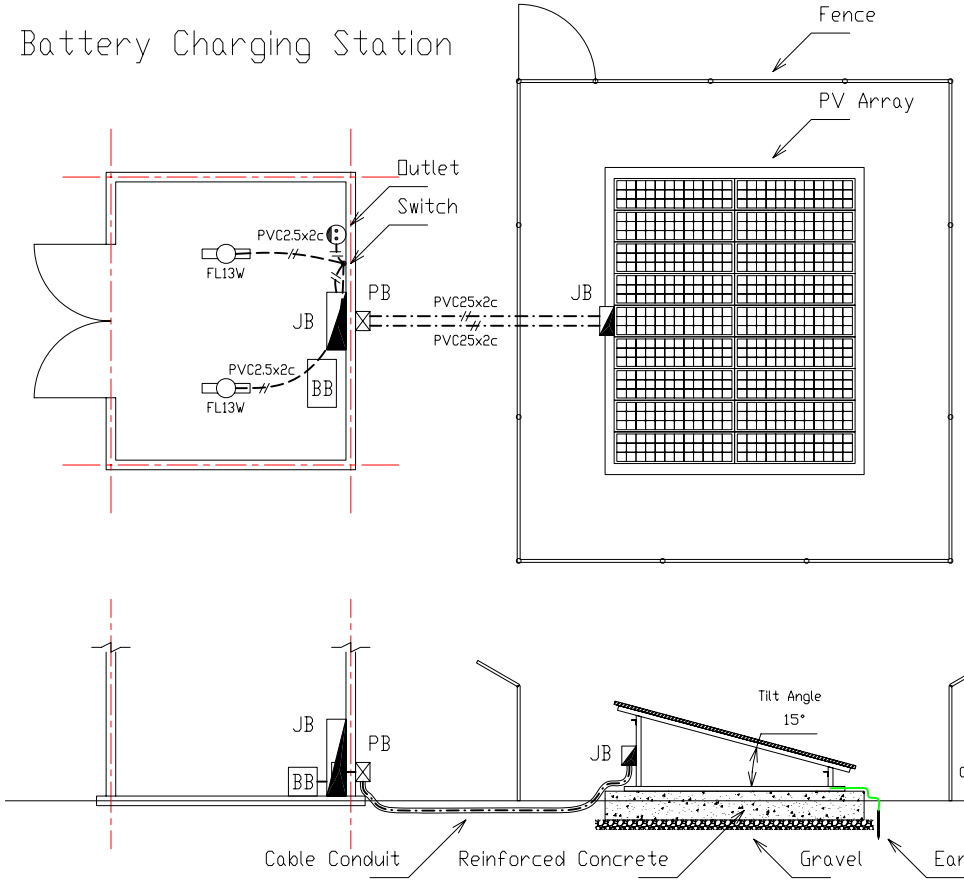
The Contractor shall execute periodical maintenance works of the PV systems twice up to February 2007. The requirements of maintenance work are as follows:

- The maintenance work shall be done for each system and at least cover the following items: weather information, appearance inspection, voltage measurement of terminals, cleaning, adjustment, measurement of battery electrolyte level, refill of distilled water, and replacement of defective components.
- The Purchaser will decide the date of maintenance work, and the Contractor shall execute the maintenance work on the date in the presence of the Purchaser, Engineer, and crews. The Contractor shall immediately prepare the result of maintenance work and report it at the site.
- The Contractor shall arrange all the materials, tools, and equipment needed for the maintenance at his own expense. No additional charge will be paid for the work to the Contractor.
- Throughout the maintenance work of the PV systems, the Contractor shall show his maintenance work to the maintenance crews assigned by the Purchaser.

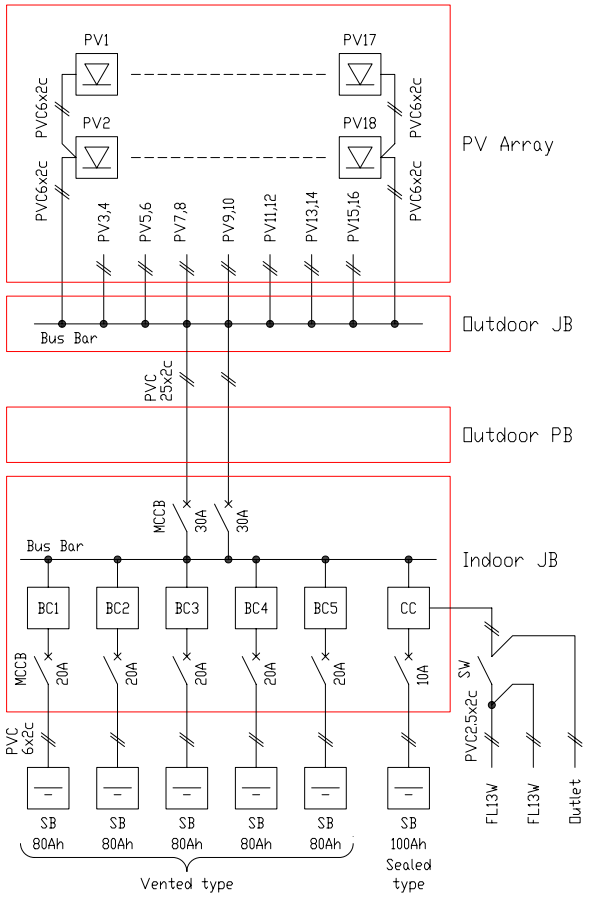
Annex 1 Drawings of PV Systems

RevNo	Revision note	Date	Signature	Checked

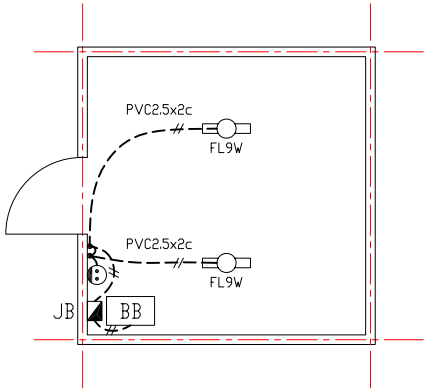
Battery Charging Station



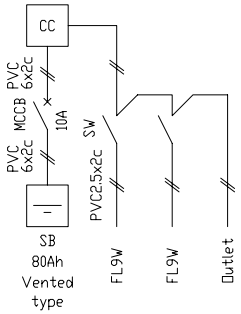
BCS Circuit



Household



Household Circuit



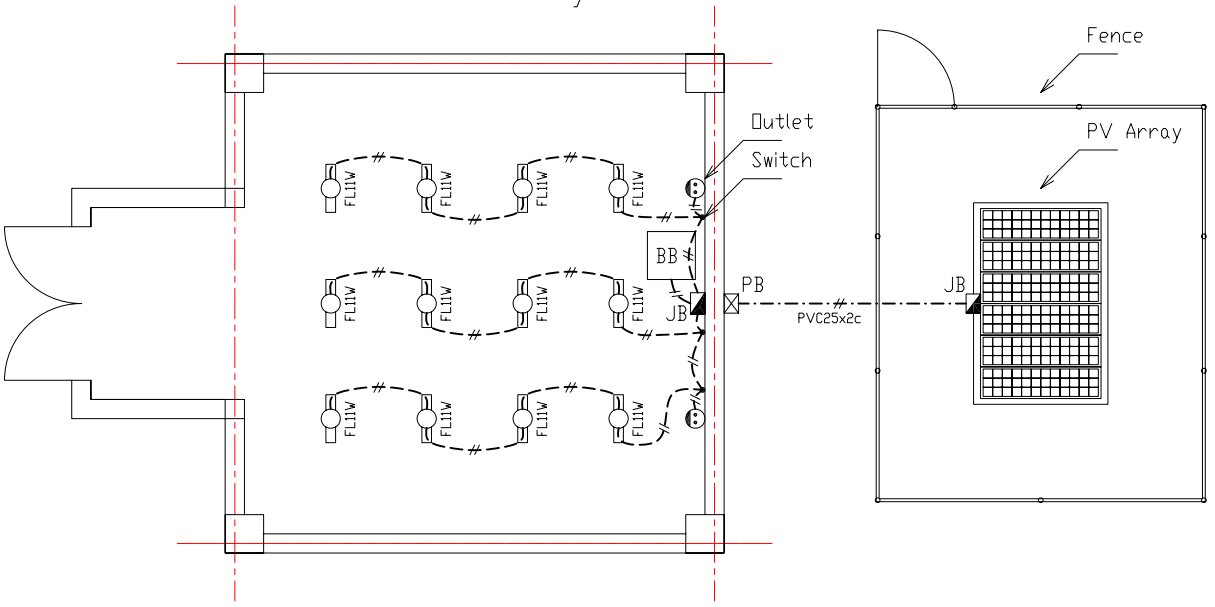
Abbreviations

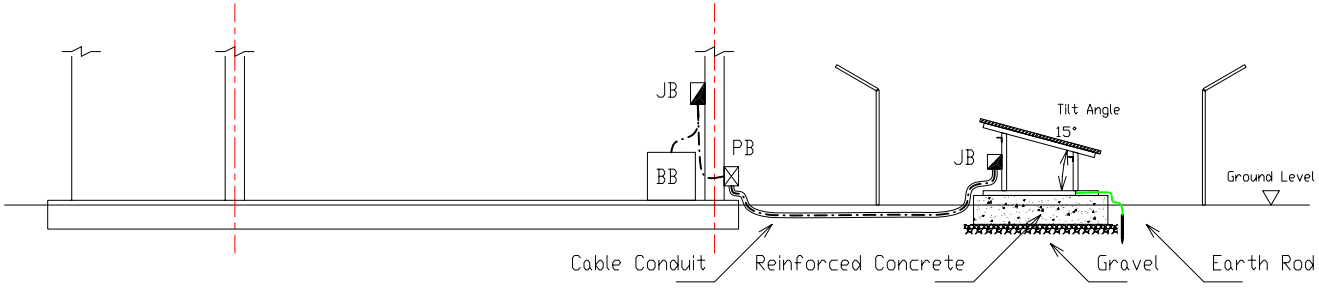
BB	Battery Box	JB	Joint Box	PVC	Polyvinyl Chloride Cable
BC	Battery Charger	MCCB	Molded Case Circuit Breaker	SB	Storage Battery
CC	Charge Controller	PB	Pull Box	SW	Switch
FL	Fluorescent Light	PV	Photovoltaic		

Itemref	Quantity	Title/Name, designation, material, dimension etc			Article No./Reference	
Designed by K.SAITO		Checked by T.OGAWA	Approved by - date M.NISHIKAWA -	File name TSJ annex1	Date 09/15/2005	Scale
Japan International Cooperation Agency MASTER PLAN STUDY FOR UTILIZATION OF SOLAR ENERGY IN THE FEDERAL REPUBLIC OF NIGERIA				BATTERY CHARGING STATION		
				TSJ-001	Edition 001	Sheet 001

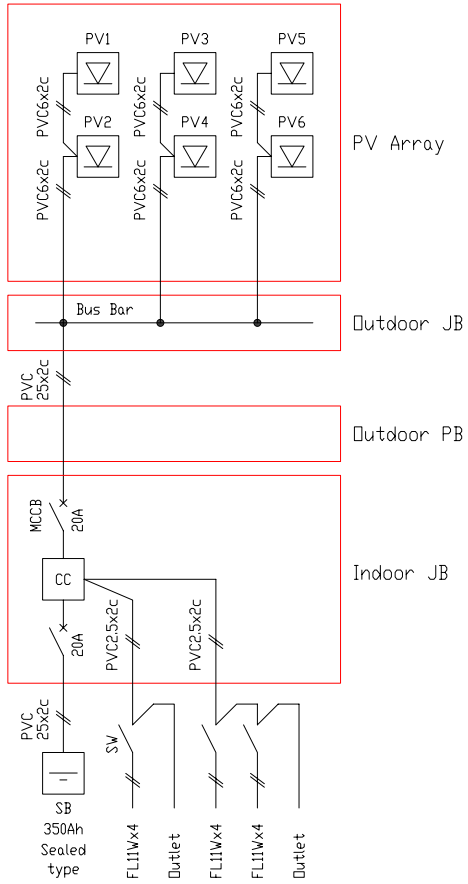
RevNo	Revision note	Date	Signature	Checked

Public Facility





Public Facility Circuit



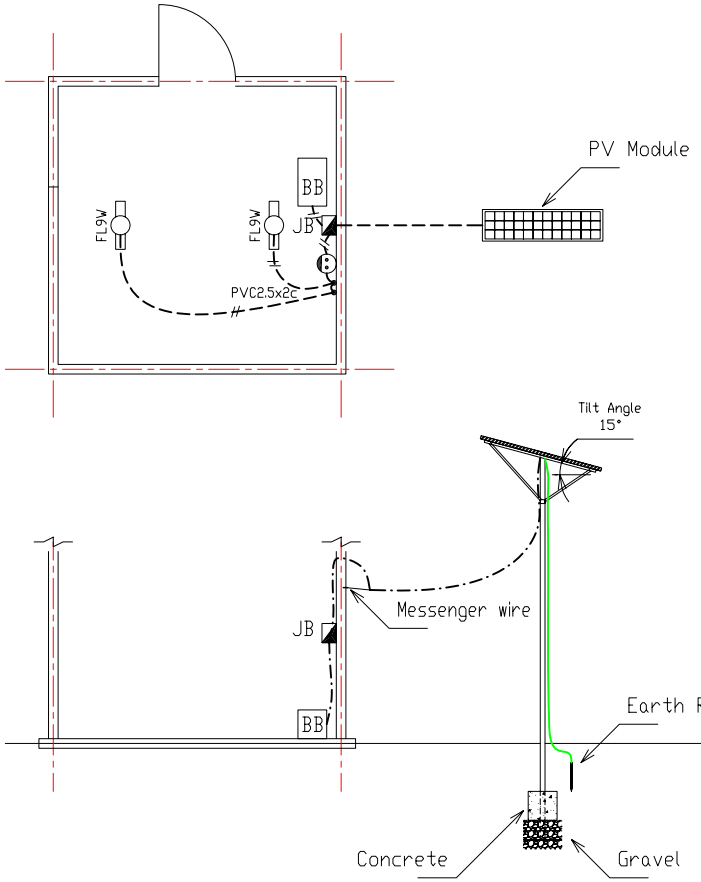
Abbreviations

BB	Battery Box	MCCB	Molded Case Circuit Breaker	SB	Storage Battery
CC	Charge Controller	PB	Pull Box	SW	Switch
FL	Fluorescent Light	PV	Photovoltaic		
JB	Joint Box	PVC	Polyvinyl Chloride Cable		

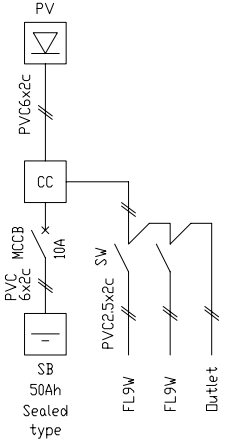
Itemref	Quantity	Title/Name, designation, material, dimension etc			Article No./Reference	
Designed by K.SAITO		Checked by T.OGAWA	Approved by - date M.NISHIKAWA -	File name TSJ annex1	Date 09/15/2005	Scale
Japan International Cooperation Agency MASTER PLAN STUDY FOR UTILIZATION OF SOLAR ENERGY IN THE FEDERAL REPUBLIC OF NIGERIA				PUBLIC FACILITY		
				TSJ-002	Edition 001	Sheet 002

RevNo	Revision note	Date	Signature	Checked

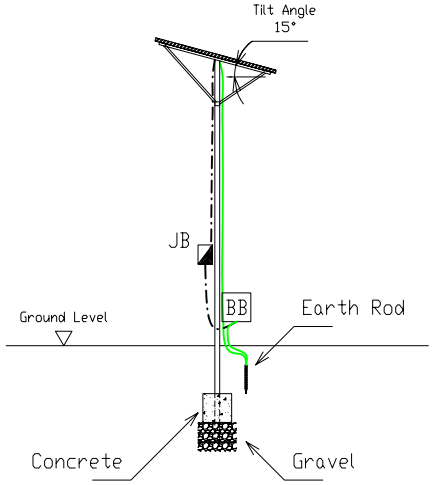
Solar Home System



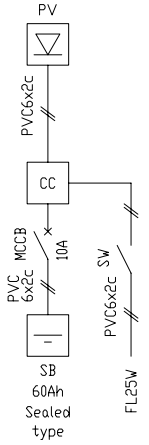
SHS Circuit



Street Lighting



Street Lighting Circuit



Abbreviations

BB	Battery Box	MCCB	Molded Case Circuit Breaker	SB	Storage Battery
CC	Charge Controller	PB	Pull Box	SW	Switch
FL	Fluorescent Light	PV	Photovoltaic		
JB	Joint Box	PVC	Polyvinyl Chloride Cable		

Itemref	Quantity	Title/Name, designation, material, dimension etc			Article No./Reference	
Designed by K.SAITO		Checked by T.OGAWA	Approved by - date M.NISHIKAWA -	File name TSJ annex1	Date 09/15/2005	Scale
Japan International Cooperation Agency MASTER PLAN STUDY FOR UTILIZATION OF SOLAR ENERGY IN THE FEDERAL REPUBLIC OF NIGERIA				SOLAR HOME SYSTEM/SOLAR LIGHTING		
				TSJ-003	Edition 001	Sheet 003

Annex 2 Technical Data Sheet

Technical Data Sheet

	Item	Requirement	Proposed	Remarks
1	**BCS**			
1.1	Station Components			
1.1.1	PV Module			
1.1.1.1	Name of manufacture	—		
1.1.1.2	Model number	—		
1.1.1.3	Country of origin	—		
1.1.1.4	Type	Mono-crystalline or poly-crystalline		
1.1.1.5	Maximum power (W)	55 W or more (Not deteriorate by 10% in ten-year operation)		
1.1.1.6	Open circuit voltage (V)	20.5 V or more		
1.1.1.7	Short circuit current (A)	3.4 A or more		
1.1.1.8	Maximum power voltage (V)	16.5 V or more		
1.1.1.9	Maximum power current (A)	3.15 A or more		
1.1.1.10	Accessories	A bypass diode is required.		
1.1.1.11	Characteristics curve	Voltage-current characteristics curve shall be attached.		
1.1.1.12	Catalogue	The catalogue of the product shall be attached.		
1.1.2	Battery Charger			
1.1.2.1	Name of manufacture	—		
1.1.2.2	Model number	—		
1.1.2.3	Country of origin	—		
1.1.2.4	Rated voltage (V)	DC 12 V		
1.1.2.5	Rated current (A)	More than DC 20 A		
1.1.2.6	Low voltage of disconnection	Adjustable between 11.1 V – 11.8 V		
1.1.2.7	Low voltage of reconnection	Adjustable between 12.4 V – 12.8 V		
1.1.2.8	High voltage of disconnection	Adjustable between 13.7 V – 14.5 V		
1.1.2.9	High voltage of reconnection	Adjustable between 13.0 V – 13.8 V		
1.1.2.10	Protection	Protected against short circuit, OV, deep discharge, and inverse connection.		
1.1.2.11	Accessories	A terminal block, display and/or LED are required.		
1.1.2.12	Catalogue	The catalogue of the product shall be attached.		
1.1.3	Charge Controller			
1.1.3.1	Name of manufacture	—		
1.1.3.2	Model number	—		
1.1.3.3	Country of origin	—		
1.1.3.4	Rated voltage (V)	DC 12 V		
1.1.3.5	Rated current (A)	More than DC 4.5 A		
1.1.3.6	Low voltage of disconnection	Adjustable between 11.1 V – 11.8 V		
1.1.3.7	Low voltage of reconnection	Adjustable between 12.4 V – 12.8 V		
1.1.3.8	High voltage of disconnection	Adjustable between 13.7 V – 14.5 V		
1.1.3.9	High voltage of reconnection	Adjustable between 13.0 V – 13.8 V		
1.1.3.10	Protection	Protected against short circuit, OV, deep discharge, and inverse connection.		
1.1.3.11	Accessories	A terminal block, display and/or LED are required.		
1.1.3.12	Catalogue	The catalogue of the product shall be attached.		
1.1.4	Storage Battery			
1.1.4.1	Name of manufacture	—		
1.1.4.2	Model number	—		
1.1.4.3	Country of origin	—		
1.1.4.4	Type	Valve regulated lead-acid, sealed type, and deep cycle use.		
1.1.4.5	Rated voltage (V)	DC 12 V		
1.1.4.6	Rated capacity (Ah)	More than 100 Ah/10hr		
1.1.4.7	Capacity at 1C[*1] discharge (Ah)	For reference, *1 1C is 1-hour rate discharging current.		
1.1.4.8	Capacity at 0.5C[*2] discharge (Ah)	For reference, *2 0.5C is 2-hour rate discharging current.		
1.1.4.9	Capacity at 0.2C[*3] discharge (Ah)	For reference, *3 0.2C is 5-hour rate discharging current.		
1.1.4.10	Capacity at 0.1C[*4] discharge (Ah)	For reference, *4 0.1C is 10-hour rate discharging current.		
1.1.4.11	Capacity at 0.05C[*5] discharge (Ah)	For reference, *5 0.05C is 20-hour rate discharging current.		
1.1.4.12	Allowable DOD	More than 50%		
1.1.4.13	Expected cycle life at DOD of 50% (cycle)	For reference		
1.1.4.14	Expected cycle life at DOD of 100% (cycle)	For reference		
1.1.4.15	Accessories	Polarity identification and terminal covers are required.		
1.1.4.16	Catalogue	The catalogue of the product shall be attached.		
1.1.5	Other Components			
1.1.5.1	Circuit Breaker (CB)			
1.1.5.1.1	Name of manufacture	—		
1.1.5.1.2	Model number	—		
1.1.5.1.3	Country of origin	—		
1.1.5.1.4	Rating for PV input circuit CB	MCCB, bipolar, rated current shall be more than 30 A		
1.1.5.1.5	Rating for battery charging circuit CB	MCCB, bipolar, rated current shall be more than 20 A		
1.1.5.1.6	Rating for lighting circuit CB	MCCB, bipolar, rated current shall be more than 10 A		
1.1.5.1.7	Catalogue	The catalogue of the product shall be attached.		

Name of Bidder

Name of Authorized Signatory, Position

Signature, Date

Technical Data Sheet

	Item	Requirement	Proposed	Remarks
1.1.5.2	Lighting			
1.1.5.2.1	Name of manufacture	—		
1.1.5.2.2	Model number	—		
1.1.5.2.3	Country of origin	—		
1.1.5.2.4	Rating	DC 12 V, fluorescent lamp, more than 13 W		
1.1.5.2.5	Catalogue	The catalogue of the product shall be attached.		
1.1.5.3	Digital Multimeter			
1.1.5.3.1	Name of manufacture	—		
1.1.5.3.2	Model number	—		
1.1.5.3.3	Country of origin	—		
1.1.5.3.4	Function	Measuring ohmic resistance and voltage		
1.1.5.3.5	Catalogue	The catalogue of the product shall be attached.		
1.1.5.4	Radio			
1.1.5.4.1	Name of manufacture	—		
1.1.5.4.2	Model number	—		
1.1.5.4.3	Country of origin	—		
1.1.5.4.4	Output	Approximately 5 W		
1.1.5.4.5	Catalogue	The catalogue of the product shall be attached.		
1.2	Household Components			
1.2.1	Charge Controller			
1.2.2	Name of manufacture	—		
1.2.3	Model number	—		
1.2.4	Country of origin	—		
1.2.5	Rated voltage (V)	DC 12 V		
1.2.6	Rated current (A)	More than DC 4.5 A		
1.2.7	Low voltage of disconnection	Adjustable between 11.1 V – 11.8 V		
1.2.8	Low voltage of reconnection	Adjustable between 12.4 V – 12.8 V		
1.2.9	High voltage of disconnection	Adjustable between 13.7 V – 14.5 V		
1.2.10	High voltage of reconnection	Adjustable between 13.0 V – 13.8 V		
1.2.11	Protection	Protected against short circuit, OV, deep discharge, and inverse connection.		
1.2.12	Accessories	A terminal block, display and/or LED are required.		
1.2.13	Catalogue	The catalogue of the product shall be attached.		
1.2.2	Storage Battery			
1.2.2.1	Name of manufacture	—		
1.2.2.2	Model number	—		
1.2.2.3	Country of origin	—		
1.2.2.4	Type	Lead-acid, vented type, and trickle use.		
1.2.2.5	Rated voltage (V)	DC 12 V		
1.2.2.6	Rated capacity (Ah)	More than 80 Ah/10hr		
1.2.2.7	Capacity at 1C*1 discharge (Ah)	For reference, *1 1C is 1-hour rate discharging current.		
1.2.2.8	Capacity at 0.5C*2 discharge (Ah)	For reference, *2 0.5C is 2-hour rate discharging current.		
1.2.2.9	Capacity at 0.2C*3 discharge (Ah)	For reference, *3 0.2C is 5-hour rate discharging current.		
1.2.2.10	Capacity at 0.1C*4 discharge (Ah)	For reference, *4 0.1C is 10-hour rate discharging current.		
1.2.2.11	Capacity at 0.05C*5 discharge (Ah)	For reference, *5 0.05C is 20-hour rate discharging current.		
1.2.2.12	Expected cycle life at DOD of 50% (cycle)	For reference		
1.2.2.13	Expected cycle life at DOD of 100% (cycle)	For reference		
1.2.2.14	Accessories	Polarity identification and terminal covers are required.		
1.2.2.15	Catalogue	The catalogue of the product shall be attached.		
1.2.3	Other Components			
1.2.3.1	Circuit Breaker (CB)			
1.2.3.1.1	Name of manufacture	—		
1.2.3.1.2	Model number	—		
1.2.3.1.3	Country of origin	—		
1.2.3.1.4	Rating	MCCB, bipolar, rated current shall be more than 10 A		
1.2.3.1.5	Catalogue	The catalogue of the product shall be attached.		
1.2.3.2	Lighting			
1.2.3.2.1	Name of manufacture	—		
1.2.3.2.2	Model number	—		
1.2.3.2.3	Country of origin	—		
1.2.3.2.4	Rating	DC 12 V, fluorescent lamp, more than 9 W		
1.2.3.2.5	Catalogue	The catalogue of the product shall be attached.		

