5. Bidding and Installation

5.1 Bidding

Through the survey in Senegal, the study team had discussed the appropriate specifications of SHS for rural electrification in Senegal with the counterpart. And the study team found that most PV components were imported from countries in Europe or America, and only a few suppliers can provide equipment and installation service in good quality. The study team suggested JICA, which is the leading organization of the tender, to invite only these capable suppliers to the tender.

There were six suppliers nominated; AFRIWATT, BUHAN & TEISSEIRE, EQUIP PLUS, MATFORCE, SEEE, TOTAL ENERGY AFRIQUE de L'OUEST.

(1) Schedule of Bidding

Only those nominated suppliers were invited to the tender briefing at JICA office, Dakar. The schedule of tender is shown below.

June 30, 2000	Tender Briefing
July 14, 2000, 12:00	Deadline of Technical Proposition
July 21, 2000, 10:00	Deadline of Financial Proposition, Opening Tender (1st Bidding)
August 4, 2000, 10:00	Opening Tender (2nd Bidding)

Because the lowest price offer exceeded the budget at the first bidding, JICA held the second bidding after budgeting again.

(2) Technical Evaluation of Propositions

Tender document required suppliers to submit not only technical document of each component but also the self-assessment of their offer, by which the supplier declares that their offer conforms to the detailed technical specification of each component. The study team evaluated the technical proposals by bidders. When there were any misunderstandings of required specifications in the supplier's propositions, the study team requested the supplier to reconsider their offer. That is, the study team paid the most effort for all suppliers to pass the technical evaluation. The result of this technical evaluation is shown in Table 5.1 and 5.2.

Table 5.1 Technical Evaluation Result of SHS BiddersLOT-2, 3 Sets of Data-logger Components

LOT1 100 Sets of SHS

Supplier	Result	Remarks/Reason of Failure
AFRIWATT	G	
BUHAN & TEISSEIRE	G	
EQUIP PLUS	G	
MATFORCE	G	
SEEE	G	
TOTAL ENERGY AFRIQUE de L'OUEST	NG	Shortage of Nominal Current of Proposed DC/DC Converter

Table 5.2 Technical Evaluation Result of Data-logger Bidders

SUPPLIER	Result	Remarks/Reason of Failure
AFRIWATT	G	
BUHAN & TEISSEIRE	G	
EQUIP PLUS	G	
MATFORCE	G	
SEEE	G	
TOTAL ENERGY AFRIQUE de L'OUEST	NG	Only provides their original components and do not have universality

Generally, the technical evaluation is done based on only the technical document provided by bidders. Namely, the bidders are required to submit all necessary documents for the evaluation. It is very important to give bidders sufficient period to prepare such kind of document. That might be even 2 months if special component were required for a project, because suppliers in Senegal have their own commercial channel and it takes significant time for suppliers to contact to a new channel.

In fact, not all bidders could prepare sufficient document for evaluation at this tender. The study team, however, evaluated the offer by suppliers by name of offered components in the PV field and by trusting the self-assessments of bidders.

(3) Result of Bidding

Only the bidders technically passed were invited financial evaluation. The following suppliers got the bidding.

100 sets of SHS: MATFORCE
3 sets of Data-logger: AFRIWATT

5.2 SHS Components Supply Survey

(1) Inspection of SHS Components

Preceding the delivery to the site of the pilot project, the study team carried out warehouse inspection in the supplier's warehouse. The purpose of the warehouse inspection was not only to count the number of each component but also to carry out the visual check on each component.

Not all components were delivered to supplier's warehouse by the delivery dead line. Because of the time constraint, the study team permitted the supplier to deliver remaining component without warehouse inspection on such components. Instead, the study team required the supplier to correct inconformity of components at the site, if any.

The components, except for the kits for quality control by CERER, were delivered to the site by the supplier's own risk after warehouse inspection.

(2) Delivery and Warehouse Inspection of Data-logger

Before installation, the supplier delivered data-logger kits to CERER in order to check its performance. The main parts of data-logger system like data-logger, battery and memory card writer has had been already set up in a protection box by the maker.

For the performance check of data-logger, all components were connected based on a wiring diagram which was previously prepared in Japan with a dummy SHS that the study team made with 2 pieces of 50Wp of PV module, a 100 Ah battery, a 10A Charge Controller and a dummy load. CERER owns all of them for the dummy SHS.

The study team confirmed that the data-logger worked as expected. However, the study team found some unexpected current gave a signal that affected the measured data because of a measuring circuit problem. An isolation device was required which is called isolation amplifier in order to solve this problem.

The testing procedure of data-logger is below.

a) All components were connected following the wiring diagram.

b) Pyranometer voltage was verified before being connected to data-logger in order to check its output.

c) Before being connected to data-logger, temperature capture (resistance bulb) terminal was identified by measuring resistance between the terminals.

d) Shunt output voltage was measured by charging electricity to confirm current conversion rate (200mV/20A) before being connected to the data-logger

e) 2 pieces of 50-Wp PV module, 10A Charge Controller, 100Ah Battery and dummy load were installed into the circuit of data-logger system.

f) Special program previously prepared in Japan for the data-logger software was transferred to the data-logger.

g) Actual value of voltage and current measured by multi-meter and monitored data by data-logger were compared on line in order to check the data accuracy.

h) Data-logger system was left operating overnight in order to check recording function of data-logger.

The activities below were taken for troubleshooting of abnormal data and identification of its cause.

a) Signal entrance was removed channel by channel to see which signal was affecting another signal

b) The shunt was replaced from plus pole to minus pole.

c) Shunt signal was isolated with applying isolation amplifier.

As a result of those trial and error above, the study team found the isolation amplifier was required to collect precise data.

After these inspections, the study team delivered all components of datalogger to the site for installation. It is `desirable, however, the supplier will be required to take all responsibility for the delivery of components up to the site from the viewpoint of security and insurance of components.

(3) Quality Control by CERER

3 sets of 100 kits were delivered to CERER for the purpose of quality control. PV module, Battery, Charge Controller and Fluorescent Lamp with Ballast inverter were tested its performance in order to confirm its conformity to the technical specifications.

1) PV Module

The rated power of a PV module was evaluated under the natural sunshine. The observed value of Vmax, the voltage of the PV module at its peak power, was 14.90 [V] at 60 degC of the cell temperature. Normally, PV modules for 12V system have to provide greater voltage than the voltage of equalization charge that is specified by the characteristics of a charge controller. A general charge controller offers around 14.7 [V] as the voltage of equalization charge. Therefore, the value of tested PV module is acceptable.

2) Charge Controller

The main concern about the characteristics of the charge controller is the threshold voltage to prevent overcharge and over-discharge and the self-consumption by the charge controller itself.

The proposed charge controller has a process called Pulse Width Modulation (PWM) that is controlled with transistors. These transistors control the charging current and voltage. The threshold of high voltage disconnect and low voltage disconnect conformed to the specifications. The self-consumption by the charge controller is enough low to satisfy the specifications.

3) Battery

The battery was confirmed if it really has the declared capacity by processing charge and discharge cycle. The test result shows that the battery might not reach the declared capacity. However, it is difficult to adjust the testing condition in all labs to get the same result. It is strongly required for those labs that wish to have function of national institute to join the network of international certification network. The study team requested the supplier to provide the certificate by internationally certificated lab and found the battery conformed the specifications.

4) Fluorescent Lamp with Ballast Inverter

The ballast inverter inside the fluorescent lamp can affect the condition of radio receiving if the frequency of ballast inverter is not appropriate. It is said that the ballast inverter whose output frequency is over 16 kHz rarely affects the condition of radio receiving. Since the proposed system for the pilot project is supposed to provide energy for radio or TV, the confirmation about the frequency of ballast inverter was carried out.

Cyclic on-off test was also carried out to confirm the lifetime of the fluorescent tube.