Name of Bidder

Name of Authorized Signatory, Position

Signature, Date

Technical Data Sheet

	Item	Requirement	Proposed	Remarks
2	**Public Facility**			
2.1	PV Module			
2.1.1	Name of manufacture	—		
2.1.2	Model number	—		
2.1.3	Country of origin	—		
2.1.4	Type	Mono-crystalline or poly-crystalline		
2.1.5	Maximum power (W)	55 W or more (Not deteriorate by 10% in ten-year operation)		
2.1.6	Open circuit voltage (V)	20.5 V or more		
2.1.7	Short circuit current (A)	3.4 A or more		
2.1.8	Maximum power voltage (V)	16.5 V or more		
2.1.9	Maximum power current (A)	3.15 A or more		
2.1.10	Accessories	A bypass diode is required.		
2.1.11	Characteristics curve	Voltage-current characteristics curve shall be attached.		
2.1.12	Catalogue	The catalogue of the product shall be attached.		
2.2	Charge Controller			
2.2.1	Name of manufacture	—		
2.2.2	Model number	—		
2.2.3	Country of origin	—		
2.2.4	Rated voltage (V)	DC 12 V		
2.2.5	Rated current (A)	More than DC 20 A		
2.2.6	Low voltage of disconnection	Adjustable between 11.1 V – 11.8 V		
2.2.7	Low voltage of reconnection	Adjustable between 12.4 V – 12.8 V		
2.2.8	High voltage of disconnection	Adjustable between 13.7 V – 14.5 V		
2.2.9	High voltage of reconnection	Adjustable between 13.0 V – 13.8 V		
2.2.10	Protection	Protected against short circuit, OV, deep discharge, and inverse connection.		
2.2.11	Accessories	A terminal block, display and/or LED are required.		
2.2.12	Catalogue	The catalogue of the product shall be attached.		
2.3	Storage Battery			
2.3.1	Name of manufacture	—		
2.3.2	Model number	—		
2.3.3	Country of origin	—		
2.3.4	Type	Valve regulated lead-acid, sealed type, and deep cycle use.		
2.3.5	Rated voltage (V)	DC 12 V		
2.3.6	Rated capacity (Ah)	More than 350 Ah/10hr		
2.3.7	Capacity at 1C[*1] discharge (Ah)	For reference, *1 1C is 1-hour rate discharging current.		
2.3.8	Capacity at 0.5C[*2] discharge (Ah)	For reference, *2 0.5C is 2-hour rate discharging current.		
2.3.9	Capacity at 0.2C[*3] discharge (Ah)	For reference, *3 0.2C is 5-hour rate discharging current.		
2.3.10	Capacity at 0.1C[*4] discharge (Ah)	For reference, *4 0.1C is 10-hour rate discharging current.		
2.3.11	Capacity at 0.05C[*5] discharge (Ah)	For reference, *5 0.05C is 20-hour rate discharging current.		
2.3.12	Allowable DOD	More than 50%		
2.3.13	Expected cycle life at DOD of 50% (cycle)	For reference		
2.3.14	Expected cycle life at DOD of 100% (cycle)	For reference		
2.3.15	Accessories	Polarity identification and terminal covers are required.		
2.3.16	Catalogue	The catalogue of the product shall be attached.		
2.4	Other Components			
2.4.1	Circuit Breaker (CB)			
2.4.1.1	Name of manufacture	—		
2.4.1.2	Model number	—		
2.4.1.3	Country of origin	—		
2.4.1.4	Rating	MCCB, bipolar, rated current shall be more than 20 A		
2.4.1.5	Catalogue	The catalogue of the product shall be attached.		
2.4.2	Lighting			
2.4.2.1	Name of manufacture	—		
2.4.2.2	Model number	—		
2.4.2.3	Country of origin	—		
2.4.2.4	Rating	DC 12 V, fluorescent lamp, more than 11 W		
2.4.2.5	Catalogue	The catalogue of the product shall be attached.		

Name of Bidder

Name of Authorized Signatory, Position

Signature, Date

Technical Data Sheet

	Item	Requirement	Proposed	Remarks
3	**SHS**			
3.1	PV Module			
3.1.1	Name of manufacture	—		
3.1.2	Model number	—		
3.1.3	Country of origin	—		
3.1.4	Type	Mono-crystalline or poly-crystalline		
3.1.5	Maximum power (W)	55 W or more (Not deteriorate by 10% in ten-year operation)		
3.1.6	Open circuit voltage (V)	20.5 V or more		
3.1.7	Short circuit current (A)	3.4 A or more		
3.1.8	Maximum power voltage (V)	16.5 V or more		
3.1.9	Maximum power current (A)	3.15 A or more		
3.1.10	Accessories	A bypass diode is required.		
3.1.11	Characteristics curve	Voltage-current characteristics curve shall be attached.		
3.1.12	Catalogue	The catalogue of the product shall be attached.		
3.2	Charge Controller			
3.2.1	Name of manufacture	—		
3.2.2	Model number	—		
3.2.3	Country of origin	—		
3.2.4	Rated voltage (V)	DC 12 V		
3.2.5	Rated current (A)	More than DC 4.5 A		
3.2.6	Low voltage of disconnection	Adjustable between 11.1 V – 11.8 V		
3.2.7	Low voltage of reconnection	Adjustable between 12.4 V – 12.8 V		
3.2.8	High voltage of disconnection	Adjustable between 13.7 V – 14.5 V		
3.2.9	High voltage of reconnection	Adjustable between 13.0 V – 13.8 V		
3.2.10	Protection	Protected against short circuit, OV, deep discharge, and inverse connection.		
3.2.11	Accessories	A terminal block, display and/or LED are required.		
3.2.12	Catalogue	The catalogue of the product shall be attached.		
3.3	Storage Battery			
3.3.1	Name of manufacture	—		
3.3.2	Model number	—		
3.3.3	Country of origin	—		
3.3.4	Type	Valve regulated lead-acid, sealed type, and deep cycle use.		
3.3.5	Rated voltage (V)	DC 12 V		
3.3.6	Rated capacity (Ah)	More than 50 Ah/10hr		
3.3.7	Capacity at 1C[*1] discharge (Ah)	For reference, *1 1C is 1-hour rate discharging current.		
3.3.8	Capacity at 0.5C[*2] discharge (Ah)	For reference, *2 0.5C is 2-hour rate discharging current.		
3.3.9	Capacity at 0.2C[*3] discharge (Ah)	For reference, *3 0.2C is 5-hour rate discharging current.		
3.3.10	Capacity at 0.1C[*4] discharge (Ah)	For reference, *4 0.1C is 10-hour rate discharging current.		
3.3.11	Capacity at 0.05C[*5] discharge (Ah)	For reference, *5 0.05C is 20-hour rate discharging current.		
3.3.12	Allowable DOD	More than 50%		
3.3.13	Expected cycle life at DOD of 50% (cycle)	For reference		
3.3.14	Expected cycle life at DOD of 100% (cycle)	For reference		
3.3.15	Accessories	Polarity identification and terminal covers are required.		
3.3.16	Catalogue	The catalogue of the product shall be attached.		
3.4	Other Components			
3.4.1	Circuit Breaker (CB)			
3.4.1.1	Name of manufacture	—		
3.4.1.2	Model number	—		
3.4.1.3	Country of origin	—		
3.4.1.4	Rating	MCCB, bipolar, rated current shall be more than 10 A		
3.4.1.5	Catalogue	The catalogue of the product shall be attached.		
3.4.2	Lighting			
3.4.2.1	Name of manufacture	—		
3.4.2.2	Model number	—		
3.4.2.3	Country of origin	—		
3.4.2.4	Rating	DC 12 V, fluorescent lamp, more than 9 W		
3.4.2.5	Catalogue	The catalogue of the product shall be attached.		

Name of Bidder

Name of Authorized Signatory, Position

Signature, Date

Technical Data Sheet

	Item	Requirement	Proposed	Remarks
4	**Street Lighting**			
4.1	PV Module			
4.1.1	Name of manufacture	—		
4.1.2	Model number	—		
4.1.3	Country of origin	—		
4.1.4	Type	Mono-crystalline or poly-crystalline		
4.1.5	Maximum power (W)	55 W or more (Not deteriorate by 10% in ten-year operation)		
4.1.6	Open circuit voltage (V)	20.5 V or more		
4.1.7	Short circuit current (A)	3.4 A or more		
4.1.8	Maximum power voltage (V)	16.5 V or more		
4.1.9	Maximum power current (A)	3.15 A or more		
4.1.10	Accessories	A bypass diode is required.		
4.1.11	Characteristics curve	Voltage-current characteristics curve shall be attached.		
4.1.12	Catalogue	The catalogue of the product shall be attached.		
4.2	Charge Controller			
4.2.1	Name of manufacture	—		
4.2.2	Model number	—		
4.2.3	Country of origin	—		
4.2.4	Rated voltage (V)	DC 12 V		
4.2.5	Rated current (A)	More than DC 4.5 A		
4.2.6	Low voltage of disconnection	Adjustable between 11.1 V – 11.8 V		
4.2.7	Low voltage of reconnection	Adjustable between 12.4 V – 12.8 V		
4.2.8	High voltage of disconnection	Adjustable between 13.7 V – 14.5 V		
4.2.9	High voltage of reconnection	Adjustable between 13.0 V – 13.8 V		
4.2.10	Protection	Protected against short circuit, OV, deep discharge, and inverse connection.		
4.2.11	Function	The controller shall have a timer-control function.		
4.2.12	Accessories	A terminal block, display and/or LED are required.		
4.2.13	Catalogue	The catalogue of the product shall be attached.		
4.3	Storage Battery			
4.3.1	Name of manufacture	—		
4.3.2	Model number	—		
4.3.3	Country of origin	—		
4.3.4	Type	Valve regulated lead-acid, sealed type, and deep cycle use.		
4.3.5	Rated voltage (V)	DC 12 V		
4.3.6	Rated capacity (Ah)	More than 60 Ah/10hr		
4.3.7	Capacity at 1C[*1] discharge (Ah)	For reference, *1 1C is 1-hour rate discharging current.		
4.3.8	Capacity at 0.5C[*2] discharge (Ah)	For reference, *2 0.5C is 2-hour rate discharging current.		
4.3.9	Capacity at 0.2C[*3] discharge (Ah)	For reference, *3 0.2C is 5-hour rate discharging current.		
4.3.10	Capacity at 0.1C[*4] discharge (Ah)	For reference, *4 0.1C is 10-hour rate discharging current.		
4.3.11	Capacity at 0.05C[*5] discharge (Ah)	For reference, *5 0.05C is 20-hour rate discharging current.		
4.3.12	Allowable DOD	More than 50%		
4.3.13	Expected cycle life at DOD of 50% (cycle)	For reference		
4.3.14	Expected cycle life at DOD of 100% (cycle)	For reference		
4.3.15	Accessories	Polarity identification and terminal covers are required.		
4.3.16	Catalogue	The catalogue of the product shall be attached.		
4.4	Other Components			
4.4.1	Circuit Breaker (CB)			
4.4.1.1	Name of manufacture	—		
4.4.1.2	Model number	—		
4.4.1.3	Country of origin	—		
4.4.1.4	Rating	MCCB, bipolar, rated current shall be more than 10 A		
4.4.1.5	Catalogue	The catalogue of the product shall be attached.		
4.4.2	Lighting			
4.4.2.1	Name of manufacture	—		
4.4.2.2	Model number	—		
4.4.2.3	Country of origin	—		
4.4.2.4	Rating	DC 12 V, fluorescent lamp, outdoor use, more than 25 W		
4.4.2.5	Catalogue	The catalogue of the product shall be attached.		

Name of Bidder

Name of Authorized Signatory, Position

Signature, Date

Annex 3 Price Schedule

Price Schedule

Bid Price Summary

No.	Item	Unit	Quantity	Unit Price (N)	Total Price (N)
1	BCS	set	1		
2	Public Facility	set	1		
3	SHS	set	60		
4	Street Lighting	set	10		
5	Transportation and Maintenance	lot	1		
6	Spare Parts	lot	1		
	Total				

Name of Bidder

Name of Authorized Signatory, Position

Signature, Date

Price Schedule

1 BCS

No.	Item	Specification	Unit	Quantity	Unit Price (N)	Total Price (N)
1.1	Station Components					
1.1.1	PV Module	55 W, silicon crystal	pcs	18		
1.1.2	Battery Charger	12 V, 20 A	pcs	5		
1.1.3	Charge Controller	12 V, 4.5 A	pcs	1		
1.1.4	Storage Battery	100 Ah, sealed type, deep cycle use	pcs	1		
1.1.5	Battery Box	Indoor use for 100 Ah battery	pcs	1		
1.1.6	Circuit Breaker	Bipolar, 30 A	pcs	2		
1.1.7	ditto	Bipolar, 20 A	pcs	5		
1.1.8	ditto	Bipolar, 10 A	pcs	1		
1.1.9	Lighting	12 V, 13 W, fluorescent lamp	pcs	2		
1.1.10	Cable	25 mm^2 x 2 c	lot	1		
1.1.11	ditto	6 mm^2 x 2 c	lot	1		
1.1.12	ditto	2.5 mm^2 x 2 c	lot	1		
1.1.13	Outlet	DC 12 V	pcs	1		
1.1.14	Switch	Bipolar, DC 12 V	pcs	1		
1.1.15	Junction Box	Outdoor use for PV terminal connection	pcs	1		
1.1.16	ditto	Indoor use for charger, controller, and CB	pcs	1		
1.1.17	Pull Box	Outdoor use for wiring	pcs	1		
1.1.18	Digital Multimeter	Measuring ohm resistance and voltage, portable	pcs	1		
1.1.19	Radio	12 V, 5 W with DC plug	pcs	3		
1.1.20	Accessories	Conduit, terminal cover, earth rod, etc.	lot	1		
1.1.21	Electrical Work	PV foundation, wiring and installation	set	1		
1.2	Household Components					
1.2.1	Charge Controller	12 V, 4.5 A	pcs	20		
1.2.2	Storage Battery	80 Ah, vented type, trickle use	pcs	20		
1.2.3	Battery Box	Indoor use for 80 Ah battery	pcs	20		
1.2.4	Circuit Breaker	Bipolar, 10 A	pcs	20		
1.2.5	Junction Box	Indoor use for controller and Fuse	pcs	20		
1.2.6	Lighting	12 V, 9 W, fluorescent lamp	pcs	40		
1.2.7	Cable	6 mm^2 x 2 c	lot	1		
1.2.8	ditto	2.5 mm^2 x 2 c	lot	1		
1.2.9	Outlet	DC 12 V	pcs	20		
1.2.10	Switch	Bipolar, DC 12 V	pcs	40		
1.2.12	Lighting	12 V, 9 W, fluorescent lamp	pcs	40		
1.2.13	Electrical Work	Wiring and installation	set	20		
	Sub-total					

Name of Bidder

Name of Authorized Signatory, Position

Signature, Date

Price Schedule

2 Public Facility

No.	Item	Specification	Unit	Quantity	Unit Price (N)	Total Price (N)
2.1	PV Module	55 W, silicon crystal	pcs	6		
2.2	Charge Controller	12 V, 20 A	pcs	1		
2.3	Storage Battery	350 Ah, sealed type, deep cycle use	pcs	1		
2.4	Battery Box	Indoor use for 350 Ah battery	pcs	1		
2.5	Circuit Breaker	Bipolar, 20 A	pcs	2		
2.6	Lighting	12 V, 11 W, fluorescent lamp	pcs	12		
2.7	Cable	25 mm^2 x 2 c	lot	1		
2.8	ditto	6 mm^2 x 2 c	lot	1		
2.9	ditto	2.5 mm^2 x 2 c	lot	1		
2.10	Outlet	DC 12V	pcs	2		
2.11	Switch	Bipolar, DC 12 V	pcs	3		
2.12	Junction Box	Outdoor use for PV terminal connection	pcs	1		
2.13	ditto	Indoor use for controller and CB	pcs	1		
2.14	Pull Box	Outdoor use for wiring	pcs	1		
2.15	Radio	12 V, 5 W with DC plug	pcs	1		
2.16	Accessories	Conduit, terminal cover, earth rod, etc.	lot	1		
2.17	Electrical Work	PV foundation, wiring, and installation	set	1		
	Sub-total					

3 SHS

No.	Item	Specification	Unit	Quantity	Unit Price (N)	Total Price (N)
3.1	PV Module	55 W, silicon crystal	pcs	1		
3.2	Charge Controller	12 V, 4.5 A	pcs	1		
3.3	Storage Battery	50 Ah, sealed type, deep cycle use	pcs	1		
3.4	Battery Box	Indoor use for 50 Ah battery	pcs	1		
3.5	Circuit Breaker	Bipolar, 10 A	pcs	1		
3.6	Lighting	12 V, 9 W, fluorescent lamp	pcs	2		
3.7	Cable	6 mm^2 x 2 c	lot	1		
3.8	ditto	2.5 mm^2 x 2 c	lot	1		
3.9	Outlet	DC 12V	pcs	1		
3.10	Switch	Bipolar, DC 12 V	pcs	2		
3.11	Junction Box	Indoor use for controller and CB	pcs	1		
3.12	Steel Pole	Galvanized steel, not less than 4 m	pcs	1		
3.13	Accessories	Terminal cover, earth rod, etc.	lot	1		
3.14	Electrical Work	Wiring, installation, and erection	set	1		
	Sub-total					

Name of Bidder

Name of Authorized Signatory, Position

Signature, Date

Price Schedule

4 Street Lighting

No.	Item	Specification	Unit	Quantity	Unit Price (N)	Total Price (N)
4.1	PV Module	55 W, silicon crystal	pcs	1		
4.2	Charge Controller	12 V, 4.5 A	pcs	1		
4.3	Storage Battery	60 Ah, sealed type, deep cycle use	pcs	1		
4.4	Battery Box	Outdoor use for 60 Ah battery	pcs	1		
4.5	Circuit Breaker	Bipolar, 10 A	pcs	1		
4.6	Lighting	12 V, 25 W, fluorescent lamp	pcs	1		
4.7	Cable	6 mm^2 x 2 c	lot	1		
4.8	Switch	Bipolar, DC 12 V	pcs	1		
4.9	Junction Box	Outdoor use for controller and CB	pcs	1		
4.10	Steel Pole	Galvanized steel, not less than 4 m	pcs	1		
4.11	Accessories	Terminal cover, earth rod etc.	lot	1		
4.12	Electrical Work	Wiring, installation, and erection	set	1		
	Sub-total					

5 Transportation and Maintenance

No.	Item	Specification	Unit	Quantity	Unit Price (N)	Total Price (N)
5.1	Transportation	To Garkon-Alli, Kiyawa, Jigawa				
5.1.1	For BCS		lot	1		
5.1.2	For Public Facility		lot	1		
5.1.3	For SHS		lot	1		
5.1.4	For Solar Lighting		lot	1		
5.2	Training	Training at the site				
5.2.1	For BCS		lot	1		
5.2.2	For Public Facility		lot	1		
5.2.3	For SHS		lot	1		
5.2.4	For Solar Lighting		lot	1		
5.3	Maintenance	Periodical maintenance at the site				
5.3.1	For BCS		lot	1		
5.3.2	For Public Facility		lot	1		
5.3.3	For SHS		lot	1		
5.3.4	For Solar Lighting		lot	1		
	Sub-total					

Name of Bidder

Name of Authorized Signatory, Position

Signature, Date

Price Schedule

6 Spare Parts

No.	Item	Specification	Unit	Quantity	Unit Price (N)	Total Price (N)
6.1	Spare Parts for BCS					
6.1.1	Battery Charger	12 V, 20 A	pcs	1		
6.1.2	Charge Controller	12 V, 4.5 A	pcs	1		
6.1.3	Storage Battery	80 Ah, vented type, trickle use	pcs	2		
6.1.4	Circuit Breaker	Bipolar, 30 A	pcs	1		
6.1.5	ditto	Bipolar, 20 A	pcs	1		
6.1.6	ditto	Bipolar, 10 A	pcs	2		
6.1.7	Lighting	12 V, 13 W, fluorescent lamp	pcs	2		
6.1.8	ditto	13 V, 9 W, fluorescent lamp	pcs	20		
6.1.9	Switch	Bipolar, DC 12 V	pcs	10		
6.1.10	Outlet	DC 12V	pcs	5		
6.1.11	Distilled Water	20 liter	pcs	1		
6.2	Spare Parts for Public Facility					
6.2.1	Charge Controller	12 V, 20 A	pcs	1		
6.2.2	Circuit Breaker	Bipolar, 20 A	pcs	1		
6.2.3	Lighting	12 V, 11 W, fluorescent lamp	pcs	6		
6.2.4	Switch	Bipolar, DC 12 V	pcs	1		
6.2.5	Outlet	DC 12V	pcs	1		
6.3	Spare Parts for SHS					
6.3.1	Charge Controller	12 V, 4.5 A	pcs	3		
6.3.2	Circuit Breaker	Bipolar, 10 A	pcs	3		
6.3.3	Lighting	12 V, 9 W, fluorescent lamp	pcs	60		
6.3.4	Switch	Bipolar, DC 12 V	pcs	30		
6.3.5	Outlet	DC 12V	pcs	15		
6.4	Spare Parts for Street Lighting					
6.4.1	Charge Controller	12 V, 4.5 A	pcs	1		
6.4.2	Circuit Breaker	Bipolar, 10 A	pcs	1		
6.4.3	Lighting	12 V, 25 W, fluorescent lamp	pcs	10		
6.4.4	Switch	Bipolar, DC 12 V	pcs	2		
	Sub-total					

Name of Bidder

Name of Authorized Signatory, Position

Signature, Date

Technical Specification of Main Equipment for the Pilot Project

Table 1　Specification for Jigawa State Lot

Item	Requirement	Delivered Equipment
1. BCS		
a. Station Components		
PV module	Crystalline 55 W and above x 18 units	Poly crystal、60 W x 18 units Suntech Power, China
Charge Controller	12 V, 4.5 A and above x 1 unit	12 V, 6 A x 1 unit MORNINGSTAR, USA
Battery Charger	12 V, 20 A and above x 5 units	12 V, 20 A x 5 units MORNINGSTAR, USA
Storage Battery	Sealed type for cycle use 100 Ah and above x 1unit	Sealed type for cycle use 200 Ah x 1 unit Gaston Battery Industrial, China
Lighting Fixture	12 V, 13 W Fluorescent light x 2 units	12 V, 15 W Fluorescent light x 2 units
b. Household Components		
Charge Controller	12 V, 4.5 A and above x 1 unit	12 V, 6 A x 1 unit MORNINGSTAR, USA
Storage Battery	Vented type for trickle use 80 Ah and above x 1 unit	Vented type for trickle use 88 Ah x 1 unit Buffalo, Japan
Lighting Fixture	12 V, 9 W Fluorescent light x 2 units	12 V, 15 W Fluorescent light x 2 units
2. Public Facility		
PV module	Crystalline 55 W and above x 6 units	Poly crystal、60 W x 6 units Suntech Power, China
Charge Controller	12 V, 20 A and above x 1 unit	12 V, 20 A x 1 unit MORNINGSTAR, USA
Storage Battery	Sealed type for cycle use 350 Ah and above x 1unit	Sealed type for cycle use 200 Ah x 2 units Gaston Battery Industrial, China
Lighting Fixture	12 V, 11 W Fluorescent light x 12 units	12 V, 15 W Fluorescent light x 2 units
3. SHS		
PV module	Crystalline 55 W and above x 1 unit	Poly crystal、60 W x 1 unit Suntech Power, China
Charge Controller	12 V, 4.5 A and above x 1 unit	12 V, 6 A x 1 unit MORNINGSTAR, USA
Storage Battery	Sealed type for cycle use 50 Ah and above x 1unit	Sealed type for cycle use 65 Ah x 1 unit Gaston Battery Industrial, China
Lighting Fixture	12 V, 9 W Fluorescent light x 2 units	12 V, 15 W Fluorescent light x 2 units
4. Street Lighting		
PV module	Crystalline 55 W and above x 1 unit	Poly crystal、60 W x 1 unit Suntech Power, China
Charge Controller	Timer function 12 V, 4.5 A and above x 1 unit	Timer function, 12 V, 10 A x 1 unit MORNINGSTAR, USA
Storage Battery	Sealed type for cycle use 60 Ah and above x 1unit	Sealed type for cycle use 65 Ah x 1 unit Gaston Battery Industrial, China
Lighting Fixture	12 V, 25 W Fluorescent light x 1 unit	12 V, 18 W Sodium lump x 1 unit

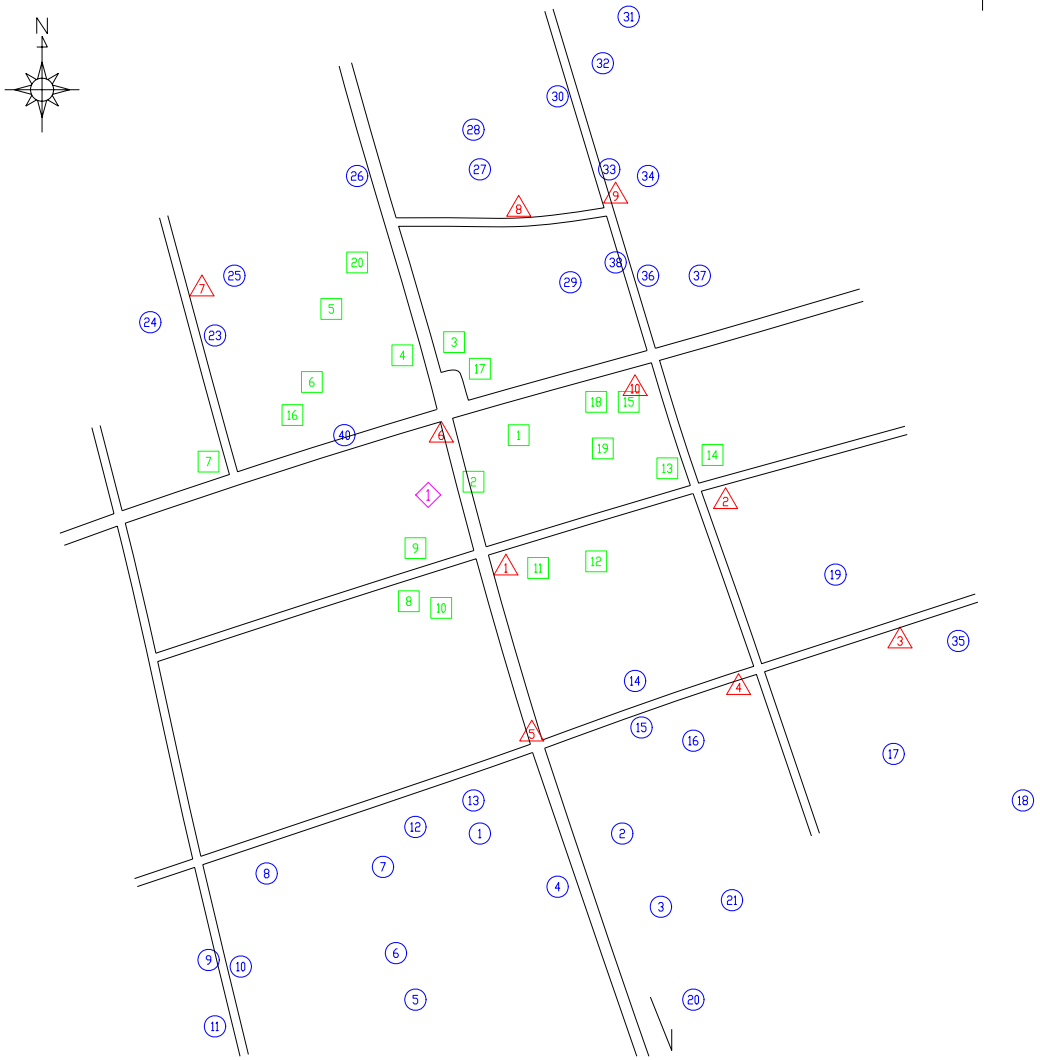
Table 2 Specification for Ondo State Lot

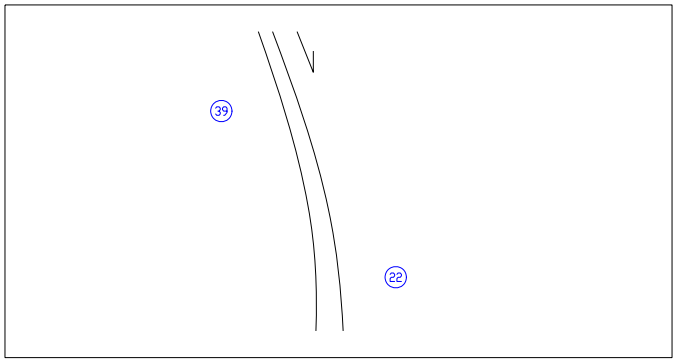
Item	Requirement	Delivered Equipment
1. Public Facility		
a. Lighting Components		
PV module	Crystalline 55 W and above x 6 units	Poly crystal、60 W x 6 units Suntech Power, China
Charge Controller	12 V, 20 A and above x 1 unit	12 V, 20 A x 1 unit MORNINGSTAR, USA
Storage Battery	Sealed type for cycle use 300 Ah and above x 1unit	Sealed type for cycle use 200 Ah x 2 units Gaston Battery Industrial, China
Lighting Fixture	12 V, 11 W Fluorescent light x 10 units	12 V, 15 W Fluorescent light x 10 units
b. PV Refrig. Components		
PV Vaccine Refrigerator	12 V x 1 unit Certified by WHO	12 V, 38.7 liter SUN FROST, USA
PV module	Crystalline 55 W and above x 4 units	Poly crystal、60 W x 4 units Suntech Power, China
Charge Controller	12 V x 1 unit	12 V, 15 A x 1 unit MORNINGSTAR, USA
2. SHS		
PV module	Crystalline 55 W and above x 1 unit	Poly crystal、60 W x 1 unit Suntech Power, China
Charge Controller	12 V, 4.5 A and above x 1 unit	12 V, 6 A x 1 unit MORNINGSTAR, USA
Storage Battery	Sealed type for cycle use 50 Ah and above x 1unit	Sealed type for cycle use 65 Ah x 1 unit Gaston Battery Industrial, China
Lighting Fixture	12 V, 9 W Fluorescent light x 2 units	12 V, 15 W Fluorescent light x 2 units
3. Street Lighting		
PV module	Crystalline 55 W and above x 1 unit	Poly crystal、60 W x 1 unit Suntech Power, China
Charge Controller	Timer function 12 V, 4.5 A and above x 1 unit	Timer function, 12 V, 10 A x 1 unit MORNINGSTAR, USA
Storage Battery	Sealed type for cycle use 50 Ah and above x 1unit	Sealed type for cycle use 65 Ah x 1 unit Gaston Battery Industrial, China
Lighting Fixture	12 V, 20 W Fluorescent light x 1 unit	12 V, 18 W Sodium lump x 1 unit

Table 3 Specification for Imo State Lot

Item	Requirement	Delivered Equipment
1. Public facility		
PV module	Crystalline 55 W and above x 8 units	Poly crystal、62 W x 8 units Suntech Power, China
Charge Controller	12 V, 30 A and above x 1 unit	12 V, 30 A x 1 unit MORNINGSTAR, USA
Storage Battery	Sealed type for cycle use 350 Ah and above x 1unit	Sealed type for cycle use 105 Ah x 4 units Concord Battery, USA
Lighting Fixture	12 V, 11 W Fluorescent light x 12 units	12 V, 11 W CFL x 12 units
2. SHS		
PV module	Crystalline 55 W and above x 1 unit	Poly crystal、62 W x 1 unit Suntech Power, China
Charge Controller	12 V, 4.5 A and above x 1 unit	12 V, 6 A x 1 unit MORNINGSTAR, USA
Storage Battery	Sealed type for cycle use 50 Ah and above x 1unit	Sealed type for cycle use 60 Ah x 1 unit Delphi Battery, USA
Lighting Fixture	12 V, 9 W Fluorescent light x 2 units	12 V, 11 W CFL x 2 units
3. Street Lighting		
PV module	Crystalline 55 W and above x 1 unit	Poly crystal、62 W x 1 unit Suntech Power, China
Charge Controller	Timer function 12 V, 4.5 A and above x 1 unit	Timer function, 12 V, 10 A x 1 unit MORNINGSTAR, USA
Storage Battery	Sealed type for cycle use 50 Ah and above x 1unit	Sealed type for cycle use 60 Ah x 1 unit Delphi Battery, USA
Lighting Fixture	12 V, 20 W Fluorescent light x 1 unit	12 V, 20 W CFL x 1 unit

RevNo	Revision note	Date	Signature	Checked
1	Corrected the positions of PV systems	05/31/2006	K.SAITO	





Public Facility
BCS
SHS
Street Lighting

0 50 100 m

No.	Name of Beneficiaries	Remarks	No.	Name of Beneficiaries	Remarks
BCS			SHS		
1	Alhassan Adamu		11	Sa'Adu Ibrahim	
2	Ibrahim Alhassan		12	Usaini Malam	
3	Mati Sabo		13	Alhaji Musa	
4	Sha'Aibu Ubah		14	Adamu Idris	
5	Abdullahi Chibi		15	Ahmed Mohd	
6	Malam Musa Taziri		16	Haruna Yakubu	
7	Hamisu Malam Malam		17	Idris Jibrin	
8	Yusuf Na'Amadu		18	Biyu Dahiru	
9	Ado Sulaiman		19	Shehu Isah	
10	Shehu Danfulani		20	Musa Haruna	
11	Yahaya Tela		21	Yusif Jinjiri	
12	Sha'Aibu Dan'Audu		22	Sama'Ila Sale	
13	Abdu Attahir		23	Ya'U Abdullahi	
14	Sha'Aibu Usman		24	Alhaji Idris	
15	Buba Garko		25	Malam Saleh	
16	Yakubu Tsumba		26	Malam Abdussalamu	
17	Usaini Takya		27	Malam Liman	
18	Mati Darto		28	Kasimuu Daftan	
19	Haruna Dan'Loto		29	Sha'Aibu Umar	
20	Malam Abdulaziz		30	Habu Yunusa	
SHS			31	Idris Tawaru	
1	Salihu Magaji		32	Hashimu Zimbo	
2	Jibrin Narabi		33	Abdul Wahabu Umaru	
3	Sa'Idu Chiko		34	Malam Haruna	
4	Alhaji Ahmed Yakubu		35	Nasalla Musa	
5	Mohd San Mamma		36	Hashimu Santa	
6	Alhaji Yusif Ibrahim		37	Ado Ziko	
7	Sani Mohd		38	Dan Azumi Attahir	
8	Malam Sani Liman		39	Primary School	
9	Malami Jibrin		40	Islamic School	
10	Lawan Salihu				

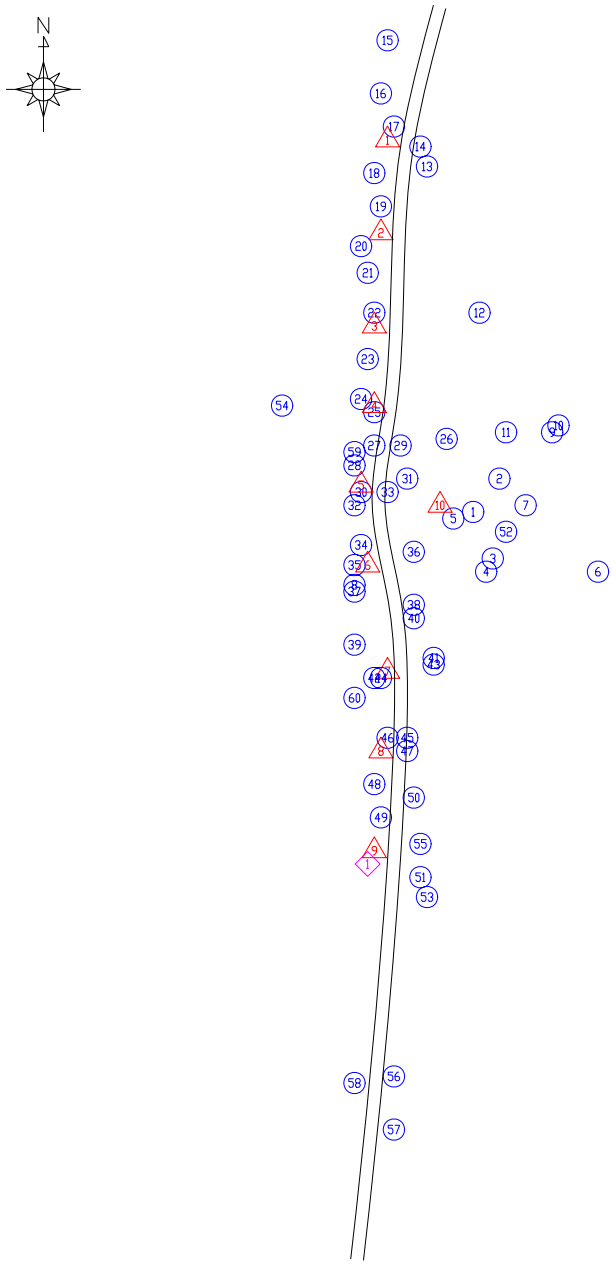
Itemref	Quantity	Title/Name, designation, material, dimension etc			Article No./Reference
Designed by K.SAITO		Checked by	Approved by - date	File name JIGAWA Map	Date 05/12/2006	Scale 1:2500

Japan International Cooperation Agency
MASTER PLAN STUDY FOR UTILIZATION OF SOLAR ENERGY IN THE FEDERAL REPUBLIC OF NIGERIA

LAYOUT OF PV SYSTEMS IN JIGAWA STATE

J-002 | Edition 002 | Sheet

RevNo	Revision note	Date	Signature	Checked
1	Corrected the positions of PV systems	06/07/06	K.SAITO	
2	Corrected the positions of PV systems	10/28/06	K.SAITO	



Public Facility
SHS
Street Lighting

0 50 100 m

No.	Name of Beneficiaries	Remarks	No.	Name of Beneficiaries	Remarks
SHS			31	Pa. James Ajayi	
1	Olu of Oke-Agunla		32	Mr. Owolanke	
2	Chief Aliu-Adesoro		33	Oke-Agunla Mosque	
3	Mr. Omotosho		34	Mr. Yusuf George	
4	Mr. J.O. Kikiowo		35	Pa. Yusuf Sule	Same as No.8
5	Mrs. B. Omosebi		36	Chief Asae	
6	Holy Ghost Church		37	Pa. Sunmola Salami	
7	Mr. Adetoye Olalusi		38	Mr. Ojo Fagbemi	
8	Pa. Yusuf Sule		39	Mr. J. Agbona II	
9	Mr. D. Ejemikin		40	Mr. W. Adewunmi	
10	Mr. Omolafe		41	Mr. Ojo Odere	
11	UNDP House	Asst. Oil program	42	Chief Akinropo	
12	L.A. Primary School		43	Pa. Akinlolu	
13	C.A.C. Church, Oke-Agunla		44	Chief Olowokere	
14	Mission House	C.A.C.	45	Chief Oluyi	
15	Chief Odopetu		46	Mrs. Akomolafe	
16	Mr. Akinropo Akinola		47	Pa. Ogunleye	
17	Mrs. Abigeal Olufayo		48	Mrs. Fagbomedo	
18	Mrs. Felicia Fadairo		49	CMS Mission House	
19	Mr. Johnson Oje		50	Mr. Ibitayo	
20	Chief Ajibola II		51	Mr. J. Agbani	
21	Mrs. Easter Ibitoye		52	Olu of Oke-Agunla	Same as No.1
22	Chief Agbona		53	Chief Aiedo Daniel	
23	Mr. Akintoye Abiola		54	Mrs. Adeyanlanu	
24	Mr. Dauda Kikiowo		55	Mr. Adelodi	
25	Mr. Popoola		56	Mr. Adetoye II	
26	Mr. Owoeye Lawrence		57	CMS Church	
27	Mr. J. Fagbamigbe		58	Private N/P School	
28	Mrs. Ayo Ibiye		59	Mrs. Ayo Ibiye	Same as No.28
29	Chief Abidakun		60	Chief Olowokere	Same as No.44
30	Chief Aro-Kolawole				

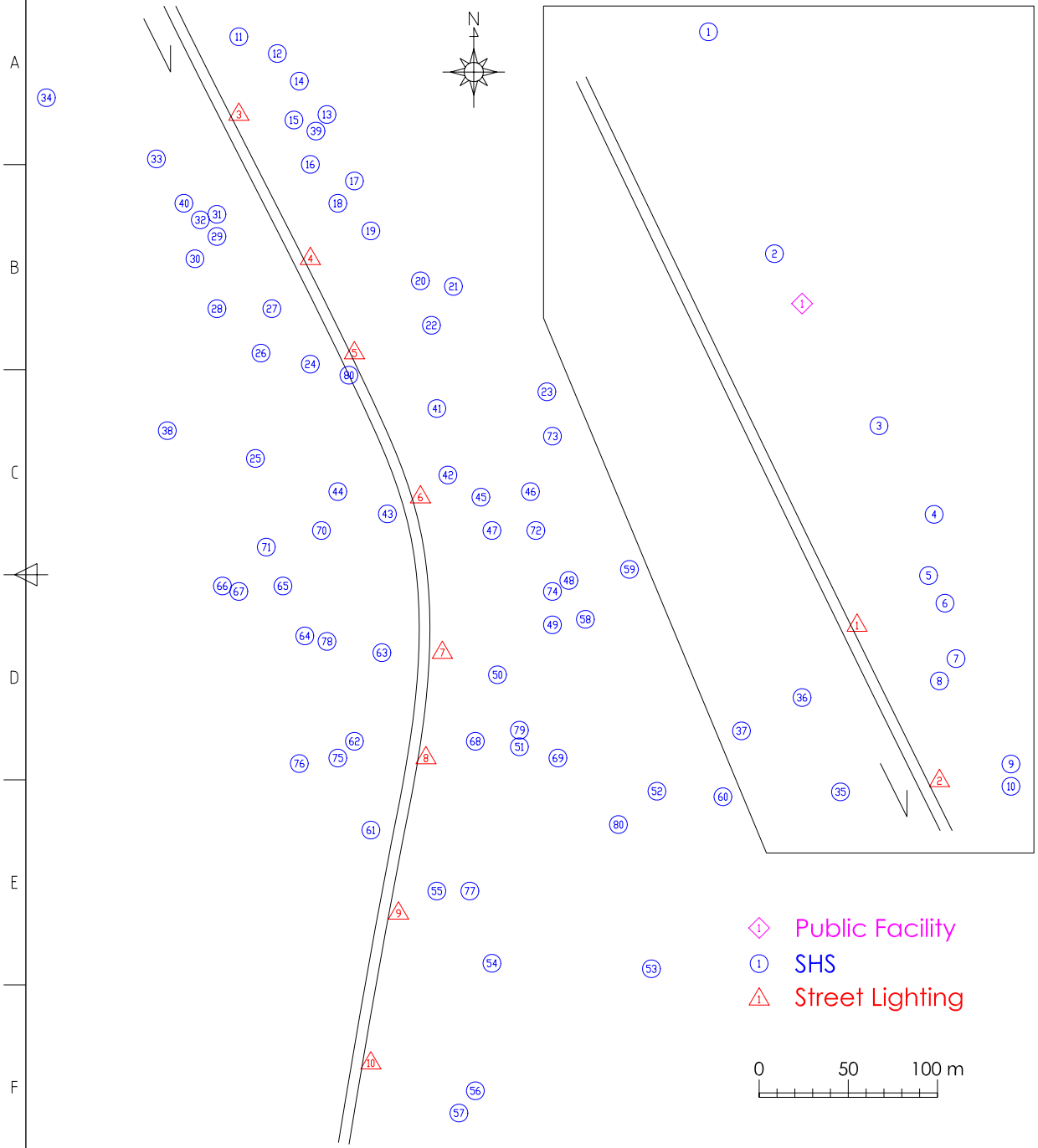
Itemref	Quantity	Title/Name, designation, material, dimension etc			Article No./Reference	
Designed by K.SAITO		Checked by	Approved by - date	File name ONDO Map	Date 05/12/2006	Scale 1:2500

Japan International Cooperation Agency
MASTER PLAN STUDY FOR UTILIZATION OF SOLAR ENERGY IN THE FEDERAL REPUBLIC OF NIGERIA

LAYOUT OF PV SYSTEMS IN ONDO STATE

O-001	Edition 003	Sheet

RevNo	Revision note	Date	Signature	Checked
1	Corrected the positions of PV systems	06/11/06	K.SAITO	



No.	Name of Beneficiaries	Remarks	No.	Name of Beneficiaries	Remarks
SHS			41	Mr. Linus Onukwuru	
1	Resident Catchiest of ST. John's Anglican Church		42	Mr. Maurice Okereafor	
2	Mr. Andrew Uzoma		43	Chief Shedrach Nwosu	
3	Mr. Raphael Akujobi		44	Mr. Chima Okoro	
4	Mr. Richard Amadi		45	Mr. Innocent Nworgu	
5	Mr. Anselem Ughaji		46	Mr. Basil Nworgu	
6	Mr. Anthony Nkwocha		47	Mr. Longinus Nworgu	
7	Mr. Cyriacus Nkwocha		48	Mr. Clifford Okere	
8	Mr. Eugene Nweke		49	Mr. Richard Okere	
9	Mr. Patrick Okoroafor		50	Mr. Festus Ibekwe	
10	Mr. Frederick Okoroafor		51	Mr Patrick Amadi	
11	Mr. Micheal Ndukwu		52	Mr. Hillary Ekeh	
12	Mr. Francis Onyekwe		53	Mr. Sabinus Elugwara	
13	Mr. Livinus Okere		54	Mr. Anugustine Elugwara	
14	Mr. Theophilos Onyekwe		55	Nze Theodore Eke	
15	Mr. Samson Okere		56	Nze Sunday Nkwocha	
16	Mr. Emmanuel Nweke		57	Mr. Stanley Nkwocha	
17	Nze Tobias Nweke		58	Mr. Damian Nkwocha	
18	Mr. John Nkwocha		59	Mr. Christian Nkwocha	
19	Mr. Sabastine Onyegbula		60	Rev. Fr. Alex Okoro	
20	Mr. Gilbert Ogbonna		61	Nze Cletus Nkwocha	
21	Mr. Silvanus Okere		62	Mr. Canice Nkwocha	
22	Mr. Maduabu Okere		63	Mr. Hyacinth Nworgu	
23	Mr. Jude Nkwocha		64	Mr. Charles Nkwocha	
24	Mr. Anaele Umunagbu		65	Mr. Linus Egbu	
25	Mr.Ikechi Nwankwala		66	Mr. Cyprian Egbu	
26	Mr. Sabinus Nkwocha		67	Mr. John Egbu	
27	Mr. Sylvester Iroegbu		68	Mr. Celestine Elugwara	
28	Dr. Anaebo Eto		69	Mr. Oliver Ekeh	
29	Mr. Desmond Eke		70	Mr. Eugene Okoro	
30	Mr. Longinus Ekeigwe		71	Mr. Celestine Egbu	
31	Chief Aloyscius Amadi		72	Mr. Gilbert Nworgu	
32	Nze Kelvin Akujobi		73	Mr. Collins Nworgu	
33	Mr. Ernest Nmezi		74	Mr. Marcillinus Okere	
34	Mr. Paul Anaele		75	Mr. Aloyscius Nkwocha	
35	Mr. Alphonscius Eke		76	Mr. Innocent Nkwocha	
36	Mr. Charles Iroegbu		77	Mr. Boniface Onyewe	
37	Mr. Celestine Iroegbu		78	Mr. Athanatus Okereafor	
38	Mr. Godwin Anaele		79	Mr. Desmond Nneji	
39	Mr. Sabinus Nweke		80	Mr. Collins Nkwocha	
40	Mr. Alexander Okere				

Itemref	Quantity	Title/Name, designation, material, dimension etc			Article No./Reference	
Designed by K.SAITO		Checked by	Approved by - date	File name IMO Map	Date 05/12/2006	Scale 1:2500
Japan International Cooperation Agency MASTER PLAN STUDY FOR UTILIZATION OF SOLAR ENERGY IN THE FEDERAL REPUBLIC OF NIGERIA				LAYOUT OF PV SYSTEMS IN IMO STATE		
				I-001	Edition 002	Sheet

Agreement

On

The Public Facilities and Individual Facilities

Of

The PV System of the Pilot Project

Under

the Master Plan Study for Utilization of Solar Power Energy

in the Federal Republic of Nigeria

1 Supply of the Pilot Project Equipment

In respect of the Pilot Project Equipment under the Master Plan Study for Utilization of Solar Power Energy in the Federal Republic of Nigeria, the following has been agreed between the Federal Government of Nigeria and the State Government of Imo/Ondo/Jigawa:

1) The Federal Ministry of Power and Steel and the Federal Ministry of Science and Technology of the Federal Republic of Nigeria would entrust the State Government of Imo/Ondo/Jigawa the whole of the Pilot Project extended by JICA Nigeria Office in terms of the receipt of its equipment, operation and maintenance during the monitoring and warranty period and thereafter for the sustainable use of the Pilot Project Equipment:
2) The said Pilot Project consisting of PV System subject to be supplied at free of charge in March 2006 shall be as per Annex I and Annex II;
3) Such equipment of the Pilot Project shall be provided to the following areas:
   a. Umuikoro/Opehi Village, Ngor Okpala Local Government Area, Imo State;
   b. Oke Agunla Village, Akure North Local Government Area, Ondo State; and
   c. Garkon Alli Village, Kiyawa Local Government Area, Jigawa State
4) Such equipment of the Pilot Project shall be exclusively and solely made use of by the above village electrification committee, the name of organization subject to further agreement, and those households selected by the village organization of the said village;
5) PV System as per Annex I and Annex II shall remain as asset of JICA Nigeria Office for indefinite period;
6) During the period after the completion of the installation of the whole of the said Pilot Project Equipment and thereafter, sustainable use of the said Pilot Project Equipment shall be ensured by the individual lessee of the said Pilot Project

Equipment in terms of maintaining in good condition for such sustainable use and repairing any portion of it as a result of natural wear and tear or as a result of vandalism or theft. Sustainable use of the said Pilot Project Equipment shall include accumulation of technical data and organization of a group of people using the said Pilot Project Equipment and recording and maintaining of the conditions of the Pilot Project Equipment as a whole;

7) In the case of the operation and maintenance of the public facilities as per Annex I, the village electrification committee, the name of which is subject to further agreement, shall be responsible for its operation and maintenance, collection of the tariff for the use of such Pilot Project Equipment. In the case the local government in which the said villages located should take responsibility of the payment for the use of the Pilot Project Equipment, the Village Electrification Committee shall record and maintain such record of such payment made in a form of subsidiary or any other form of payment relevant to the prevailing government payment system;
8) In the case of the Battery Charging Station supplied to Garkon Alli Village, Jigawa State, the entire charging station shall be operated and maintained by the village electrification committee of Garkon Alli Village; and
9) Any other difficulties facing in the future should be subject to discussion between the Federal Ministry of Power and Steel and the Federal Ministry of Science and Technology and the State Government of Imo/Ondo/Jigawa.