Since the crest factor also affects the lifetime of a bulb, it was also tested using oscilloscope.

The result mostly conformed to the specifications but the crest factor was relatively high compared to the allowable value required (It was 2.8 while the specified value was 1.7, which is said the maximum value to guarantee the enough lifetime of bulbs). The study team requested the supplier to provide the test result of the maker and found it conformed to the specifications.

5) Conclusion

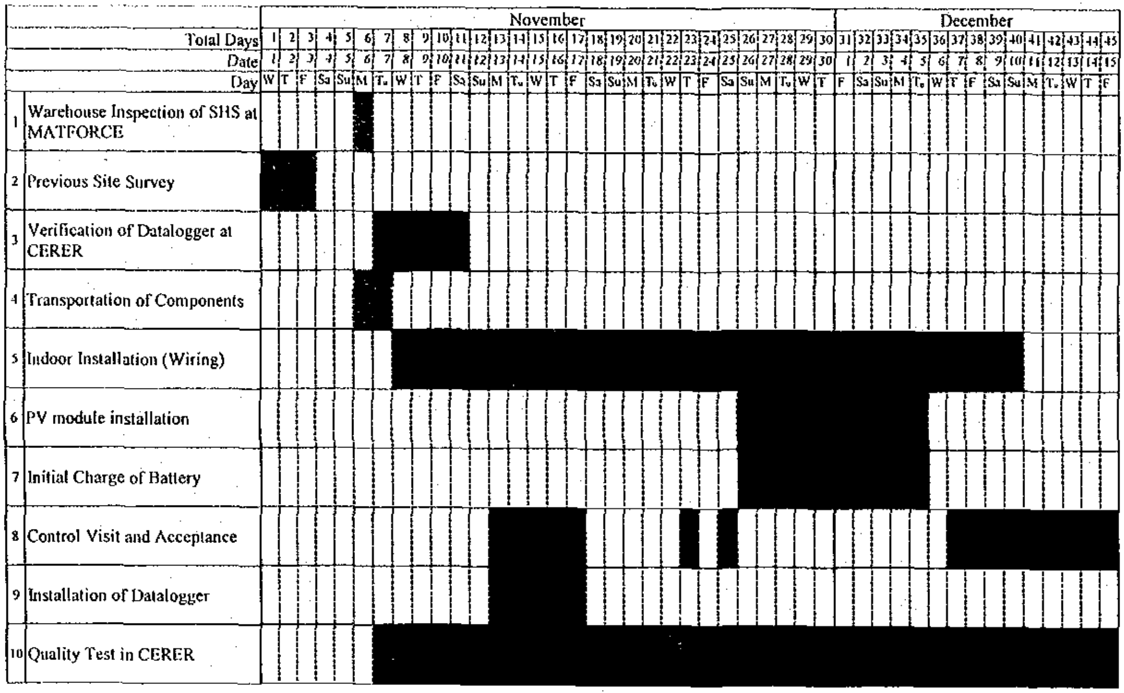
Some test results showed inconformity with the specifications while the value shown by the maker conformed to the specifications. There is no way to confirm which value is correct. It is necessary to request the supplier to give certificate by a internationally standardized laboratory. There seems to be enough equipments or devices in CERER to carry out the test of certification. Joining network of the international standardization may be useful for CERER and CERER is strongly required to have ability to publish the certificate for solar industry components.

5.3 Installation of SHS

(1) Schedule of Installation

Table .5.3 Shows the Schedule of Installation.

Table 5.3 Schedule of Installation



(2) Control of Installer

Although the supplier sent 2 teams of installer at the beginning of the installation, it dispatched eventually 4 teams of installer, which consists of 2 or 3 persons for each team. They shared the number of installation by dividing the total kits equally because the installer was paid by the supplier according to the number of installation. Normally it is better to divide the installation work based on the task that becomes critical pass of the job. About the installation of SHS, the task that determines the progress of installation is the internal wiring and charging battery. Namely, in order to finish the installation as early as possible, each installation team would better concentrate on a specific single task like inside wiring, PV module installation and so on. In this installation, because not all teams belongs to the supplier but some teams are temporarily hired, who were paid by the number of SHS they installed, the installers needed to share the number of installation equally. This inefficient job assignment for each team can lead to delay of installation.