2. Administration of the Pilot Project

1) Purposes of the Use of Pilot Project Equipment

The PV System of the Pilot Project as above should be made available as follows:

a. Those equipment as per Annex I shall be made use of for the public purposes and administered by the organization of the above villages; and
b. For the individual use of the above villages as per Annex II.

2) Administration of the Pilot Project Equipment

a. Public facilities such as lighting system for the meeting place, clinics etc. as per Annex I are subject to direct administration of the village organization.
b. Individual facilities as per Annex II. should be leased to individuals of the above villages upon agreement made between the village organization termed as “Village Electrification Committee” and individual household.

3) Administration of the Pilot Project Organization

State government shall be responsible for the administration of village organization termed as “Village Electrification Committee” in terms of technical assistance and administrative manner of the village organization, which should play an important role for the operation and maintenance of the Pilot Project under the guidance of JICA Nigeria Office and its entrusted consultant as follows:

a. Village Electrification Committee shall prepare “Lease Agreement on the PV System for Individual Lessee” and enter into lease contract with selected

individual household that would make use of the Pilot Project equipment;

b. Determine the amount of payment for the use of Pilot Project equipment;
c. Collect and save the payment made by the individual lessees and maintain account for the purpose of operation and maintenance of the Pilot Project;
d. Maintain accountant for the payment of the use of Pilot Project equipment;
e. Maintain technicians for repairing Pilot Project Equipment, log book on the repairing works and liaise with the state government for any difficulties beyond the capacity of the village organization.

3. Duration of Lease

The term of lease of PV System under the lease agreement shall be indefinite period.

4. Ownership of PV System

The ownership of the PV System shall be JICA Nigeria Office and the PV System shall be made use of for the public and individual purposes.

5. Use of PV System

a. Ownership of PV System

The ownership of the above (tick marked) PV System shall remain indefinite period with JICA Nigeria Office. The lessee shall not be allowed to sell any part or whole of the above (tick marked) PV System to other individuals or private or public organizations at all.

b. Relocation of the PV System Within the Same Village

In the event that the lessee shall move to other place within the village, the above (tick marked) PV system shall be relocated to the lessee's new place of resident and the cost of relocation shall be born by the lessee.

c. Relocation of the PV System to Other Village

In the event that the lessee shall move to other place than the village in which the lessee reside, the lease agreement of the above (tick marked) PV System shall be terminated as expressed in "d. Termination of Lease".

d. Termination of Lease

In case the lessee should wish to terminate the lease, the lessee shall notify Village Electrification Committee one month in advance and the lessee shall dismantle at the cost of lessee whole of the above (tick marked) PV System and return it to Village Electrification Committee in which the lessee resides.

e. Transfer of Lease

The lessee shall be able to transfer the lease of the whole of the above (tick marked) PV System the resident residing within same village in which the lessee resides. The lessee shall notify the Village Electrification Committee for his/her intention of the transfer of the above (tick marked) PV System one month in advance. Any cost incurred for the transfer of the above (tick marked) PV System shall be born by the lessee while technical assistance on the installation of the above (tick marked) PV System shall be provided by the Village Electrification Committee.

6. Payment for the PV System

Amount of payment made directly to the village organization for the use of PV System of the Pilot Project shall be agreed upon between the village organization and all the

community because they all benefit from the use of public facilities.
The amount of payment should include the future replacement cost of batteries and other consumables.

7. Warranty of the PV System
Natural wear and tear of the battery, fluorescent lamp, indoor wiring, switches, and wall outlet of the PV System shall not be covered by the warranty of the supplier of the PV System for one year from the date of completion of installation for both public facilities and individual facilities.

Date:_____, 2006

_____
JICA Nigeria Office (JICA)

_____	_____
Federal Ministry of Power and Steel	Federal Ministry of Science and Technology

_____	_____	_____
Jigawa State Government	Ondo State Government	Imo State Government
_____	_____	_____
Kiyawa Local Government	Akure North Local Government	Ngor Okpala Local Government
_____	_____	_____
Garkon Alli Village Organization	Oke Agunla Village Organization	Umuikoro/Opehi Village Organization

Annex I (1) Pilot Project Equipment for Public Facilities

1. Pilot Project Equipment: Public Facilities for Garkon Alli Village, Jigawa State

Items of Equipment	Quantities	Notes
(1) Public Facilities	1 Mosque	
1) PV module 60W	6 pcs	
2) Charge controller (12V, 20A)	1 set	
3) Battery (Sealed type, 400Ah)	1 set	
4) Circuit breaker (2p-20A)	1 set	
5) Stand/cable	1 lot	
6) Fluorescent lamp (DC12V-15W)	12 sets	
(2) Battery Charging Station	1 lot	
1) PV module 60W	18 pcs	
2) Charge controller (12V, 10A)	1 set	
3) Battery charger (12V, 20A)	5 sets	including one (1) spare
4) Battery (Sealed type, 100Ah)	1 set	
5) Circuit breaker (2p-30A)	2 sets	
Circuit breaker (2p-20A)	1 set	
Circuit breaker (2p-10A)	1 set	
6) Stand/Cable	1 lot	
7) Fluorescent lamp (DC12V-15W)	2 sets	
(3) Street lighting	10 sets	
1) PV module 60W	1 pc /set	
2) Charge controller (12V, 10A)	1 set/set	
3) Battery (Sealed type, 65Ah)	1 set/set	
4) Circuit breaker (2p-10A)	1 set/set	
5) Stand/cable	1 lot/set	
6) Sodium lamp (DC12V-18W)	1 sets/set	

Annex I (2) Pilot Project Equipment for Public Facilities

2. Pilot Project Equipment: Public Facilities for Oke Agunla Village, Ondo State

Items of Equipment	Quantities	Notes
(1) Lighting for Health Care Center	1 HCC	
1) PV module 60W	6 pcs	
2) Charge controller (12V, 20A)	1 set	
3) Battery (Sealed type, 400Ah)	1 set	
4) Circuit breaker (2p-20A)	1 set	
5) Stand/cable	1 lot	
6) Fluorescent lamp (DC12V-11W)	10 sets	
(2) PV Refrigerator for Health Care Center		
1) PV Refrigerator	1 set	Certified by WHO
2) PV module 60W	4 pcs	
3) Charge controller (12V)	1 set	
4) Battery (Sealed type, 200Ah)	1 set	
5) Circuit breaker (2p-20A)	1 lot	
6) Stand/cable	1 lot	
(3) Street lighting	10 sets	
1) PV module 60W	1 pc /set	
2) Charge controller (12V, 10A)	1 set/set	
3) Battery (Sealed type, 65Ah)	1 set/set	
4) Circuit breaker (2p-10A)	1 set/set	
5) Stand/cable	1 lot/set	
6) Sodium lamp (DC12V-18W)	1 sets/set	

Annex I (3) Pilot Project Equipment for Public Facilities

3. Pilot Project Equipment: Public Facilities for Umuikoro/Opehi Village, Imo State

Items of Equipment	Quantities	Notes
(1) Lighting for Public Meeting Place	1 PMP	
1) PV module 62W	8 pcs	
2) Charge controller (12V, 30A)	1 set	
3) Battery (Sealed type, 420Ah)	1 set	
4) Circuit breaker (2p-32A)	1 set	
5) Stand/cable	1 lot	
6) Fluorescent lamp (DC12V-11W)	12 sets	
(2) Street lighting	10 sets	
1) PV module 55W	1 pc /set	
2) Charge controller (12V, 10A)	1 set/set	
3) Battery (Sealed type, 60Ah)	1 set/set	
4) Circuit breaker (2p-10A)	1 set/set	
5) Stand/cable	1 lot/set	
6) Fluorescent lamp (DC12V-20W)	1 sets/set	

Annex II (1) Pilot Project Equipment for Individual Facilities

1. Pilot Project Equipment: Individual Facilities for Garkon Alli Village, Jigawa State

Items of Equipment	Quantities	Notes
(1) Solar Home System (SHS)	40 houses	
1) PV module 60W	1 pc /house	
2) Charge controller (12V, 6A)	1 set/house	
3) Battery (Sealed type, 65Ah)	1 set/house	
4) Circuit breaker (2p-10A)	1 set/house	
5) Stand/cable	1 lot/house	
6) Fluorescent lamp (DC12V-11W)	2 sets/house	
(2) Battery and house wiring for BCS	20 houses	
1) Charge controller (12V, 6A)	1 set/house	
2) Battery (Vent type, 80Ah)	1 set/house	
3) Circuit breaker (2p-10A)	1 set/house	
4) Stand/cable	1 set/house	
5) Fluorescent lamp (DC12V-9W)	2 sets/set	

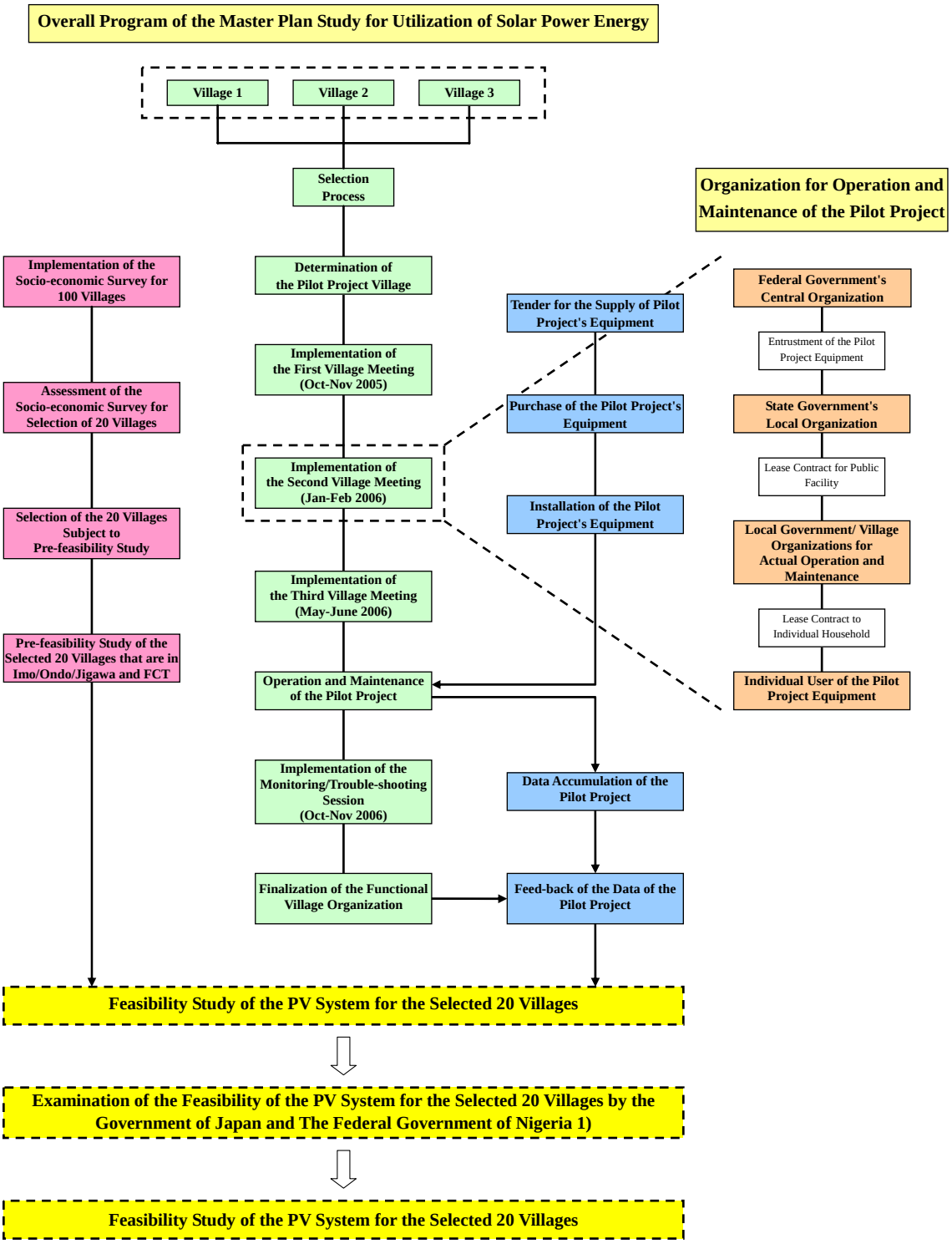
2. Pilot Project Equipment: individual Facilities for Oke Agunla Village, Ondo State

Items of Equipment	Quantities	Notes
(1) Solar Home System (SHS)	60 houses	
1) PV module 60W	1 pc /house	
2) Charge controller (12V, 6A)	1 set/house	
3) Battery (Sealed type, 65Ah)	1 set/house	
4) Circuit breaker (2p-10A)	1 set/house	
5) Stand/cable	1 lot/house	
6) Fluorescent lamp (DC12V-9W)	2 sets/house	

3. Pilot Project Equipment: Individual Facilities for Umuikoro/Opehi Village, Imo State

Items of Equipment	Quantities	Notes
(1) Solar Home System (SHS)	80 houses	
1) PV module 62W	1 pc /house	
2) Charge controller (12V, 6A)	1 set/house	
3) Battery (Sealed type, 60Ah)	1 set/house	
4) Circuit breaker (2p-10A)	1 set/house	
5) Stand/cable	1 lot/house	
6) Fluorescent lamp (DC12V-11W)	2 sets/house	

Figure 1 Implementation of the Pilot Project



Note: 1) Implementation of the Solar PV System for the Selected 20 Villages is subject to further application made by the Government of Nigeria to the Government of Japan.

Lease Agreement

On

The PV System

For

Individual Lessee

1. We, the Name of Leaser: _____
   Address: _____, _____ State, would like to make PV System available for the use of individuals to lease as follows:

   ☐ a. Solar Home System (PV module for 60-62W, Charge controller: 12V, 6A, Battery: Sealed Type, 60-65Ah, Circuit Breaker: 2pieces, 10A each, Stand/cable and Fluorescent Lamp: DC12V, 9-11W, 2 sets)

   ☐ b. Battery Charging System (Charge controller: 12V, 6A, Battery: Vent Type, 80Ah, Circuit breaker: 2pieces, 10A each, Stand/cable and Fluorescent Lamp: DC12V, 9W, 2 sets)

2. I, Name of the Lessee: _____
   Address: _____Village, _____
   Local Government Area, _____ State,
   ID No.: _____

   would like to apply for the above (tick marked) PV System for individual use and would agree conditions as per this Lease Agreement.

3. Duration of Lease
   The term of lease of PV System under the lease agreement shall be indefinite period.

4. Ownership of PV System
   a. Ownership of PV System
   The ownership of the above (tick marked) PV System shall remain indefinite period with JICA Nigeria Office. The lessee shall not be allowed to sell any part or whole of the above (tick marked) PV System to other individuals or private or public organizations at all.

   b. Relocation of the PV System within the Same Village
   In the event that the lessee shall move to other place within the village, the above (tick

marked) PV System shall be relocated to the lessee's new place of resident and the cost of relocation shall be born by the lessee.

c. Relocation of the PV System to Other Village

In the event that the lessee shall move to other place than the village in which the lessee reside, the lease agreement of the above (tick marked) PV System shall be terminated as expressed in "d. Termination of Lease".

d. Termination of Lease

In case the lessee should wish to terminate the lease, the lessee shall notify Village Electrification Committee (the name subject to agreement) one month in advance and the lessee shall dismantle at the cost of lessee whole of the above (tick marked) PV System and return it to Village Electrification Committee in which the lessee resides.

e. Transfer of Lease

The lessee will be able to transfer the lease of the whole of the above (tick marked) PV System to the resident residing within same village in which the lessee resides. The lessee shall notify the Village Electrification Committee his/her intention of the transfer of the above (tick marked) PV System one month in advance. Any cost incurred for the transfer of the above (tick marked) PV System shall be born by the lessee while technical assistance on the installation of the above (tick marked) PV system shall be provided by the Village Electrification Committee.

5. Payment for the PV System

a. Initial Payment

The following amount shall be paid to the Village Electrification Committee in which the lessee resides as initial charge for the lease of above (tick marked) PV System:

1) Solar Home System: _____ Naira
2) Battery Charging System: _____Naira

b. Monthly Payment

The following amount shall be paid to the Village Electrification Committee in which the lessee resides as monthly charge for the lease of above (tick marked) PV System:

1) Solar Home System: _____ Naira
2) Battery Charging System: _____Naira

The above monthly charge will be made in cash and paid to the person designated by the Village Electrification Committee of _____Village, _____ Local Government Area, _____ State on the designated date of payment.

c. Default of Payment

Should the lessee fail to make the above monthly payment for three consecutive months, this Lease Agreement shall be terminated upon decision made by the Village Electrification Committee in which the lessee resides.

d. Removal of PV System upon Default of Payment

Upon decision made by the Village Electrification Committee for the termination of this Lease Agreement due to the default of monthly payment for three consecutive months by the lessee, the Village Electrification Committee shall take action as necessary but not limited to as follows:

i. Notify and request for assistance on the default of such payment of such individual lessee to the local government and the state government responsible to the Pilot Project;
ii. Consider the above (tick marked) PV System shall be removed at the expenses of the Village Electrification Committee upon decision made for removal and transfer of the said PV System in question to other potential lessee within the village;
iii. The entire system is so transferred and installed to other individual as the Village Electrification Committee should make such decision for new lease agreement and that it would be subject to the agreement of such nominated individual; and
iv. Village Electrification Committee shall maintain inventory of such removal and transfer of PV system in the log book maintained at the office of Village Electrification Committee.

e. Non-refundable Policy of the Payment for Lease

All of the payment made under this contract shall not be refunded.

6. Warranty of the PV System

Natural wear and tear of the battery, fluorescent lamp, indoor wiring, switches, and wall outlet of the above (tick marked) PV System shall not be covered by the warranty of the supplier of the above (tick marked) PV System for one year from the date of completion of installation.

7. Liability of the Lessee and Leaser

a. Liability of Lessee

The lessee shall repair and/or replace at the his/her expenses, the battery, fluorescent lamp, indoor and outdoor wiring, switches and wall outlet of the above (tick marked) PV System.

In the event that the above (tick marked) PV System malfunctioned, the lessee shall notify the Village Electrification Committee for checking, technical assistance for repairing and execution of such repairing works and any replaced portion of the above (tick marked) PV System shall be so recorded in the log book maintained at the Village Electrification Committee.

b. Liability of Leaser

The Leaser shall be responsible at the expenses of the Leaser the installation of the whole of the above (tick marked) PV System and its maintenance works during the lease period.

The Leaser shall also be responsible for providing technical assistance on repairing and replacing of any parts of the above (tick marked) PV System upon request made by the lessee.

Replacement of the battery, charge controller and solar panels as they become malfunction or upon reaching their own life period, which varies from __ years to __ years subject to frequency and running hours of its use, shall be made at the cost of the Leaser. Such replacement should be clearly recorded and notified to JICA Nigeria Office through the state government responsible to oversee the above (tick marked) PV System and that it shall notify to the Federal Government of Nigeria

I HAVE READ AND UNDERSTOOD THE ABOVE LEASE AGREEMENT AS STATED AND I CERTIFY THAT THE INFORMATION PROVIDED BY THE VILLAGE ELECTRIFICATION COMMITTEE IS COMPLETE AND ACCURATE. I WOULD THEREFORE AGREE TO BE BOUND BY THE TERMS AND CONDITIONS CONTAINED HEREWITH.

Date:_____

Primary Lease

Lessee: _____ Leaser:_____

Secondary Lease (In the case of transfer is made):

Date:_____

Lessee: _____ Leaser:_____

Master Plan Study for Utilization of Solar Energy

in the Federal Republic of Nigeria

October 2006

Japan International Cooperation Agency (JICA)

Preamble

In response to the request of the Government of the Federal Republic of Nigeria (hereinafter referred to as “Nigeria”), the Government of Japan decided to conduct Master Plan Study for Utilization of Solar Energy in the Federal Republic of Nigeria (Hereinafter referred to as “Study”) in accordance with the relevant laws and regulations in force in Japan and entrusted the Study to the Japan International Cooperation Agency (hereinafter referred to as “JICA”), the official agency responsible for the implementation of the technical cooperation programs in the Government of Japan.

JICA sent the Master Plan Study Team (hereinafter referred to as “Team”) to Nigeria and conduct the Study in close cooperation with the authorities concerned in Nigeria. The Study includes a Pilot Project (hereinafter referred to as “Project”) using Photovoltaic (PV) systems, which is implemented in one (1) village each in Jigawa State, Ondo State, and Imo State.

The scope of the Project in Jigawa state includes the procurement, installation, and maintenance of the PV systems consisting of one (1) Battery Charging Station (BCS) including twenty (20) electrified households, one (1) Public Facility, forty (40) Solar Home Systems (SHSs), and ten (10) Street Lightings.

Meanwhile, the PV systems consist of one (1) Public Facility including one (1) PV vaccine refrigerator, sixty (60) SHSs, and ten (10) Street Lightings in Ondo state; the PV systems consist of one (1) Public Facility, eighty (80) SHSs, and ten Street Lightings (10) in Imo State,

The installation of the PV systems is completed late in June 2006, and the Project will be monitored up to February 2007 to evaluate the sustainability of PV systems in Nigeria.

The manual is specially prepared to instruct the concept and maintenance of PV systems of the Project and consists of three chapters: for users, for maintenance staff, and for engineers. The contents are as follows:

- For Users

  The chapter starts with the components of PV systems and illustrates what the users should do and should not do to keep the PV systems in good condition.

- For Maintenance Staff

  The chapter describes what the maintenance staff should do as a routine work. It also contains how to deal with the troubles of the PV systems.

- For Engineers

  The chapter starts with the general description of PV generation. For future reference, it also describes PV systems design.

PV Systems Manual

For Users

1.1 Components of PV Systems

JICA provides two kinds of PV systems for independent house use—Solar Home System (SHS) and Battery Charging Station (BCS). The SHS consists of the following components:

- PV Module: Getting the sunlight, the PV module generates electricity,
- Storage Battery: The electricity generated by the PV module during the daytime charges the storage battery. At night, the battery discharges and supplies electricity. JICA provides a sealed type battery which is maintenance-free,
- Charge Controller: The charge controller controls the charge/discharge of the battery and has a function to prevent the battery from over-discharge,
- Circuit Breaker: In case of short circuit, the circuit breaker automatically cuts off the circuit,
- Switch: The switch is used to turn on and off the lightings,
- Outlet: The outlet is used for DC appliances such as a radio, black and white television set, etc, and
- Lighting: The lighting, Compact Fluorescent Lump (CFL), is specially designed for DC use and is more efficient than an ordinary AC bulb.

Meanwhile, the BCS consists of the same components as the SHS except that the PV modules are not installed independently but aggregated at the station as a PV array. The Users of the BCS are required to take their batteries to the station every 4 or 5 days and charge them. Additionally, the battery is flooded type which is required to fill distilled water regularly.

Fig. 1-1 shows the configuration of PV systems.

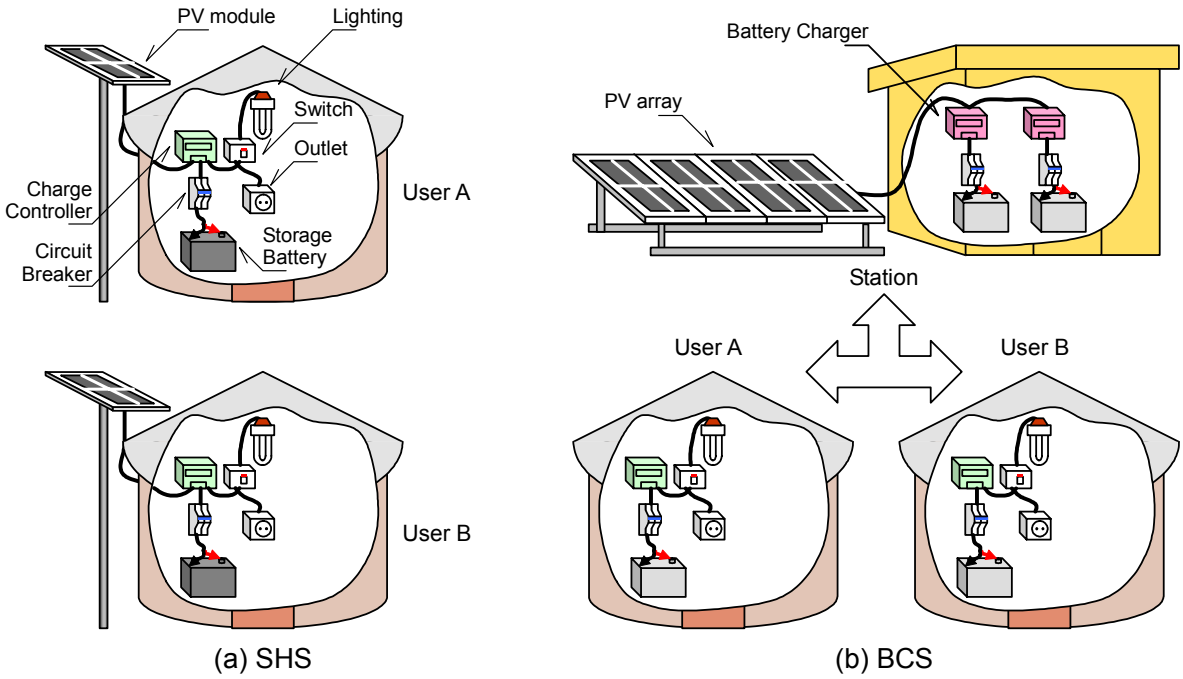
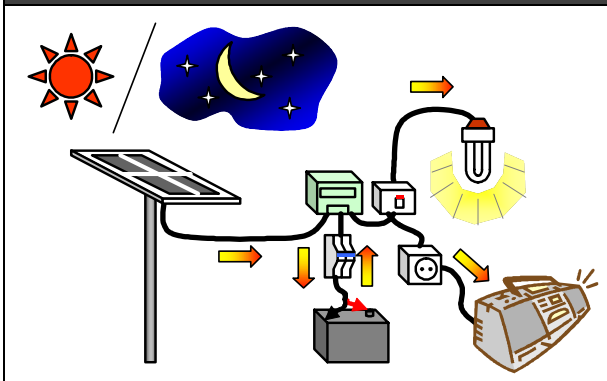
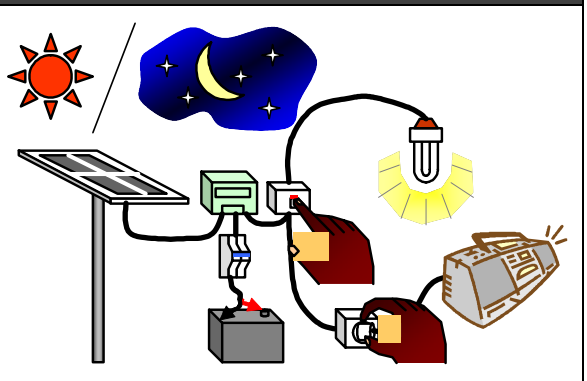
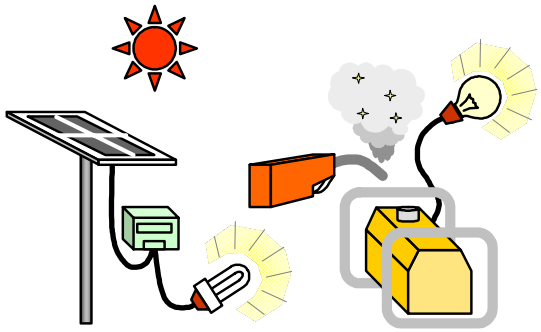
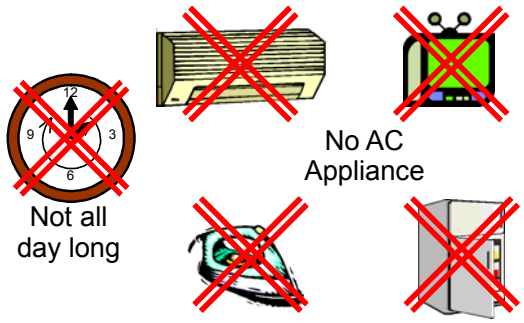


Fig. 1-1 Configuration of PV Systems

1.2 Feature of PV Systems

Table 1-1 illustrates the feature of PV systems.

Table 1-1 Feature of PV Systems

Reliable You can use electricity whenever you need power.	***Simple*** When you need electricity, you just turn on the switch or plug in an appliance.
	
Ecologically Friendly During the generation, the PV systems do not produce any harmful substance.	***Having Limitations*** You can not use the PV systems all day long. In addition, AC appliances are not applicable.
	

1.3 Concept of PV Systems

The output of the PV module totally depends on the weather. The more sunshine the PV module receives, the more electricity you can use. Meanwhile, the storage battery provides electricity at night. Even though you can not get any sunshine for a few days during the rainy season, the battery sustains the system and supplies you with electricity. However, the charge controller automatically disconnects the load when the battery voltage becomes too low to sustain the system.

Fig. 1-2 illustrates the concept of PV systems.

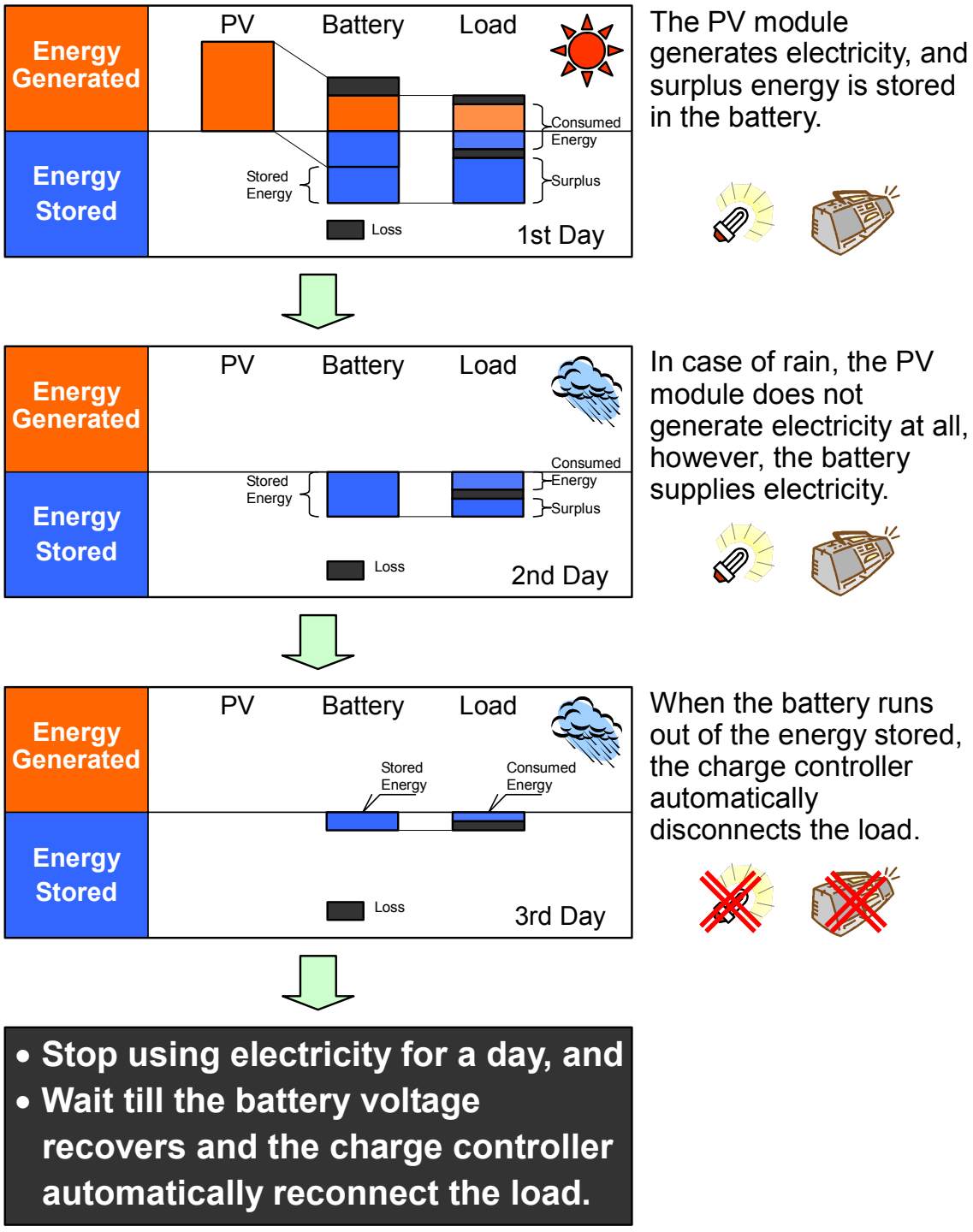


Fig. 1-2 Concept of PV Systems

1.4 Plan of Energy Consumption

Generally, the northern part of Nigeria shows the better solar irradiation conditions, in other words, you can use the PV systems longer in the north if the systems are identical. However, the hour of use depends on the load you use. So you need to make a plan of energy consumption considering the load you use.

Table 1-2 shows the daily limits of energy consumption which are calculated based on the solar irradiation conditions and specification of PV systems. As you see, high solar irradiation in Jigawa state allow you to consume energy most. For the purpose of using the PV system for as long a time as possible, you shall use energy within the limitation.

Table 1-2 Limit of Energy Consumption at SHS

	Jigawa	Ondo	Imo
Minimum Average solar irradiation [kW/m^2-day]	5.34	3.50	3.73
Capacity of PV module [W]	60	60	62
Lighting [W]	15 x 2	15 x 2	11 x 2
Limit of energy consumption [Wh/day]	120	85	90

Table 1-3 shows a quick reference matrix of energy consumption. First you select a nominal input of the load you use in the column of Watt, and then you find out energy consumption in Watt-hour in the same row depending on the time of use.

Table 1-3 Quick Reference Matrix of Energy Consumption in Watt-hour

Time / Watt	10 min	20 min	30 min	1 hour	2 hour	3 hour	4 hour	5 hour
1	0.2	0.3	0.5	1.0	2.0	3.0	4.0	5.0
2	0.3	0.7	1.0	2.0	4.0	6.0	8.0	10.0
5	0.8	1.7	2.5	5.0	10.0	15.0	20.0	25.0
9	1.5	3.0	4.5	9.0	18.0	27.0	36.0	45.0
10	1.7	3.3	5.0	10.0	20.0	30.0	40.0	50.0
11	1.8	3.7	5.5	11.0	22.0	33.0	44.0	55.0
15	2.5	5.0	7.5	15.0	30.0	45.0	60.0	75.0
20	3.3	6.7	10.0	20.0	40.0	60.0	80.0	100.0

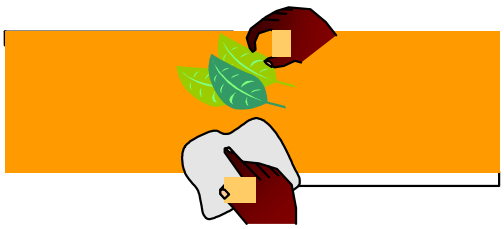
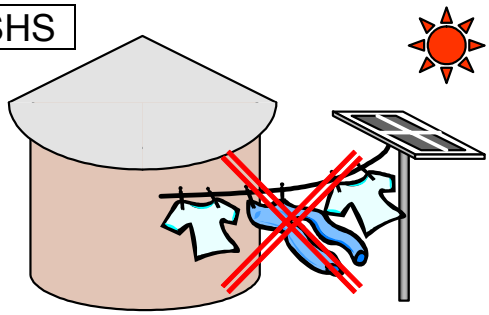
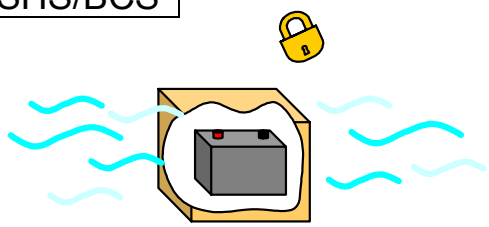
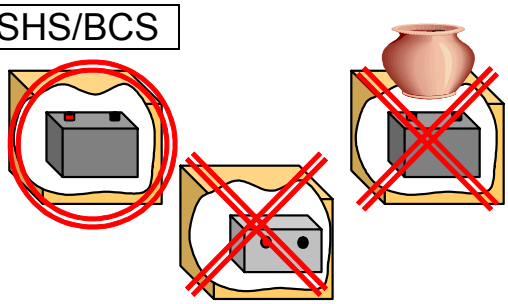
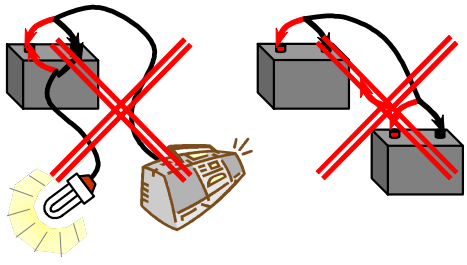
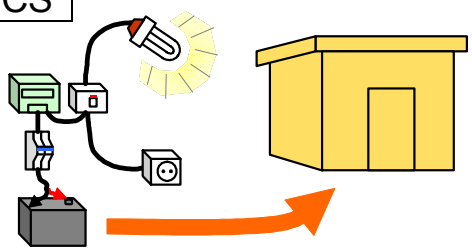
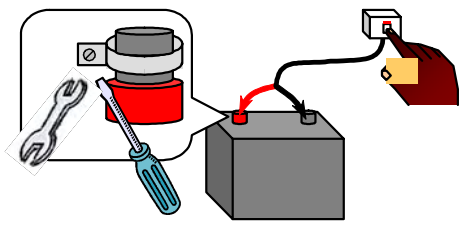
The following calculation shows an example of plan of energy consumption. In case of Jigawa, an nominal input of the two sets of lighting is 30 Watt. If you use them for 3.5 hours, the energy consumption yields 105 Watt-hour. Meanwhile, the energy consumption of radio for 3.0 hours is 15 Watt-hour, and we derive an accumulated energy consumption of 120 Watt-hour which meets the requirement of limit in Table 1-2.

Jigawa)	Light	30	Watt	x	3.5	hour	=	105.0	Wh
	Radio	5	Watt	x	3.0	hour	=	15.0	Wh
						Total		120.0	Wh

1.5 Points of Remember

In order to keep the PV systems in good condition, you should do and should not to do as illustrated in Table 1-4.

Table 1-4 Points of Remember

Should remove obstacles from the PV module to get as much sunshine as possible.	**Should** keep the PV module surface clean.
SHS 	SHS 
Should not hang the laundry on the cable to dry.	**Should** keep the battery in the battery box and lock it.
SHS 	SHS/BCS 
Should not put the battery sideways and leave any object on the battery box.	**Should not** connect the load to the battery terminal directly and connect the batteries in parallel.
SHS/BCS 	SHS/BCS 
Should take the battery to the station every 4 or 5 days and recharge it.	**Should** use a proper tool and be careful not to cause short circuit.
BCS  Take the batter to the station and recharge it	BCS Turn off the switch before connect/disconnect the cable 

PV Systems Manual

For Maintenance Staff

2.1 Components of PV Systems

JICA provides four kinds of PV systems—Battery Charging Station (BCS), Public Facility, Solar Home System (SHS), and Street Lighting. The components of the above PV systems are similar and have the following functions:

- PV Module/Array: Getting the sunlight, the PV module generates electricity,
- Storage Battery: The electricity generated by the PV module during the daytime charges the storage battery. At night, the battery discharges and supplies electricity. JICA provides sealed type batteries for SHSs and flooded type batteries for BCS households,
- Battery Charger: The charger is used to charge the storage batteries at BCS,
- Charge Controller: The charge controller controls the charge/discharge of the battery and has a function to prevent the battery from over-discharge,
- Circuit Breaker: In case of short circuit, the circuit breaker automatically cuts off the circuit,
- Switch: The switch is used to turn on and off the lightings,
- Outlet: The outlet is used for DC appliances such as a radio, black and white television set, etc,
- Lighting: The lighting, Compact Fluorescent Lump (CFL), is specially designed for DC use and is more efficient than an ordinary AC bulb, and
- PV Vaccine Refrigerator: The refrigerator is certified by the World Health Organization (WHO) and is specially designed for the purpose of preserving vaccines.

All the PV systems of the Project are operated at DC 12 V. Therefore, the Users are required to be careful when they choose the components of the system.

Fig. 2-1 illustrates the configuration of PV systems.

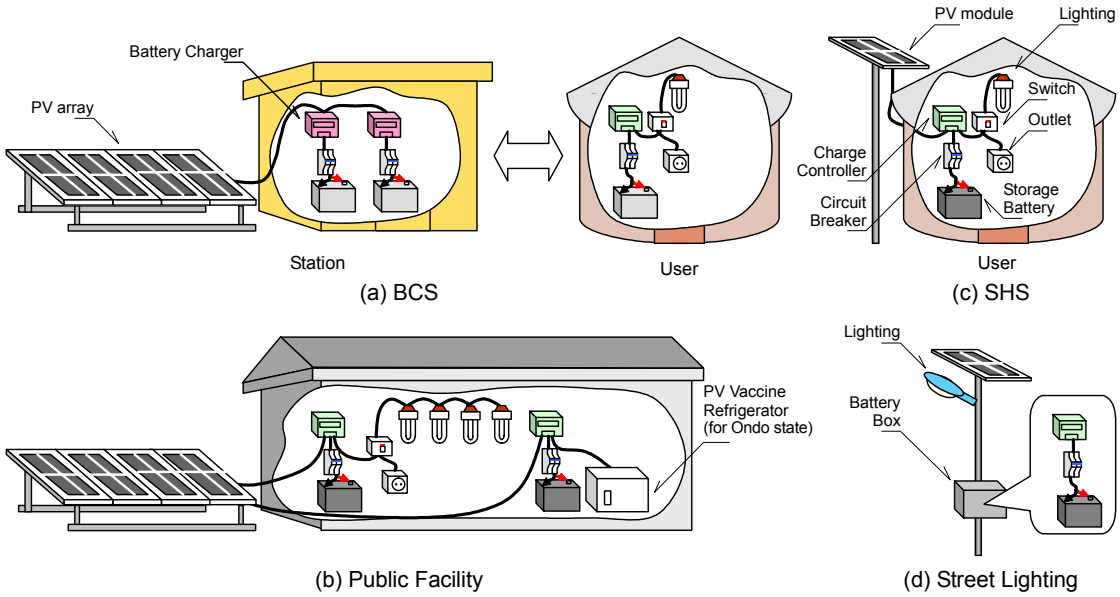


Fig. 2-1 Configuration of PV Systems

Table 2-1 to 3 illustrates the specification of the components in each state respectively.

Table 2-1 Specification of the Components in Jigawa State

Item	Specification
a. BCS	
i) Station	
PV Module	Polycrystal 60 W x 18 units
Charge Controller	12 V, 6 A x 1 unit
Battery Charger	12 V, 20 A x 5 units
Storage Battery	Sealed type for cycle use, 200 Ah x 1 unit
Lighting	12 V, 15 W Fluorescent Lamp x 2 units
ii) Household（per household）	
Charge Controller	12 V, 6 A x 1 unit
Storage Battery	Flooded type for trickle use, 88 Ah x 1 unit
Lighting	12 V, 15 W Fluorescent Lamp x 2 units
b. Public Facility	
PV Module	Polycrystal 60 W x 6 units
Charge Controller	12 V, 20 A x 1 unit
Storage Battery	Sealed type for cycle use, 200 Ah x 2 units
Lighting	12 V, 15 W Fluorescent Lamp x 12 units
c. SHS（per household）	
PV Module	Polycrystal 60 W x 1 unit
Charge Controller	12 V, 6 A x 1 unit
Storage Battery	Sealed type for cycle use, 65 Ah x 1 unit
Lighting	12 V, 15 W Fluorescent Lamp x 2 units
d. Street Lighting（per light）	
PV Module	Polycrystal 60 W x 1 unit
Charge Controller	12 V, 10 A x 1 unit, timer function
Storage Battery	Sealed type for cycle use, 65 Ah x 1 unit
Lighting	12 V, 18 W Sodium Lump x 1 unit

Table 2-2 Specification of the Components in Ondo State

Item	Specification
a. Public Facility	
i) Lighting	
PV Module	Polycrystal 60 W x 6 units
Charge Controller	12 V, 20 A x 1 unit
Storage Battery	Sealed type for cycle use, 200 Ah x 2 units
Lighting	12 V, 15 W Fluorescent Lamp x 10 units
ii) PV Vaccine Refrigerator	
PV Vaccine Refrigerator	38.7 liter x 1 unit
PV Module	Polycrystal 60 W x 4 units
Charge Controller	12 V, 15 A x 1 unit
Storage Battery	Sealed type for cycle use, 200 Ah x 1 unit, 100 Ah x 1 unit
b. SHS（per household）	
PV Module	Polycrystal 60 W x 1 unit
Charge Controller	12 V, 6 A x 1 unit
Storage Battery	Sealed type for cycle use, 65 Ah x 1 unit
Lighting	12 V, 15 W Fluorescent Lamp x 2 units
c. Street Lighting（per light）	
PV Module	Polycrystal 60 W x 1 unit
Charge Controller	12 V, 10 A x 1 unit, timer function
Storage Battery	Sealed type for cycle use, 65 Ah x 1 unit
Lighting	12 V, 18 W Sodium Lump x 1 unit

Table 2-3 Specification of the Components in Imo State

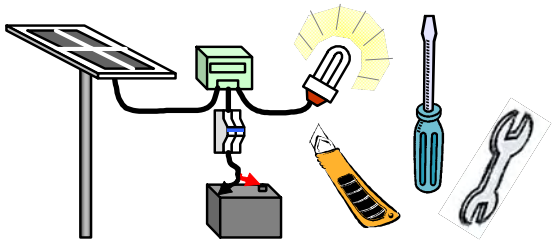
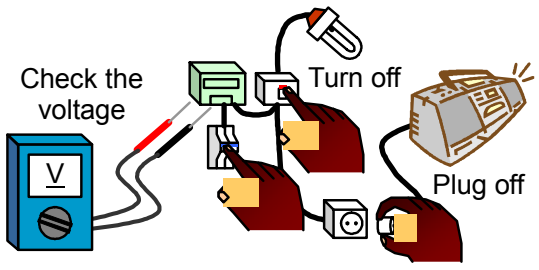
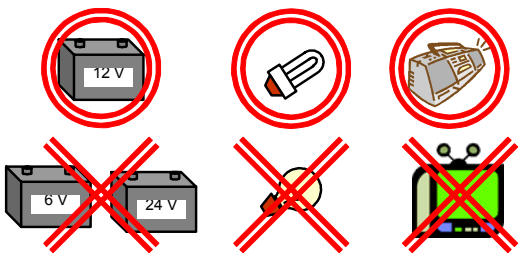
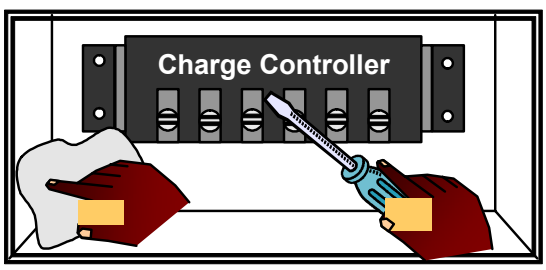
Item	Specification
a. Public Facility	
PV Module	Polycrystal 62 W x 8 units
Charge Controller	12 V, 30 A x 1 unit
Storage Battery	Sealed type for cycle use, 105 Ah x 4 units
Lighting	12 V, 11 W CFL x 12 units
b. SHS（per household）	
PV Module	Polycrystal 62 W x 1 unit
Charge Controller	12 V, 6 A x 1 unit
Storage Battery	Sealed type for cycle use, 60 Ah x 1 unit
Lighting	12 V, 11 W CFL x 2 units
c. Street Lighting（per light）	
PV Module	Polycrystal 62 W x 1 unit
Charge Controller	12 V, 10 A x 1 unit, timer function
Storage Battery	Sealed type for cycle use, 60 Ah x 1 unit
Lighting	12 V, 20 W CFL x 1 unit

2.2 Maintenance Works

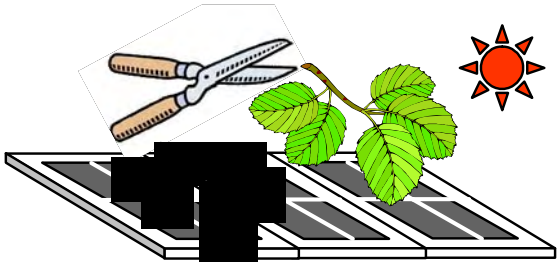
Generally, the PV systems do not need complicated maintenance works except filling distilled water in the flooded type batteries. You are required to check out the systems regularly and keep them in good condition.

The Points of remember are illustrated in the Table 2-4.

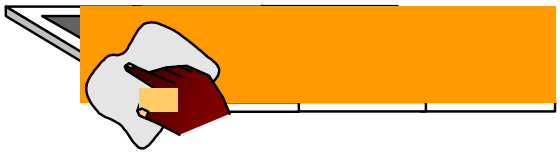
Table 2-4 Points of Remember

Should use proper tools during the maintenance work.	**Should** turn off the breaker and switch and check the voltage before the work.
	
Should use components which are designed for DC 12 V use.	**Should** fasten the screws if they are loose and clean the inside of the boxes.
	

Should remove obstacles from the PV arrays.

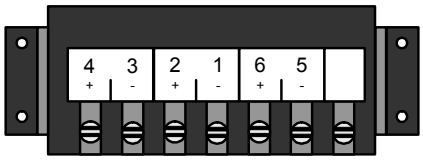


Should keep the PV arrays surface clean (Clean them up twice a month)



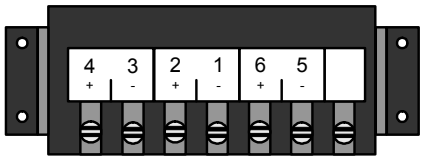
Clean up the surface
twice a month

Should connect the cable in the order of the terminal number when you replace the charge controller.



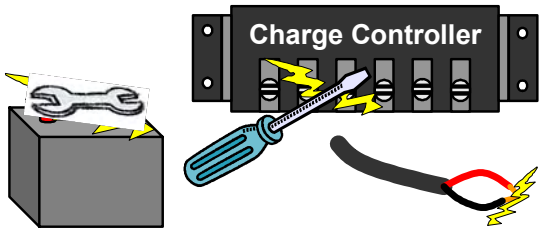
Turn off the switch/breaker and then connect the cables in the order of
1 ➔ 2 ➔ 3 ➔ 4 ➔ 5 ➔ 6

Should disconnect the cable in the opposite order of the terminal number when you replace the charge controller.

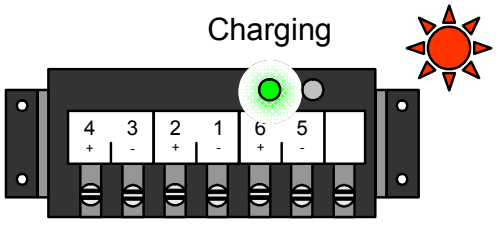


Turn off the switch/breaker and then disconnect the cables in the order of
6 ➔ 5 ➔ 4 ➔ 3 ➔ 2 ➔ 1

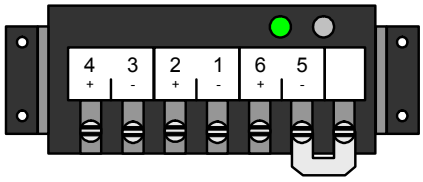
Should be careful not to cause short circuit.