(3) Inspection and Acceptance of Installation

Summary

The study team carried out inspection and acceptance as soon as each installation is finished in accordance with the technical specification of installation. Whenever any bad conditions were found, the study team pointed them out and directed the installer to correct them. General matters pointed out are as follows:

- Some installations of PV module were not vertical.
- Some PV modules were set on the position where they were not exposed to the sufficient sunshine.
- Some batteries were located in the room where the user uses stove (cooker).
- Some wiring was without cable protection when they pierced buildings or when they are buried.
- Some wiring was not beautiful in appearance because of inappropriate interval clips.
- Some Lamps were not located in appropriate position to get better lighting.
- LED lamps were not given any inclination to get better lighting.

Those matters pointed out were corrected and it is expected that users got satisfied with those correction.

(4) The Point of the Inspection 1: Wiring

1) Wiring Loss

Each team started the installation with interior wiring. The length of wiring in a line has to be determined so as not to exceed the allowable voltage drop. In the technical specification specified the maximum voltage drop as follows

PV module to Charge Controller: maximum 2 %; $\Delta V \leq 0.24$ [V]

Charge Controller to Battery: maximum 1 %; $\Delta V \leq 0.12$ [V]

Charge Controller to Loads: maximum 5 %; $\Delta V \leq 0.6$ [V]

The voltage drop increases in proportion to the increase of current flow and in inverse proportion to the increase of cable thickness.

$$\Delta V = IR \qquad \textbf{Eq. 5.1}$$

$$R = \rho \frac{\ell}{S} \qquad \textbf{Eq. 5.2}$$

Where,

ΔV: Voltage Drop [V]
I: Current of the Line [A]
R: Resistance of Cable [Ω]
ρ : resistance factor (Cupper; 1.72 x 10-2 [$\Omega mm^2/m$], 20 degC)
ℓ: Length of Cable (One-Way) [m]
S: Thickness of Cable [mm^2]

As for the installed SHS, the thickness of cable was 4.0 mm^2 for PV-Charge Controller and Charge Controller-Battery, and 2.5 mm^2 for Charge Controller-Loads.

When considering the allowable length of cable, the back and forward of flow should be taken into consideration. Therefore, the allowable length is given using Eq.5.3:

$$2 \times \ell = \frac{\Delta V \times S}{\rho \times I} \quad \therefore \ell = \frac{\Delta V \times S}{2 \times \rho \times I} \qquad \textbf{Eq. 5.3}$$

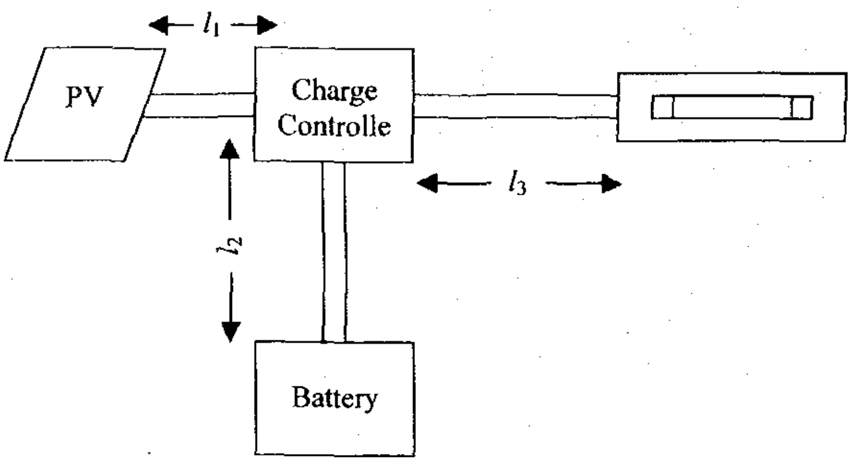


Figure 5.1 Simplified Diagram of SHS

Typical structure of SHS is shown in Figure 5.1. Applying values of the installed system, the allowable length between each component is given by the equation below.