Should confirm that the green light is on when the sunshine is present.

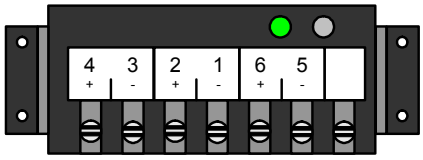


Should connect the jumper when a sealed type battery is used.

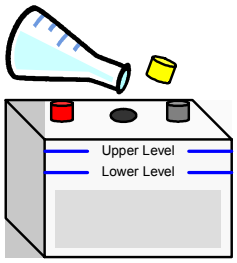
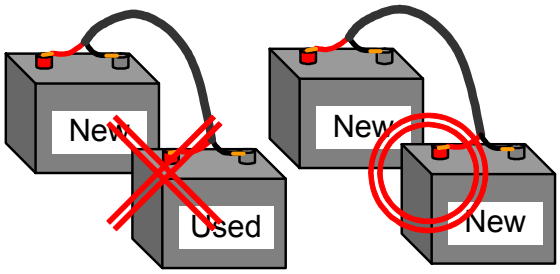


With the jumper, the charging voltage becomes 14.1 V for a sealed type battery.

Should remove the jumper when a flooded type battery is used.



Without the jumper, the charging voltage becomes 14.4 V for a flooded type battery.

Should confirm the level of electrolyte if a flooded type battery is used and fill distilled water up to the upper level.	**Should** replace the used batteries with the new ones at once.
 Do not use well water. Use only distilled water.	

2.3 Trouble Shooting

Most troubles can be checked at the terminals of the charge controller. In case that the User experiences a blackout, you shall check the system as follows:

a. Load Disconnection

- Check the indicator on the charge controller. If the red light is on, the charge controller has disconnected the load automatically because the battery voltage is too low to sustain the system.
- Make the User stop using electricity for a day and wait till the battery voltage recovers.
- When the battery voltage exceeds 12.6 V, the charge controller automatically reconnects the load.

b. Fault of Charge Controller

- Check the indicator on the charge controller. The green light is on during the daytime when the sunshine is present.
- Confirm that the breaker and switches are turned on.
- After turn off the breaker and switches, check all the wirings and their polarities. In addition, check all the terminal screws whether they are fastened tightly.
- Turn on the breaker and measure the voltage of each terminal.
- If the PV voltage—the voltage between the terminal 3 and 4—is close to the open voltage of the PV module and battery voltage—the voltage between the terminal 1 and 2—is low, the charge controller may be damaged. ➔ Replace the charge controller.
- If the battery voltage is too high, reconnect the cable on the PV terminals. The green light shall be off. If not, the charge controller may be damaged. ➔ Replace the charge controller.

c. Deterioration of Storage Battery

- The storage battery gradually deteriorates as the charge/discharge cycle goes by. Although the life cycle depends on how to use the battery, the expected lifetimes are approximately 5 or 6 years for a cycle use battery—a battery for PV generation application—and 1 or 2 years for a trickle use battery—a automobile battery, respectively
- If the load is disconnected quite often even though the User saves electricity, the battery will be replaced.

PV Systems Manual

For Engineers

3.1 Photovoltaic Power Generation

(1) Introduction

Photovoltaic (PV) power generation using solar energy which is clean and inexhaustible has great potential for supplying energy. Additionally, the generation will contribute to preventing global warming since it does not emit any carbon-dioxide.

PV systems consist of PV modules, inverters, batteries, and other components. To get needed voltage and current for a particular application, PV modules are connected in series and parallel to compose an array. The system is categorized either grid-connected system or stand-alone system. As is shown in Fig. 3-1, the grid-connected system can provide the load with electricity by both the PV module and grid. The system is used for a large system with capacity of a few kilowatts, and the surplus energy generated by the PV module will be sold to the utility company. Meanwhile, the stand-alone system is generally used in rural and remote areas where no distribution line exists. In order to provide power when the PV module generates no electricity, the system is equipped with the battery.

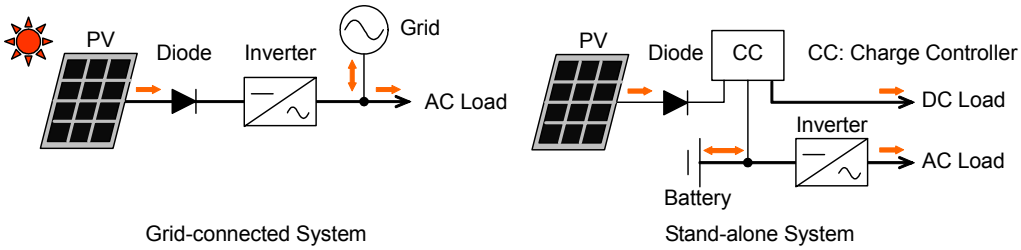


Fig. 3-1 Configuration of PV Systems

(2) Key Components of PV Systems

PV Module—A PV cell is a semiconductor device which converts light energy into electric energy by photovoltaic effect. Exposing the PV cell to light shown in Fig. 3-2, electron holes and electrons are generated around the p-n junction and transfer to p-type and n-type semiconductor respectively. Those electric charges cause an electric potential between the semiconductors. PV cells are categorized into three types: silicon semiconductor, compound semiconductor, and others. Among them, silicon semiconductor PV cells are only commercially available and categorized into crystalline and amorphous according to the materials. Table 3-1 shows their properties.

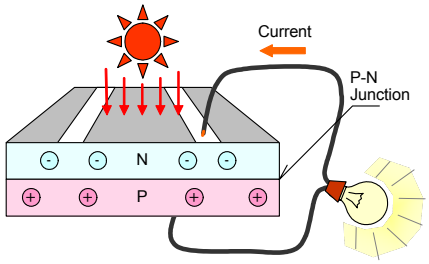


Fig. 3-2 Conceptual Diagram of Photovoltaic Effect

Table 3-1 Properties of Silicon Semiconductor PV Cells

Item \ Type	Monocrystal	Polycrystal	Amorphous
Conversion Efficiency	14 - 15%	11 - 13%	6 - 9%
Advantage	Widely used	High production volume	Cost reduction available
Disadvantage	High cost	High cost	Likely deteriorate

A PV module consists of tens of PV cells in series to get proper voltage for electrical appliances. As is shown in Fig. 3-3, PV cells are enclosed with Ethylene-Vinyl Acetate (EVA), and the semiconductors are connected with ribbon wirings. Furthermore, the cells filled with EVA resin are sandwiched between a front cover (reinforced-glass made) and back cover (film made), and rimmed with an aluminum frame.

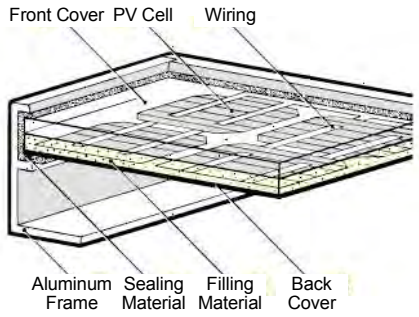


Fig. 3-3 Configuration of PV Module

The Fig. 3-4 shows a nameplate of PV module with capacity of 165 watt. The electrical characteristics is tested under the Standard Test Condition (STC) in accordance with IEC 60904-1—irradiance of 1000 W/m^2 with IEC 60904-3 reference solar spectral irradiance distribution, air mass (AM) 1.5 spectrum and cell temperature of 25 degrees. In addition, AM is defined as the ratio between the path length of perpendicular incidence and that of direct incidence as shown in Fig. 3-5. The electrical characteristics—Maximum power, open circuit voltage, short circuit current, maximum power voltage, and maximum power current—is greatly influenced by the condition of irradiance and cell temperature. As is shown in Fig. 3-6, the current *I* is maintained virtually constant against the voltage *V* until *V* gets at the maximum power voltage V_{pm}. In other words, PV modules function as constant current sources.

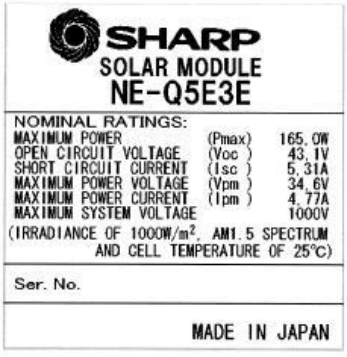


Fig. 3-4 Nameplate of PV Module

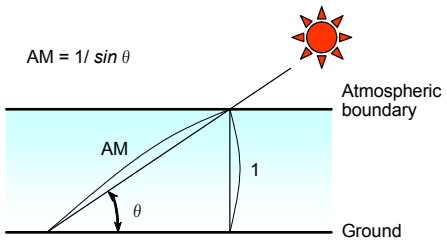
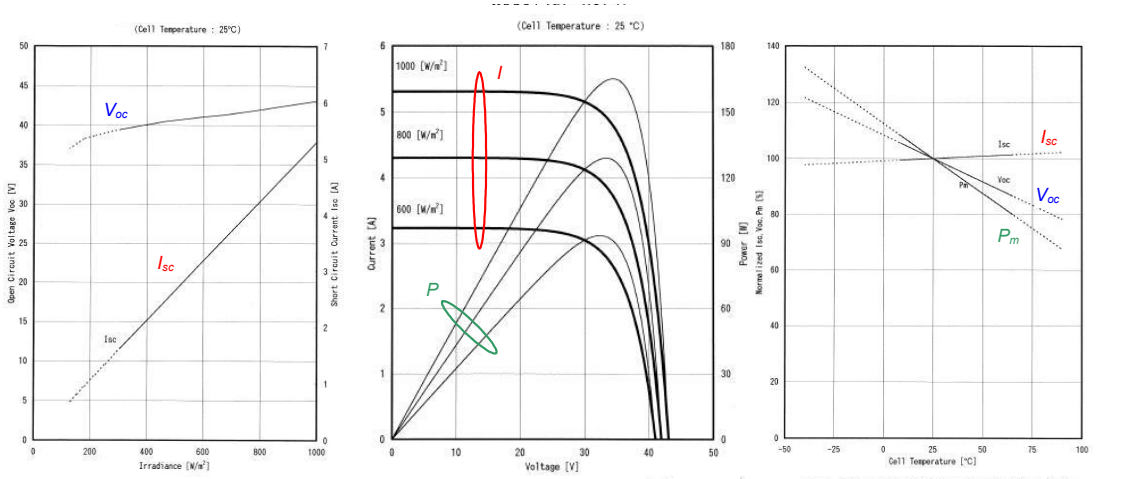


Fig. 3-5 Definition of Air Mass



V_{oc} and I_{sc} – irradiance characteristics *I and P – V characteristics* *P_m, V_{oc}, and I_{sc} – cell temperature characteristics*

Fig. 3-6 Electrical Characteristics of PV Module

Storage Battery—For PV system applications, lead batteries are widely used because they have a large capacity and are moderate-priced. Lead batteries are roughly classified into cycle and trickle use. A PV system repeats the cycles of charging electricity generated by the PV modules in the daytime and discharging it in the night. In general, batteries used for automobiles and Uninterruptible Power Supply (UPS) are float-charged at a constant voltage, and they are not appropriate for deep discharge—i.e. Depth of Discharge (DOD) * is large—and the repeating of charge and discharge. Consequently, in the event that batteries for trickle use are applied to the PV systems, there is possibility that the lifetimes of the batteries remarkably fall. Fig. 3-7 indicates the examples of battery discharge characteristics for trickle use with the depth of discharges as a parameter.

* Ratio of the amount of electric discharge against rated capacity

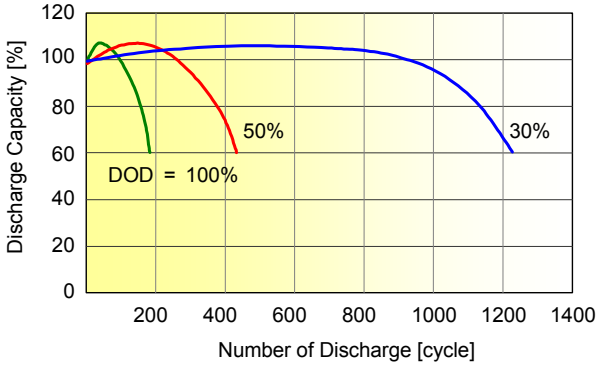


Fig. 3-7 Battery Discharge Characteristics

Fig. 3-8 shows a configuration of vented type battery. The negative and positive electrodes consist of expanded lead alloy filled with pasty lead powder. The active material for positive electrode is lead dioxide, while spongiform lead is used for the negative electrode. The separator prevents the electrodes from short circuit, and the glass mat is used to hold active materials on the electrodes.

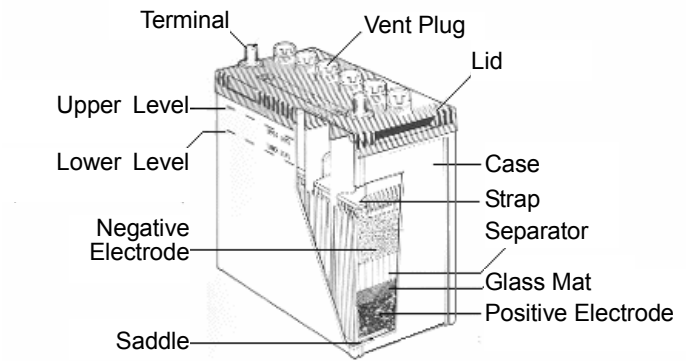


Fig. 3-8 Configuration of Vented Type Battery

Dilute sulfuric acid is used for the electrolyte. The chemical equation of the charge and discharge is expressed as follows:

$$\left.\begin{array}{l} PbO_2 + 2H_2SO_4 + Pb \rightarrow discharge \rightarrow Pb\,SO_4 + 2H_2O + Pb\,SO_4 \\ PbO_2 + 2H_2SO_4 + Pb \leftarrow charge \leftarrow Pb\,SO_4 + 2H_2O + Pb\,SO_4 \end{array}\right\} \quad (1)$$

The specific gravity of electrolyte indicates the State of Charge (SOC) of the battery. Using a hydrometer, the specific gravity can be measured as shown in Fig. 3-9. Using the following equation, the measured value can be converted to the standard value at 20℃.

$$SG_{20} = SG_t + 0.0007\,(t-20) \quad (2)$$

Where, SG_{20} : Specific Gravity at 20℃, SG_t : Specific Gravity at t℃, t : Electrolyte Temperature—using ambient temperature in practice. Finally, the converted value indicates the SOC of the battery as shown in Table 3-2. Note that the SG_{20} varies depending on the battery and electrolyte.

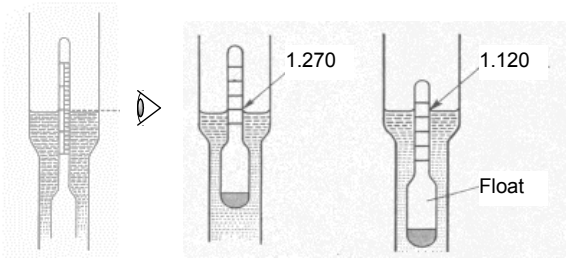


Fig. 3-9 Measuring Method of Specific Gravity

Table 3-2 Example of Specific Gravity-State of Charge Characteristics at 20℃

Specific Gravity	State of Charge [%]
1.280	100
1.240	75
1.200	50
1.160	25
1.120	0

Fig 3-10 shows a Valve Regulated Lead Acid (VRLA) battery—i.e. sealed type batteries. The VRLA battery contains small amount of electrolyte. Since the battery is sealed, it can be laid down. Fig. 3-11 shows the principal of the sealing means. Oxygen gas which is generated in the negative electrode at late stage of charge is absorbed by the spongiform lead of the electrode, and the gas is consumed inside the battery.

Fig. 3-10 VRLA Battery

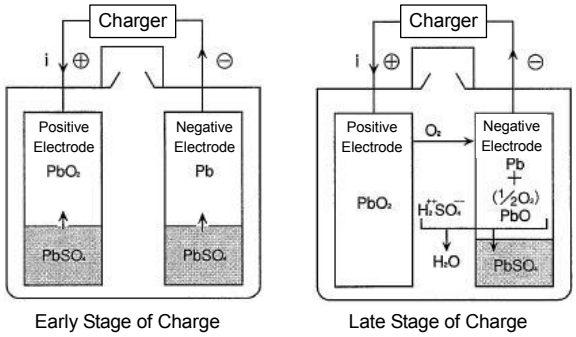


Fig. 3-11 Sealing Means of VRLA Battery

The capacity of a battery is a product of discharge current and time—Ampere-hour. When a battery is discharged at a constant current *I* for discharge time of *t* hours until the voltage *V* descends to the discharge termination voltage, the value of current is defined as an hour rate and expressed as (*1/ t) C* discharge. The hour rate capacities vary in accordance with the discharging currents. As shown in Fig. 3-12, the more discharge current becomes, the lower the discharge termination voltage turns out.

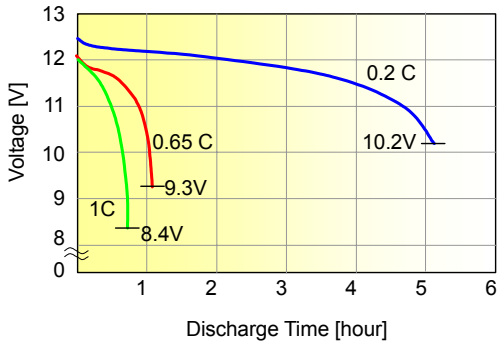


Fig. 3-12 Discharge Characteristics of Lead Acid Battery

Charge Controller and Inverter—A charge controller is used to control the battery charging by monitoring the battery voltage. Most controllers use Pulse-Width Modulation (PWM) control and automatically connect and disconnect the battery and load by semiconductor switches.

Fig. 3-13 Charge Controller

An Inverter is used to supply AC load with electricity. There are two types of inverters—one is sinewave type and the other is pseudo sinewave type as shown in Fig. 3-14. The sinewave type inverter supply the identical power frequency as the grid and can be used for any electrical appliances. Meanwhile, the pseudo sinewave type can not be used for the loads which operate depending on the wave form such as inverter type fluorescent lumps.

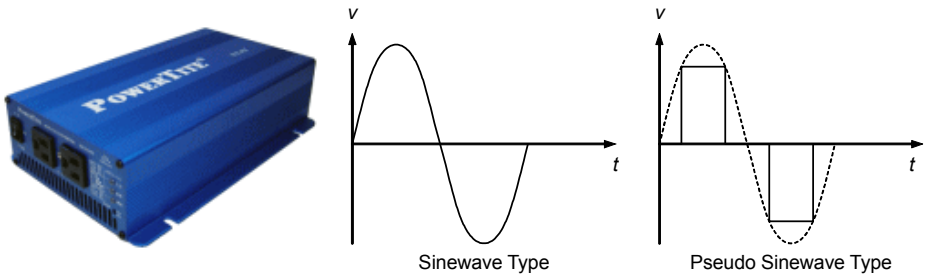
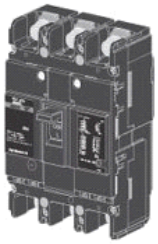


Fig. 3-14 Conceptual Diagram of Inver

Others—A fuse is used in main circuit of the PV system for preventing electrical appliances from the damage caused by short circuit. Especially, the fuse shall be connected between the battery and charge controller since the battery is easily broken by its short circuit current.

A Molded Case Circuit Breaker (MCCB) is used to switch on and off the circuit. In case of fault, it breaks the fault current after the certain time period in inversely relation to the percentage of fault current.



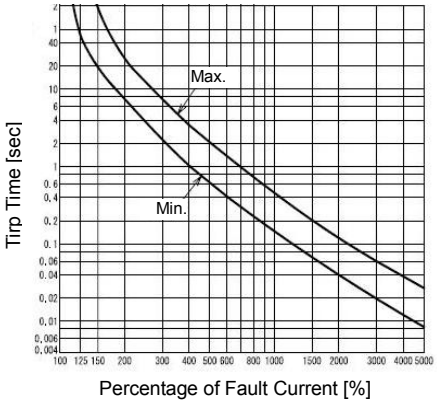


Fig. 3-15 Fuse for Low Voltage Circuit

Fig. 3-16 Operating Characteristics of MCCB

3.2 PV Systems Design

(1) Introduction

Meteorological conditions greatly affect energy outputs of PV systems; however, the detailed data nearby project sites are often not available. In addition, since the installation conditions also have an effect on the energy outputs, the prediction of the energy is hard and difficult. In practice, a PV systems design is carried out by reference to the design of similar systems. Fig. 3-17 shows the flow chart of PV systems design

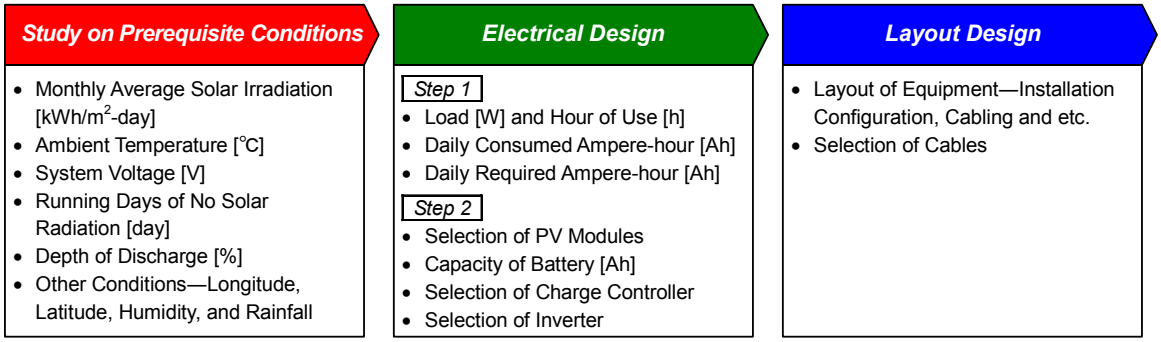


Fig. 3-17 Flow Chart of PV Systems Design

(2) Design Parameters

Direction and Tilt angle of PV modules—Since the earth rotates with axial inclination of 23.45 degree, solar irradiances on the ground have seasonal and location variations. Fig. 3-18 illustrates the orbit of the sun in the northern hemisphere. In midsummer, the sun orbits the highest path, while it takes the lowest path in midwinter. Fig. 3-19 shows the solar irradiance variation observed at Hamamatsu city, Japan, with latitude of 34.5 degree. The four curves represent the solar irradiance northward (N), southward (S), eastward (E), and westward (W). As is shown the figure, the southward irradiance becomes the highest. Thus the PV module shall face south to get the maximum solar irradiation. Additionally, the PV module shall be installed considering that no obstacle will shade the modules in midwinter.

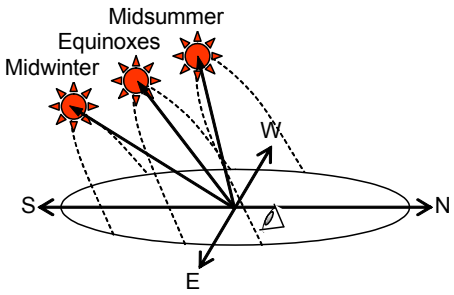


Fig. 3-18 Orbit of the Sun

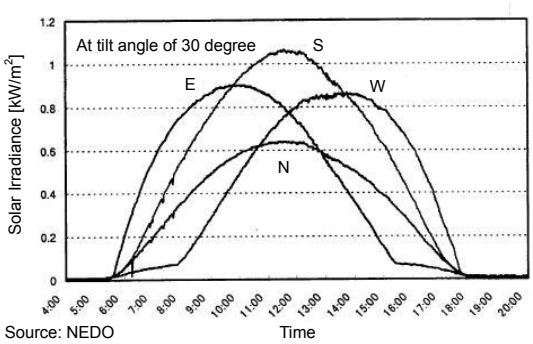


Fig. 3-19 Solar Irradiance Variation

According to the study in Japan, the optimum tilt angle which provides the maximum annual solar irradiation is slightly smaller than the latitude of the location. In addition, the PV module shall be set up at the tilt angle between 10 and 15 degrees at least to prevent rain water from remaining on the difference in level between their front cover and aluminum frame. Consequently, 15 degrees is recommended as the tilt angle in Nigeria because the country is located between the latitudes of 4 and 14 degree.

Solar Irradiation—Once you obtain the monthly average solar irradiation nearby the site, you have to determine the design value among the data. Being on the safe side, the minimum solar irradiation is recommended to use as the design value.

Ambient Temperature—Since the output of PV modules is greatly affected by the cell temperature, you have to carefully take ambient temperature into consideration. Typically, the output of PV modules will decrease approximately by 20% if the temperature rises by 50 degrees. If any average temperature over 45 degrees is expected at the site, you shall take it for the design value. Otherwise, assume 45 degrees as the design ambient temperature.

System Voltage—For the purpose of reducing the loss caused by the circuit current, the higher system voltage is preferable; however, most commercially available PV system products are designed for 12 V or 24 V use according to the rated voltage of batteries. For Solar Home Systems (SHSs) application, 12 V is suitable as the system voltage because rated power of SHSs is generally in the rage of 100 W. For the lager systems, 24 V or more is recommended as long as the products are available.

Running Days of No Solar Radiation and Depth of Discharge—The batteries supply the loads with electricity while the PV modules do not generate. The required capacity of the batteries is subjected to the running days of no solar radiation and DOD. Typically, 3 days are expected for no solar radiation, while DOD is assumed 50% as the design value.

(3) Design Methods

Study on Prerequisite Conditions—Firstly, determine the following design values:

- Monthly average solar irradiation SI_A [kW/m^2-day]—the minimum value of monthly average solar irradiations is recommend to use for the design,
- Ambient temperature T [degree]—45 degrees as long as the higher temperature is not expected,
- System voltage V_s [V]—12 V or 24 V,
- Running days of no solar radiation D_{NSR} [day]—3 days, and
- Depth of discharge DOD [%]—50%

And then, collect the other information such as the longitude, latitude, humidity, and rainfall. The information does not directly affects the electrical design of the PV systems; however, you have to confirm whether the rainfall which contributes to the self-cleaning of PV modules is expected or not at the site.

Electrical Design

➢ Daily Consumed Ampere-hour

Assume the loads and their hour of use. For AC loads, you have to take a conversion efficiency of inverter into consideration and assume it to be 90%. Dividing the loads by the system voltage, you derive the daily consumed ampere-hour AH_C from the quotient.

➢ Daily Required Ampere-hour

Find out the daily required ampere-hour AH_R considering the following correction coefficients:

- Correction coefficient of contamination K_D
- Correction coefficient of temperature K_T
- Correction coefficient of battery circuit K_B, and
- Other correction coefficient K_O

K_D represents the decrease of PV module outputs caused by the dust on their surface. According to the result of five-point observations in Japan, we assume K_D to be 0.98.

K_T represents the decrease of PV module outputs caused by the cell temperature rise. Define K_T as follows:

$$K_T = 1 + \alpha\ (T + \Delta T - 25) \quad (3)$$

Where, α [degree^{-1}] : Coefficient of temperature, T [degree] : Ambient temperature, and ΔT [degree] : Temperature rise of PV modules. Assume PV modules outputs decrease by 20% when the temperature rises by 50 degrees and derive α to be - 0.4%/degree. ΔT varies according to the installation configuration of PV modules and is in the range of 18 to 25 degrees. Being on the safe side, assume that ΔT is 25 degrees. When T is 45 degrees, the K_T yields 0.82.

K_B represents the loss caused by charging and is generally to be 0.80 for lead acid batteries. K_O represents the other losses caused by wiring and charge controllers. Assume that it is 0.90.

Define the product of the above coefficients as the design coefficient as follows:

$$K = K_D \cdot K_T \cdot K_B \cdot K_O \quad (4)$$

When T is 45 degrees, K yields 0.58. Dividing the AH_C by K, and derive the AH_R.

➢ Selection of PV Module

Determine the number of PV modules needed for the system. The PV output current I_{PV} is given by:

$$I_{PV} = AH_R / H_{SR} = AH_R / (SI_A / 1000) \quad (5)$$

Where, AH_R [Ah/day] : Daily required ampere-hour, SI_A [kWh/m^2-day] : Average monthly solar irradiation, and H_{SR} [hour/day] : Hours of solar radiation—1000 W/m^2 represents the ideal solar irradiance on the ground.

Meanwhile, the PV output voltage V_{PV} is given by:

$$V_{PV} = V_S \cdot K_C + \Delta V_D + \Delta V_L \quad (6)$$

Where, V_S [V] : System voltage, K_C : Coefficient of full-charging, ΔV_D [V]: Voltage drop of diode, and ΔV_L : Voltage drop of wiring. K_C is generally to be 1.24 for lead acid batteries. ΔV_D is typically to be 0.7 V, while ΔV_L is determined according to the users' criteria. Referring to standard electrical characteristics of PV modules, you will decide the number and connection of PV modules so as to the PV array output meets the above requirement.

- Selection of Battery

The capacity of battery C_B is give by:

$$C_B = AH_C \cdot D_{NSR} / (K_L \cdot DOD /100) \quad (7)$$

Where, AH_C [Ah/day] : Daily consumed ampere-hour, D_{NSR} [day] : Running days of No solar radiation, DOD [%] : Depth of discharge, and K_L: Coefficient of wiring and controller loss. Assume that K_L is 0.9.

- Selection of Charge Controller

Considering the charge controllers which are commercially available, decide the number of charge controllers N_C first, and then determine the rated input current of I_{IC} and output current I_{OC} as follows:

$$I_{IC} = I_{PV} / N_C \quad (8)$$

$$I_{OC} = P_M / (V_S \cdot N_C) \quad (9)$$

Where, I_{PV} [A] : PV output current , P_M [W] : Maximum Load input, V_S [V] : System voltage. Confirm that the rated currents of the charge controller meet the above requirement.

- Selection of Inverter

Determine the rated output current of I_{OI} and input current I_{II} as follows:

$$I_{OI} = P_{AC} / V_{AC} \quad (10)$$

$$I_{II} = I_{OI} \cdot V_{AC} / (V_S \cdot \eta) \quad (11)$$

Where, P_{AC} [W] : AC load input, V_{AC} [V] : AC load voltage, V_S [V] : System voltage, and η : conversion efficiency of inverter. We will select the inverters among commercially available product which meet the above requirement. The inverter shall be directly connected to the battery.

According to the type of the AC load, the higher power is required to start up the loads. For example, a color television consumes as 5 times higher power as the rated power when it stars, and a refrigerator needs as 10 times higher power as the rated power when its compressor starts. To determine the rated output of inverters, the above conditions have to be considered. A maximum load input P_{mI} is given by

$$P_{ml} = C_m \cdot P_{AC} \quad (12)$$

Where, C_m : Multiple number between maximum load input and rated load input. The output power of the inverter shall meet the above requirement.

- Layout Design

Table 3-3 shows rated current associated with voltage drops for PVC cables regulated in Nigeria. In the regulation, total voltage drops between the consumer's terminals and any points in the installation shall not exceed 2.5% of the nominal voltage. Using the table, you will easily find out the voltage drops which are caused by the current.

Table 3-3 Rated Current associated with Voltage drops for PVC cables

Conductor		Enclosed in cable conduit		Unenclosed	
Cross-sectional area [mm^2]	Number / diameter of wires	Rated current [A]	Voltage drop [mV/A·m]	Rated current [A]	Voltage drop [mV/A·m]
1.0	1/1.13	11	40	13	40
1.5	1/1.38	13	27		27
	7/0.50		30	16	30
2.5	1/1.78				
	7/0.67	18	16	23	16
4	7/0.85	24	10	30	10
6	7/1.04	31	6.8	38	6.8
10	7/1.35	42	4.0	51	4.0
16	7/1.70	56	2.6	63	2.6
25	7/2.14	73	1.6	89	1.6
35	19/1.53	90	1.2	109	1.2

Source: 1996 Electricity Act. Electrical Installation Regulations, Nigeria

(4) Design Example

Table 3-4 shows an example of PV system design. In this example, the stand-alone system having both DC and AC loads is designed.

Table 3-4 Example of PV system Design

1. Prerequisite Conditions

・Site	FCT, Nigeria	
・Average Solar Irradiation [kWh/m^2-day]	4.18	on Aug.
・Ambient Temperature [℃]	45.0	No information
・System Voltage [V]	12.0	12V products prevail.
・Running Days of No Solar Radiation [day]	3.0	
Depth of Discharge [%]	50.0	

2. Daily Consumed Ampere-hour

・Daily Consumed Ampere-hour [Ah/day] 29.5

Load	Power (W)	Hour of use (h/day)	Efficiency	Consumed Ah (Ah/day)
DC Load, Fluorescent light (11W x 4)	44.0	6.0	1.0	22.0
AC Load, Color TV (40W x 1)	40.0	2.0	0.9	7.5
			Total	29.5

3. Daily Required Ampere-hour

・Daily Required Ampere-hour [Ah/day] = Daily Consumed Ampere-hour / Design Coefficient
51.0

Correction Coefficient of Contamination	0.98	PV output decreases due to the contamination.
Correction Coefficient of Temperature	0.82	Output decreasing rate is -0.4%/deg
Correction Coefficient of Battery Circuit	0.80	Loss due to chargeing
Other Correction Coeffient	0.90	Loss due to wires and controllers
Design coefficient	0.58	

4. Selection of PV module

・Hours of Solar Radiation [h/day] = Average Solar Irradiation / 1000
4.2

・PV output current [A] = Daily Required Ampere-hour / Hours of Solar Radiation
12.2

・PV output voltage (V) = System voltage x charging coefficient + voltage drop
15.9

Coefficient of Ful-charging	1.24	for lead acid battery
Voltage Drop of Diode [V]	0.70	for preventing adverse current
Voltage Drop of Wiring [V]	0.30	2.5% of system voltage (Nigeria standard)

・PV module specification

Maximum power rating (W)	55	Refer to Shell SM55 (55W)
Rated current (A)	3.15	ditto
Rated voltage (V)	17.4	ditto

・Noumber of Modules in Series

Since the rated voltage 17.4V > PV output voltage 15.9V, Number of modules in series shall be 1.

・Noumber of Modules in Parallel

PV output current (A)	12.20	
Rated current (A)	3.15	
Number of modules in parallel	4	

5. Capacity of Battery

- Capacity of Battery [Ah] = Daily Consumed Ah x Running Days of No Solar Radiation / (Coefficient of Wiring and Controller Loss x DOD / 100)

196.7	== >	200	Round up

Daily Consumed Ampere-hour [Ah/day]	29.5	
Running Days of No Solar Radiation [day]	3.0	
Depth of Discharge [%]	50.0	
Coefficient of Wiring and Controller Loss	0.9	loss due to wires and controllers

6. Selection of Charge Controller

- Input Current [A] = PV output current / Number of controllers

12.20	== >	13	Round up

PV Output Current [A]	12.20	
Number of Charge Controllers	1	4 modules/controller

- Output Current [A] = Maximum Load input / System Voltage / Number of controllers

3.67	== >	4	Round up

Maximum Load Input [W]	44.0	DC Load
System Voltage (V)	12.0	
Number of Controllers	1	

Being on the safe side, both the input and output current shall be 20A.

7. Selection of Inverter

- Output current [A] = Maximum Load Input / AC Load Voltage

0.17	== >	1	Round up

Maximum Load Input [W]	40.0	AC Load
AC Load Voltage[V]	230.0	

- Input Current [A] = Output Current x AC Load Voltage / System Voltage / Conversion Efficiency

3.70	== >	4	Round up

Output current [A]	0.17	
AC Load Voltage [V]	230.00	
System Voltage [V]	12.00	
Conversion Efficiency	0.9	

- Output Power [W] = Maximum Load Input X Multiple Number

200.00	== >	200	Round up

Maximum Load Input [W]	40.0	AC Load
Multiple number	5.0	The load is color TV.

8. Specification

System Voltage [V]	12	
PV Array Output [W]	220	55W x 4 modules
Battery [A]	200	
Charge controller [A]	20	1 unit
Inverter [W]	200	1 unit

The Federal Republic of Nigeria
Master Plan Study for Utlization of Solar Energy

Log Book
on the
Operation and Maintenance
of
the Pilot Project for Solar PV System

Village: Garkon Alli
Local Government Area: Kiyawa
State: Jigawa

Project Funded by

Japan International Cooperation Agency (JICA)

Log Book on the Operation and Maintenance of the Pilot Project for Solar PV System

Village: Garkon Alli **Local Government Area: Kiyawa** **State: Jigawa**

Type of Solar PV System(Tick as appropriate):
1) **Solar Home System** ☐
2) **Battery Charging System** ☐

Name of Lessee: _____ **ID:** _____

Note: "0" denotes sample writing.

No.	Payment			Record on Maintenance Works											Security
	Date	Amount(₦)	Received by	Date of Breakdown	Lamp	Wiring	Switch	Battery	Charge Controller	Solar Panels	Description	Date of Action Taken and Its Contents	Result	Payment Made for Repairing Works	
0	2007/1/1	850	(Signature)	-	x	x	-	-		-	Broken during the renovation of the house	Assistance asked to the State Government for repairing	After 5 days, State Gov. sent engineer	Wiring: 500 Naira, Lamp: 400Naira	Solar panel was stolen on April/xx/20xx
Jan															
Feb															
Mar															
Apr															
May															
Jun															
Jul															
Aug															
Sep															
Oct															
Nov															
Dec															

Conditions of the Households and Life Stype that Affect the Use of Solay PV System, Complaints and Comments:

Recorded by: _____ **Reviewed by:** _____ **Approved by:** _____

Monthly Record of SHS Year:_____ Village: Garkon Alli **Local Government Area: Kiyawa** **State: Jigawa**

No.	No. of Payment			Area of Repairing Works						No. of Maintenance Works		Security of the Solar PV System
	Made	Not Made	Total Amount of Payment (N)	Lamp	Wiring	Switch	Battery	Charge Controller	Solar Panels	No. of Works	No. of Responses made by the State Government	
0	56	4	1590	-	2	1	-	-		3	3	No vanadalism this month.
Jan												
Feb												
Mar												
Apr												
May												
Jun												
Jul												
Aug												
Sep												
Oct												
Nov												
Dec												

Recorded by: **Reviewed by:** **Approved by:**

Revenue: Year_____ Village: Garkon Alli Local Government Area: Kiyawa State: Jigawa

No.	Revenue				Spending		Balance to Date (₦)	Description
	Made	Not Made	Total Amount Collected this month (₦)	Total Cumulative Amount to date (₦)	Total Amount Spent for Maintenance Works (₦)	Remuneration (₦)		
0	56	4	36,400	36,400	1,590	10,000	10,000	
Jan								
Feb								
Mar								
Apr								
May								
Jun								
Jul								
Aug								
Sep								
Oct								
Nov								
Dec								

Recorded by:_____ **Reviewed by:_____**

Monthly Record of BCS: Month_____, 2006 Village: Garkon Alli Local Government Area: Kiyawa State: Jigawa

BCS House No.	Individual Battery Charging Works					Maintenance Works of Battery Charging Station						Descriptions
	Serial No. of Battery	Conditions of Battery (water, etc.)	Date. of Charging	Total No. of Battery Charging of the Month	Extra Payment (₦) *	Charging Plug	Wiring	Switch	Battery	Charge Controller	Solar Panels	
Sample Writing	(No.)	Good	Jan/5, 15, 25	3	-	-	-	Getting loose	-	-	-	
BCS 01												
BCS 02												
BCS 03												
BCS 04												
BCS 05												
BCS 06												
BCS 07												
BCS 08												
BCS 09												
BCS 10												
BCS 11												
BCS 12												
BCS 13												
BCS 14												
BCS 15												
BCS 16												
BCS 17												
BCS 18												
BCS 19												
BCS 20												

Note: * - Payment imposed on excessive charging.

Recorded by:_____ Reviewed by:_____ Approved by:_____

Data Sheet for Charging Record

BCS Charging Record Month _____

No.	Date / Voltage	Record 1	Record 2	Record 3	Record 4	Record 5	Record 6	Record 7	Record 8	Remarks
1	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
2	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
3	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
4	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
5	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
6	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
7	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
8	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
9	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
10	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
11	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
12	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
13	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
14	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
15	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
16	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
17	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
18	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
19	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
20	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	
	Before Charging	/	/	/	/	/	/	/	/	
	After Charging	/	/	/	/	/	/	/	/	

Example of filling out the data sheet

No.	Date / Voltage	Record 1	Record 2	Record 3	Record 4	Record 5	Record 6	Record 7	Record 8	Remarks
1	Before Charging	1 / 12.0 V	6 / 12.5 V	10 / 12.0 V	17 / 11.8 V	22 / 12.0 V	27 / 12.5 V	/	/	Filling the battery with
	After Charging	2 / 14.5 V	7 / 14.0 V	12 / 14.5 V	18 / 14.5 V	23 / 14.0 V	28 / 14.5 V	/	/	distilled water on 22nd.

Data Sheet for Charging Record

BCS No. _____ Month _____

Weather 1. Sunny  , 2. Cloudy  , 3. Rainy  , 4. Occasionally rainy  , 5. Occasionally Cloudy

Load 1. Lighting 1  , 2. Lighting 2  , 3. Radio  , 4. Others (Indicate it in the remarks)

Date	Weather	Energy Consumption Record															Remarks
		Record 1			Record 2			Record 3			Record 4			Record 5			
		Load	From	To	Load	From	To	Load	From	To	Load	From	To	Load	From	To	
1																	
2																	
3																	
4																	
5																	
6																	
7																	
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28																	
29																	
30																	
31																	

Example of filling out the data sheet

Date	Weather	Energy Consumption Record															Remarks
		Record 1			Record 2			Record 3			Record 4			Record 5			
		Load	From	To	Load	From	To	Load	From	To	Load	From	To	Load	From	To	
1	1	3	10:00	12:00	1	19:00	21:00	2	19:00	22:00							
2	4	4	12:00	14:00	1	15:00	16:00	1	19:00	23:00							B/W TV, 30W

Data Sheet for Charging Record

Public Facility Month _____

Weather 1. Sunny  , 2. Cloudy , 3. Rainy  , 4. Occasionally rainy  , 5. Occasionally Cloudy 

Load 1. Lighting 1  x 4 , 2. Lighting 2  x 4 , 3. Lighting 3  x 4 , 4. Radio  , 5. Others (Indicate it in the remarks)

Date	Weather	Energy Consumption Record															Remarks
		Record 1			Record 2			Record 3			Record 4			Record 5			
		Load	From	To	Load	From	To	Load	From	To	Load	From	To	Load	From	To	
1																	
2																	
3																	
4																	
5																	
6																	
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27																	
28																	
29																	
30																	
31																	

Example of filling out the data sheet

Date	Weather	Energy Consumption Record															Remarks
		Record 1			Record 2			Record 3			Record 4			Record 5			
		Load	From	To	Load	From	To	Load	From	To	Load	From	To	Load	From	To	
1	1	1	19:00	21:00	2	19:00	21:00	3	19:00	21:00							
2	4	4	12:00	14:00	5	15:00	17:00	1	19:00	21:00							B/W TV, 30W

Data Sheet for Charging Record

SHS No. _____ Month _____

Weather 1. Sunny  , 2. Cloudy  , 3. Rainy  , 4. Occasionally rainy  , 5. Occasionally Cloudy

Load 1. Lighting 1  , 2. Lighting 2  , 3. Radio  , 4. Others (Indicate it in the remarks)

Date	Weather	Energy Consumption Record															Remarks
		Record 1			Record 2			Record 3			Record 4			Record 5			
		Load	From	To	Load	From	To	Load	From	To	Load	From	To	Load	From	To	
1																	
2																	
3																	
4																	
5																	
6																	
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31																	

Example of filling out the data sheet

Date	Weather	Energy Consumption Record															Remarks
		Record 1			Record 2			Record 3			Record 4			Record 5			
		Load	From	To	Load	From	To	Load	From	To	Load	From	To	Load	From	To	
1	1	3	10:00	12:00	1	19:00	21:00	2	19:00	22:00							
2	4	4	12:00	14:00	1	15:00	16:00	1	19:00	23:00							B/W TV, 30W

Data Sheet for Charging Record

Spare Parts and Lending Goods

No.	Item	Specification	Unit	Remaining Quantities													Remarks
				Initial	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	
1. Spare Parts for BCS																	
1.1	Battery Charger	12 V, 20 A	pcs	1													
1.2	Charge Controller	12 V, 6 A	pcs	1													
1.3	Storage Battery	88 Ah, vented type, trickle use	pcs	2													
1.4	Circuit Breaker	Bipolar, 30 A	pcs	1													
1.5	ditto	Bipolar, 20 A	pcs	1													
1.6	ditto	Bipolar, 10 A	pcs	2													
1.7	Lighting	12 V, 15 W, fluorescent lamp	pcs	22													
1.8	Switch	Bipolar, DC 12 V	pcs	10													
1.9	Outlet	DC 12V	pcs	5													
1.10	Distilled Water	20 liter	pcs	1													
2. Spare Parts for Public Facility																	
2.1	Charge Controller	12 V, 20 A	pcs	1													
2.2	Circuit Breaker	Bipolar, 20 A	pcs	1													
2.3	Lighting	12 V, 15 W, fluorescent lamp	pcs	6													
2.4	Switch	Bipolar, DC 12 V	pcs	1													
2.5	Outlet	DC 12V	pcs	1													
3. Spare Parts for SHS																	
3.1	Charge Controller	12 V, 6 A	pcs	2													
3.2	Circuit Breaker	Bipolar, 10 A	pcs	2													
3.3	Lighting	12 V, 15 W, fluorescent lamp	pcs	40													
3.4	Switch	Bipolar, DC 12 V	pcs	20													
3.5	Outlet	DC 12V	pcs	10													
4. Spare Parts for Street Lighting																	
4.1	Charge Controller	12 V, 10 A	pcs	2													
4.2	Circuit Breaker	Bipolar, 10 A	pcs	2													
4.3	Lighting	12 V, 18 W, Sodium lamp	pcs	5													
5. Lending Goods																	
5.1	Radio	12V, 5W with DC plug	pcs	4													
5.2	Digital Multimeter	Portable	pcs	1													
5.3	Maintenance Tool	Driver, wrench, etc.	lot	1													

Example of filling out the inventory

No.	Item	Specification	Unit	Remaining Quantities													Remarks
				Initial	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	
1. Spare Parts for BCS																	
1.7	Lighting	12 V, 15 W, fluorescent lamp	pcs	22			22	20	19	15	10	20	19	18	18	17	Purchase 10 sets of FL in Aug.
5. Lending Goods																	
5.1	Radio	12V, 5W with DC plug	pcs	4			4	4	4	4	4	4	4	4	4	4	

Questionnaire about the Pilot Project State: Jigawa/Ondo/Imo, User: SHS/BCS No. _____

1. Attribute

a. Name: _____ b. Age: _____ c. Number of family members: Male _____, Female _____

d. Occupation: ☐ Employed worker ☐ self-employed worker ☐ Farmer ☐ Others ( )

e. Yearly income _____ f. Number of rooms _____

2. General

2.1 Are you satisfied with the PV systems? Tick one (1) choice.

☐ Yes, very much ☐ Yes, moderately ☐ No, not much ☐ No, not at all

2.2 What is the reason of the above answer? Tick one (1) choice.

☐ Expensive tariff ☐ Reasonable tariff ☐ Reliable/Easy to use ☐ Environmentally friendly

2.3 Do you understand how to use the PV systems? Tick one (1) choice.

☐ Yes, very well ☐ Yes, moderately ☐ No, not well ☐ No, not at all

2.4 Do you understand that the PV systems have the limitations? Tick one (1) choice.

☐ Yes, very well ☐ Yes, moderately ☐ No, not well ☐ No, not at all

2.5 Who use the PV systems often? Tick one (1) choice.

☐ Husband ☐ Wife ☐ Children ☐ Visitors

2.6 From a husband point of view, what did the PV systems improve? Mark the number in order.

( ) Household work ( ) Child care ( ) Reading/ Studying ( ) Security

( ) Income ( ) Saving expenses ( ) Information ( ) Having fun

2.7 From a housewife point of view, what did the PV systems improve? Mark the number in order.

( ) Household work ( ) Child care ( ) Reading/ Studying ( ) Security

( ) Income ( ) Saving expenses ( ) Information ( ) Having fun

2.8 Did you start any business after you started using the PV systems? Tick one (1) choice.

☐ house industry ☐ Sewing ☐ None ☐ Others ( )

2.9 How much did you spend for energy (kerosene, battery, etc.) before you started using the PV systems? Write the monthly amount. _____

2.10 How much do you spend for energy (kerosene, battery, etc.) now? Write the monthly amount. _____

2.11 If possible, how may lighting points do you need? Write the number._____

2.12 Which system do you like best? Tick one (1) choice.

☐ 55 W SHS for two (2) sets of lamps and one (1) radio at the rate of N500/month.

☐ 110 W SHS for four (4) sets of lamps, one (1) radio, and one (1) TV set at the rate of N750/month.

☐ 165 W SHS for six (6) sets of lamps, one (1) refrigerator, and one (1) TV set at the rate of N1,000/month.

☐ BCS for two (2) sets of lamps and one (1) radio at the rate of N50/charge.

2.13 If possible, which appliances do you want to use? Mark the number in order.

( ) Fan ( ) TV set ( ) Refrigerator ( ) Lighting ( ) Others ( )

2.14 Do you own a generator? Tick (1) one choice and write the output.

☐ Yes. Output:_____W ☐ No

2.15 What appliances do you own? Tick as many as you own.

☐ Radio ☐ Fan ☐ TV set ☐ Lighting ☐ Others ( )

3. Public Facility/Street Lighting

3.1 What do you think Public Facility/Street Lighting? Tick one (1) choice.

☐ Beneficial ☐ Not beneficial ☐Others ( )

3.2 If possible, how long do you want to use Street Lighting? Tick one (1) choice.

☐ 4 hours ☐ 6 hours ☐ 8 hours ☐ 10 hours ☐ 12 hours

3.3 Are you willing to pay tariffs for Public Facility/Street Lighting? Tick one (1) choice.

☐ Yes, very much ☐ Yes, moderately ☐ No, not much ☐ No, not at all

3.4 What is the reason of the above answer? Tick one (1) choice.

☐ Beneficial ☐ Not beneficial ☐ L.G. shall pay for them ☐Others ( )

Questionnaire about the Pilot Project State: Jigawa/Ondo/Imo, User: SHS/BCS No. _____

4. SHS *SHS users only
4.1 What do you think the monthly tariff of SHS? Tick one (1) choice. ☐ Inexpensive ☐ Reasonable ☐ Expensive
4.2 Considering the charging fee at BCS, which do you prefer, SHS or BCS? Tick one (1) choice. ☐ SHS ☐ BCS
4.3 What is the reason of the above answer? Tick one (1) choice. ☐ Expensive tariff ☐ Reasonable tariff ☐ Reluctant to carry the battery ☐Others ( )
5. BCS *BCS users in Jigawa state only
5.1 What do you think the charging fee at BCS? Tick one (1) choice. ☐ Inexpensive ☐ Reasonable ☐ Expensive
5.2 Considering the monthly charge of SHS, which do you prefer, SHS or BCS? Tick one (1) choice. ☐ SHS ☐ BCS
5.3 What is the reason of the above answer? Tick one (1) choice. ☐ Expensive tariff ☐ Reasonable tariff ☐ Reluctant to carry the battery ☐Others ( )
6. Village Committee
6.1 Does the committee manage the Pilot Project? Tick one (1) choice. ☐ Yes, very well ☐ Yes, moderately ☐ No, not well ☐ No, not at all
6.2 Does the maintenance staff maintain the PV system properly? Tick one (1) choice. ☐ Yes, very well ☐ Yes, moderately ☐ No, not well ☐ No, not at all
7. Local Government and State Government
7.1 Do you think the L.G./S.G. contribute to the Pilot Project enough? Tick one (1) choice. ☐ Yes, very much ☐ Yes, moderately ☐ No, not much ☐ No, not at all
7.2 What do you expect the L.G./S.G. to do? Tick one (1) choice. ☐ Financial support ☐ Technical support ☐Others ( )
8. Comments on the Pilot Project, if any
Thank you for your cooperation.