$$\ell 1 \leq \frac{\Delta V \times 4.0}{2 \times 1.72 \times 10^{-2} \times I} = \frac{27.9}{I}$$ **Eq. 5.4**

$$\ell 2 \leq \frac{\Delta V \times 4.0}{2 \times 1.72 \times 10^{-2} \times I} = \frac{14.0}{I}$$ **Eq. 5.5**

The maximum length of cable is calculated by applying the maximum current to equations above. Installed 55Wp module generates 3.33A of current at maximum power point. Therefore, the maximum length of ℓ 1 should be 8.4 m. ℓ 2 is also calculated in the same way. Because keeping low voltage drop is important when the battery is charged, the allowable voltage drop is regarded as the voltage drop of charging process when ℓ 2 is calculated. ℓ 2 should be 4.2 m at the most. However, the distance between the Charge Controller and the Battery is preferable to be as short as possible. Therefore, that distance of them in all installations was confirmed to be less than 1.5 m.

When considering ℓ 3, the current value substituted for equation 5.7 should be chosen carefully.

Suppose the wiring plan as shown Figure 5.2, the voltage drop is calculated adding up the voltage drop at each branch point.

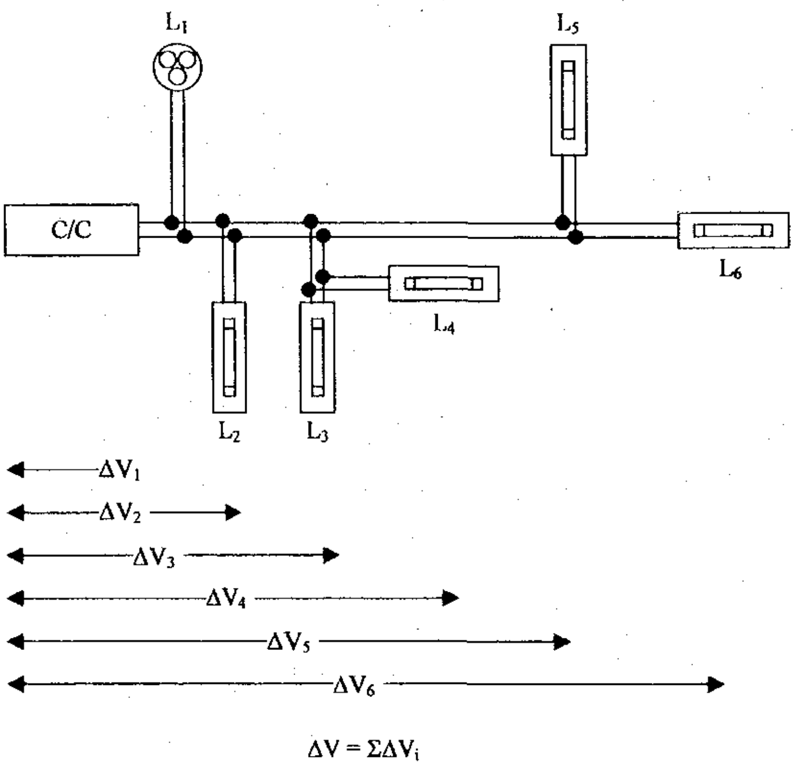


Figure 5.2 Sample Wiring of Load

In other words, the voltage drop is calculated by counting how many loads there are on the same line.

$$\Delta V = \sum \Delta V_i \quad \text{Eq. 5. 6}$$

It is more convenient to know the allowable length of cable in advance when all valuables are known.

$$\ell 3 \leq \frac{\Delta V \times 2.5}{2 \times 1.72 \times 10^{-2} \times I} = \frac{43.6}{I} \quad \text{Eq. 5. 7}$$

Based on the equation above, a table of maximum distance can be prepared.