Signature: _____

Result of Questionnaire about the Pilot Project

1. Attribute

Table 1-1 Number of answers

State	Number of objectives	Number of answers	Ratio of respondents	Remarks
Jigawa	58	58	100%	Excluding 2 systems for schools
Ondo	51	46	90%	Excluding 9 systems for schools, church, etc.
Imo	80	68	85%	
Total	189	172	91%	

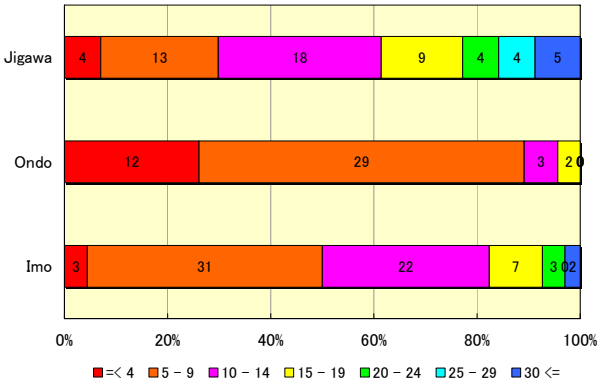

Fig. 1-1 Number of family members

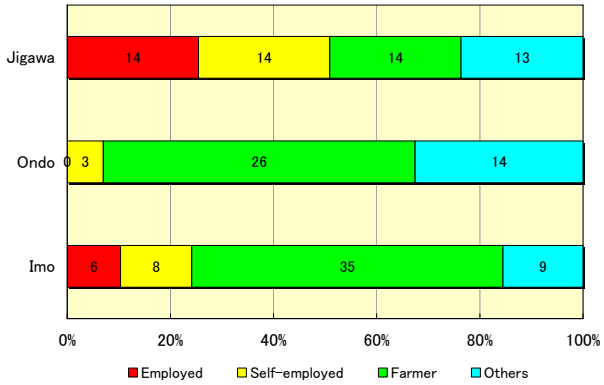

Fig. 1-2 Occupation

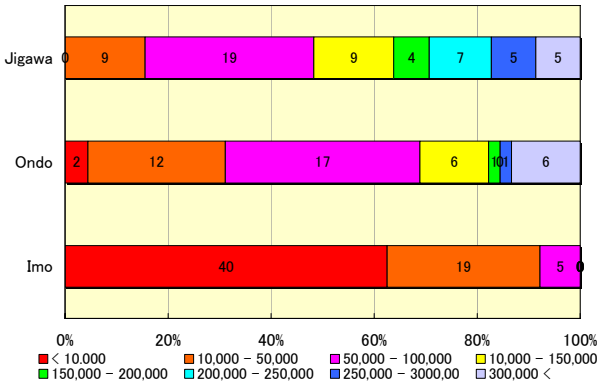

Fig. 1-3 Yearly income (Naira)

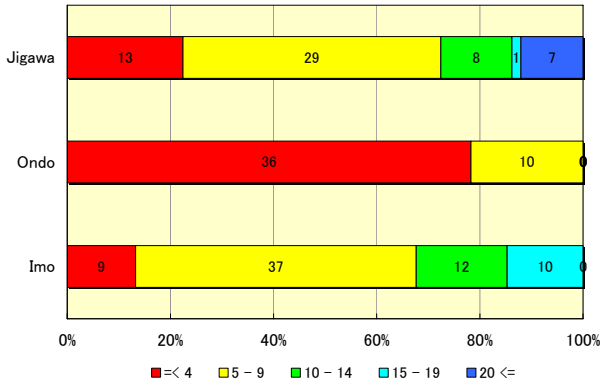

Fig. 1-4 Number of rooms

2. General

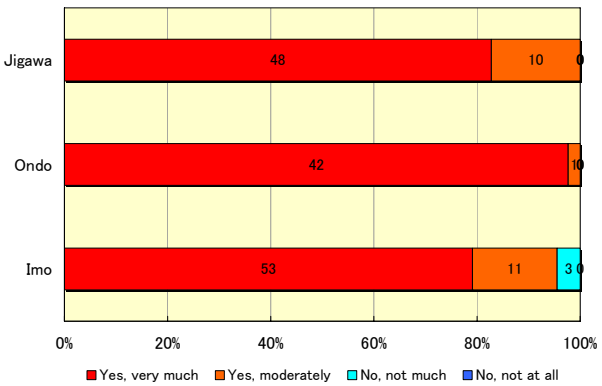

Fig. 2-1 Degree of satisfaction

"Are you satisfied with the PV systems?"

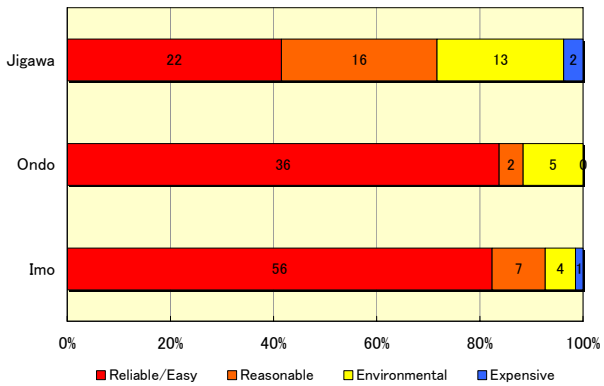

Fig. 2-2 Reason of the degree of satisfaction

"What is the reason of the above answer?"

Result of Questionnaire about the Pilot Project

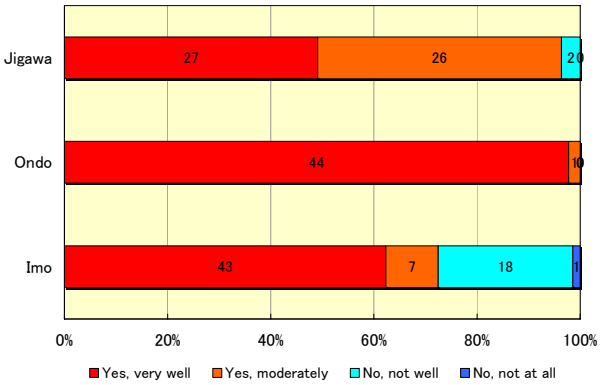

Fig. 2-3 How to use the PV systems

"Do you understand how to use the PV systems?"

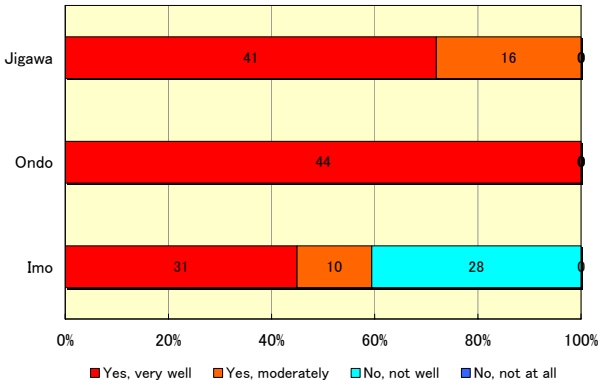

Fig. 2-4 Limitation of the PV systems

"Do you understand that the PV systems have the limitations?"

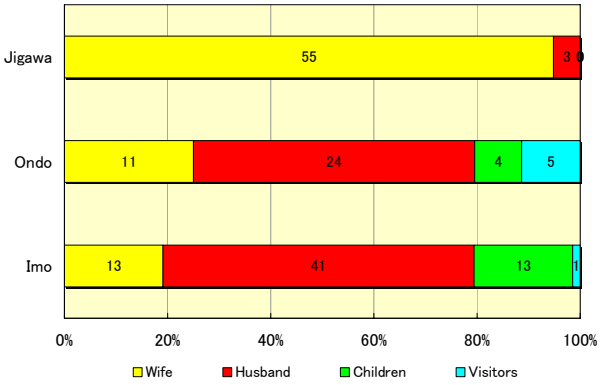

Fig. 2-5 Frequent user of the PV systems

"Who use the PV systems often?"

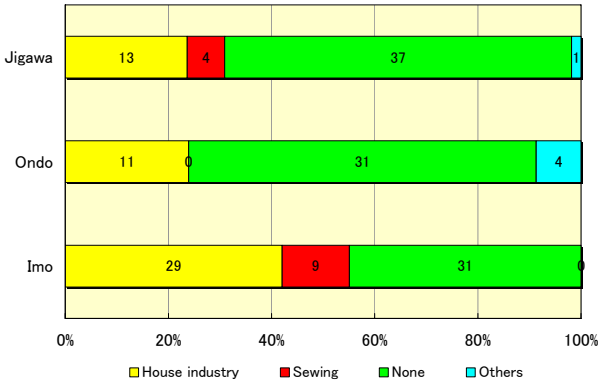

Fig. 2-6 Business using the PV systems

"Did you start any business after you started using the PV systems?"

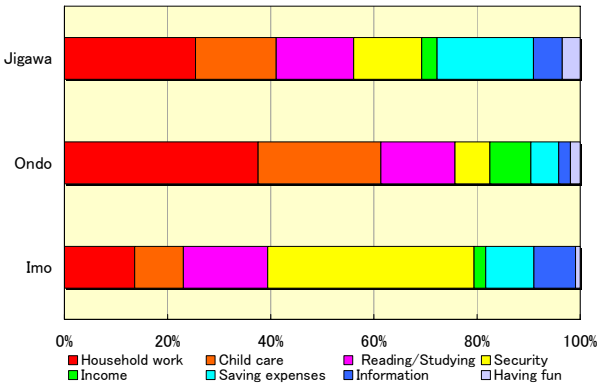

Fig.2-7 Improvement of living as a husband

"From a husband point of view, what did the PV systems improve?"

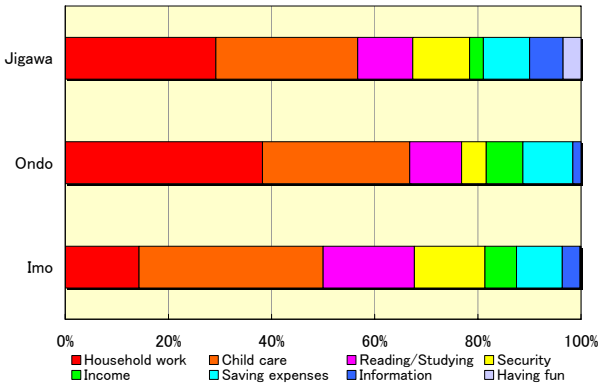

Fig.2-8 Improvement of living as a housewife

"From a housewife point of view, what did the PV systems improve?"

Table 2-1 Reduction of energy expense

State	Average reduction in Naira	Average reduction ratio
Jigawa	388	64%
Ondo	458	58%
Imo	204	45%
Average	359	57%

"How much did you spend for energy (kerosene, battery, etc.) before you started using the PV systems? How much do you spend for energy now?"

Table 2-2 Number of owners of generator

State	Number of owners
Jigawa	2 out of 58
Ondo	2 out of 46
Imo	9 out of 68
Total	13 out of 172

"Do you own a generator?"

Result of Questionnaire about the Pilot Project

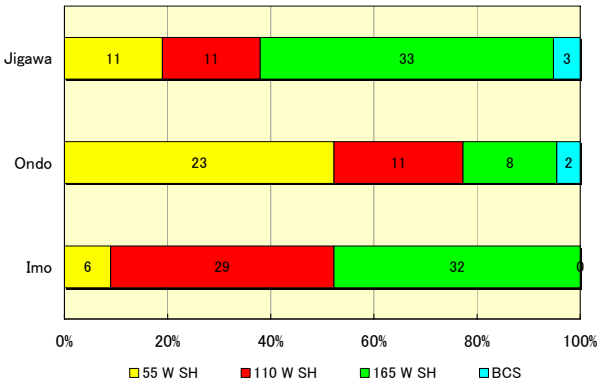

Fig. 2-9 Preferred PV systems

"Which system do you like best?"

Description of PV systems

- 55 W SHS for two (2) sets of lamps and one (1) radio at the rate of N500/month.
- 110 W SHS for four (4) sets of lamps, one (1) radio, and one (1) TV set at the rate of N750/month.
- 165 W SHS for six (6) sets of lamps, one (1) refrigerator, and one (1) TV set at the rate of N1,000/month.
- BCS for two (2) sets of lamps and one (1) radio at the rate of N50/charge.

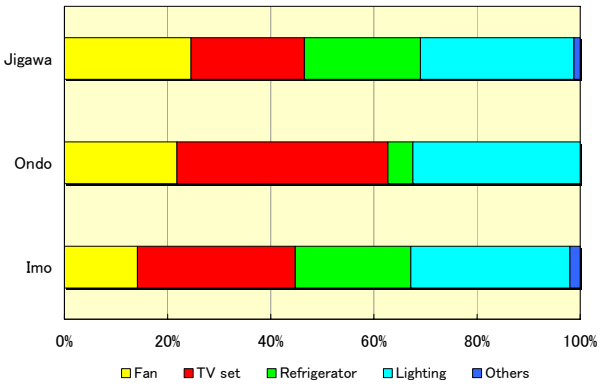

Fig. 2-10 Preferred electrical appliances

"If possible, which appliances do you want to use?"

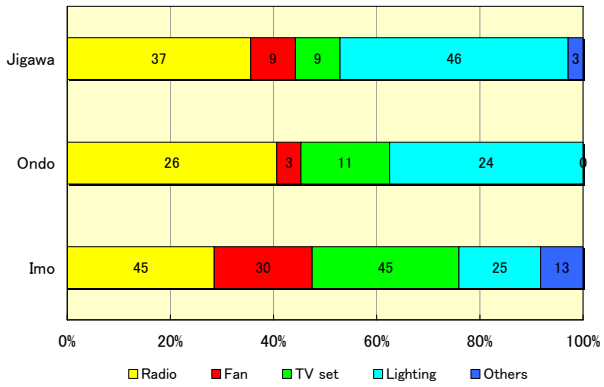

Fig. 2-11 Owned electrical appliances

"What appliances do you own?"

Table 2-3 Number of needful lighting points

State	Number of lighting points
Jigawa	7
Ondo	3
Imo	7
Average	6

"If possible, how may lighting points do you need?"

3. Public Facility/Street Lighting

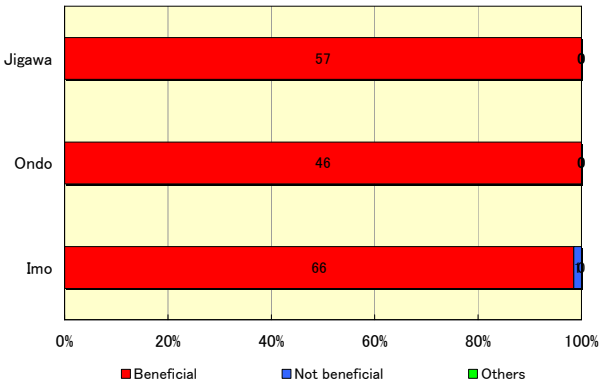

Fig. 3-1 Benefit of Public Facility/Street Lighting

"What do you think Public Facility/Street Lighting?"

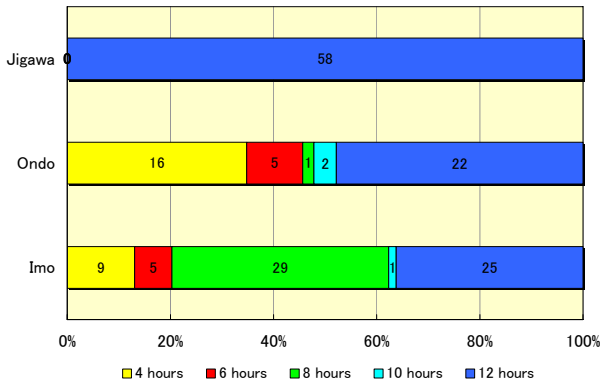

Fig. 3-2 Hour of use of Street Lighting

"If possible, how long do you want to use Street Lighting?"

Result of Questionnaire about the Pilot Project

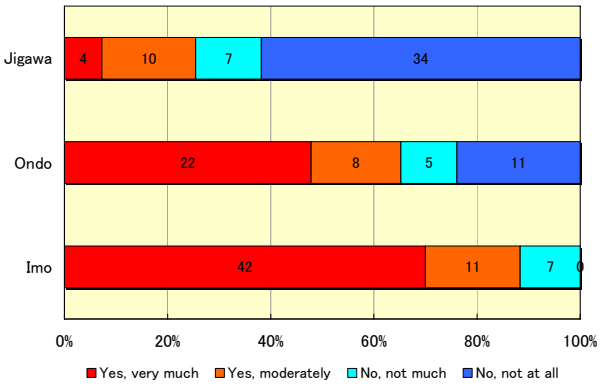

Fig. 3-3 Willing to pay for Public Facility/Street Lighting

"Are you willing to pay tariffs for Public Facility/Street Lighting?"

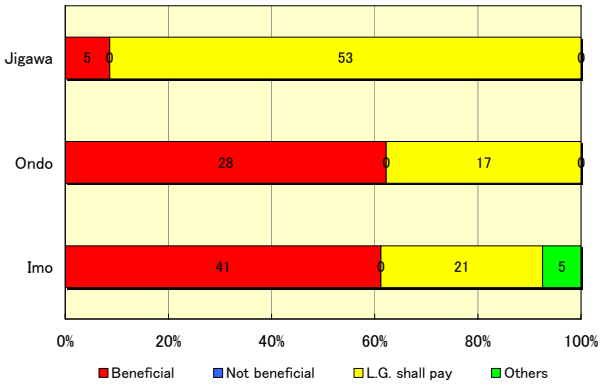

Fig. 3-4 Reason of the willingness to pay

"What is the reason of the above answer?"

4. SHS and BCS

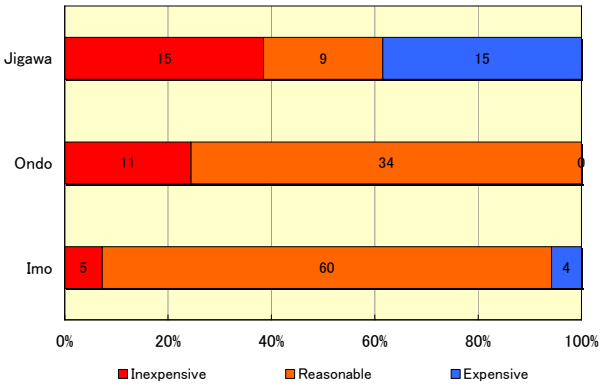

Fig. 4-1 Monthly tariff of SHS

"What do you think the monthly tariff of SHS?"

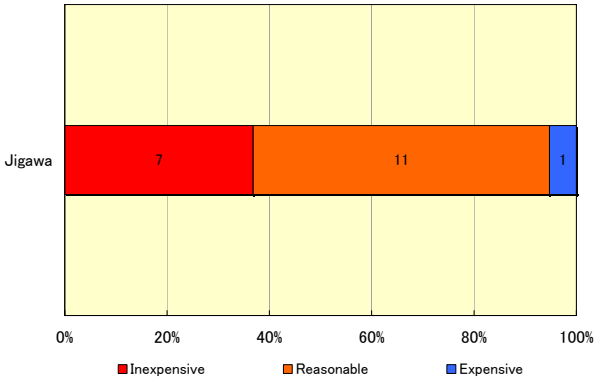

Fig. 4-2 Charging fee at BCS

"What do you think the charging fee at BCS"

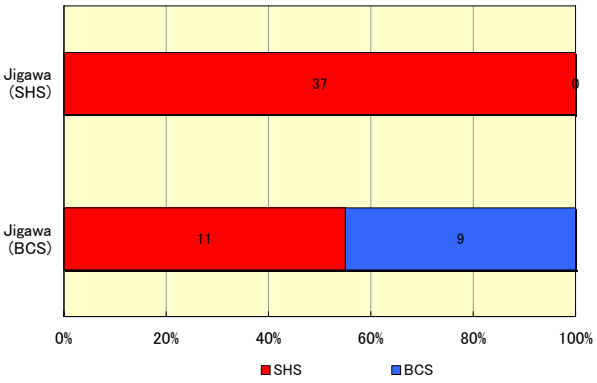

Fig. 4-3 Choice between SHS and BCS

"Considering the charging fee at BCS,
which do you prefer, SHS or BCS?"

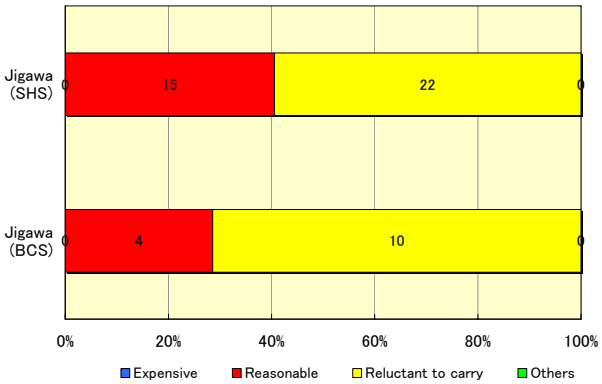

Fig. 4-4 Reason of the choice

"What is the reason of the above answer?"

Table 4-1 Tariff of charges（Naira）

State	Monthly tariff of SHS	Charging fee at BCS
Jigawa	400	30
Ondo	250	—
Imo	350	—

Result of Questionnaire about the Pilot Project

5. Village Committee

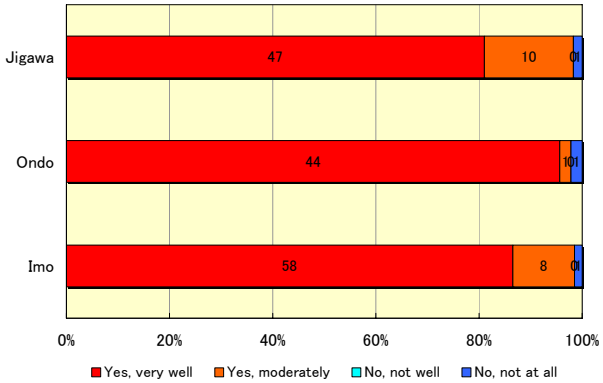

Fig. 5-1 Evaluation of the committee

"Does the committee manage the Pilot Project?"

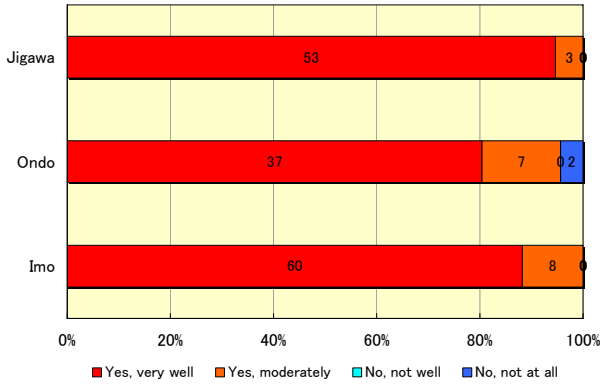

Fig. 5-2 Evaluation of the maintenance staff

"Does the maintenance staff maintain the PV system properly?"

6. Local Government and State Government

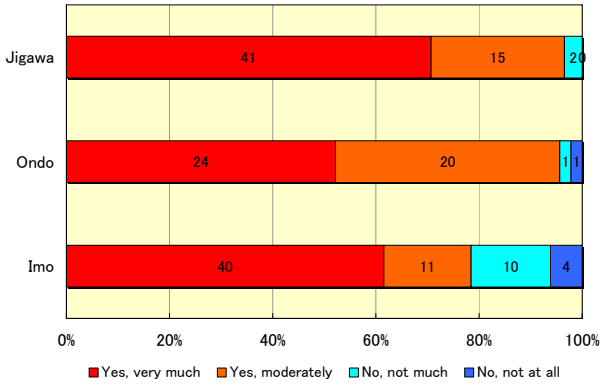

Fig. 6-1 Evaluation of the L.G./S.G.

"Do you think the L.G./S.G. contribute to the Pilot Project enough?"

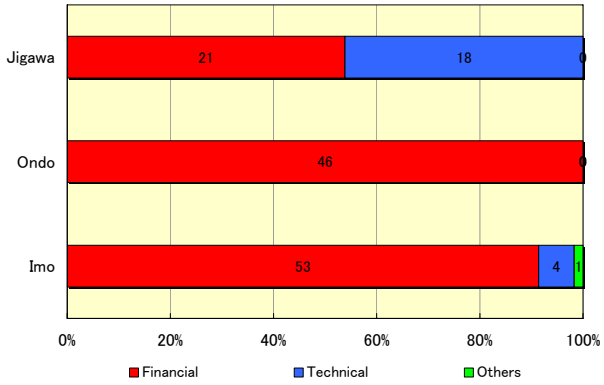

Fig. 6-2 Expectation from the L.G./S.G.

"What do you expect the L.G./S.G. to do?"

Note)

1) All numbers in the figures show the number of answers which are categorized by the alternatives.
2) In Fig. 1-3, most of the respondents in Imo state answered that their yearly income are below N50,000. However, the result of socio-economic survey shows that their average income are approximately N200,000. Therefore, the respondents do not figure out their income correctly.
3) In Fig. 2-6, not all respondents who answered that they stared business sell products to the others. As a result of the interviews, some respondents started house industry for their private use.
4) In Fig. 2-7, 8, and 10, the answers are weighted based on the priorities since the questionnaires are multiple choices.