Table 5.4 Allowable Distance Between Charge Controller to Loads (One-Way)

Current [A]	1	2	3	4	5
Distance [m]	43.6	21.8	14.5	10.9	8.7

Theoretically, these calculated maximum distance should be respected strictly. However, it is also important to consider what the purpose of SHS introduction is. If the voltage drop calculation results in guaranteeing the work of the load at its estimated lowest voltage, the designer need to take a flexible deal with the acceptance because the important thing is to provide high quality lighting to users.

2) Inspection of Wiring

The distance to keep the voltage drop enough low between each component was *determined as a reference to make the inspection easy.*

Table 5.5 Allowable Distance of Cable of Each Route for Inspection

Distance (One-Way)	Route	Remarks
5 m	PV module – Charge Controller	To respect the specification of voltage drop
1.5 m	Charge Controller – Battery	To respect the specification of voltage drop
20 m	Charge Controller – Load	Assumed that 2 pieces of 8W lamp is on the same line.

The distance between the Charge Controller and the Load was accepted as long as the distance is less than 20 m because it is rare case to put all loads on the same line. The distance of cable to loads was carefully verified only when the loads are connected in series on the same cable and the distance was over 20m.

Not only the inspection of distance but also a visual aesthetics was checked. All cables were confirmed if they were fixed with clips at a regular interval so as to keep the vertical and the horizontal. Further, the condition of cable protection was checked when the cable pierced the buildings. Especially when the cables wired cross 2 buildings, the cable was recommended to be buried with being put into a conduit. In order to avoid the rain infiltration through the hole pierced on the wall, the installer was requested to fill the hole with silicone.

Figure 5.3 Wiring

(5) The Point of the Inspection 2, Installation of Indoor Components

Before the installation period, the supplier interviewed each subscriber to determine the place to install interior components (Fluorescent lamp, LED lamp, Switch, Power Outlet). Because almost all subscribers had no experience with electricity, some subscribers didn't indicate the exact place to get the best performance and the best convenience of components like lamps. Therefore, the installer sometimes had to change the place of component once after they are fixed.

The study team pointed out unwise way of installation of indoor components as shown below and the installer corrected those awkward.

- The LED lamp had to be given an appropriate inclination so as to get better lighting because the light from LED lamp goes straight.
- Some fluorescent lamps were fixed on the inappropriate position, say, behind the curtain where the user cannot get better lighting from the lamp.

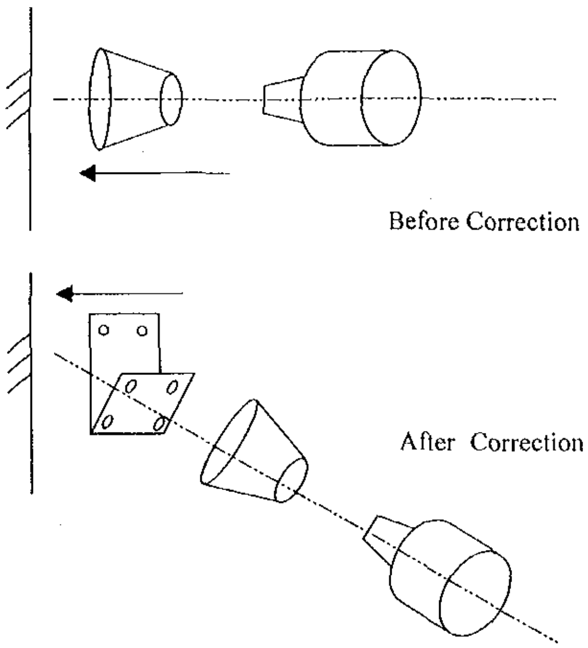


Figure 5.4 Correction of LED Lamp Inclination

As for the batteries, the study team checked if the battery box was located in a room where no smokes, flames and sparks like cooker. The battery was located in warehouse of each household in most cases. Since most household keep gas cookers in their warehouse, the study team strongly indicated users to keep flames away from battery box.

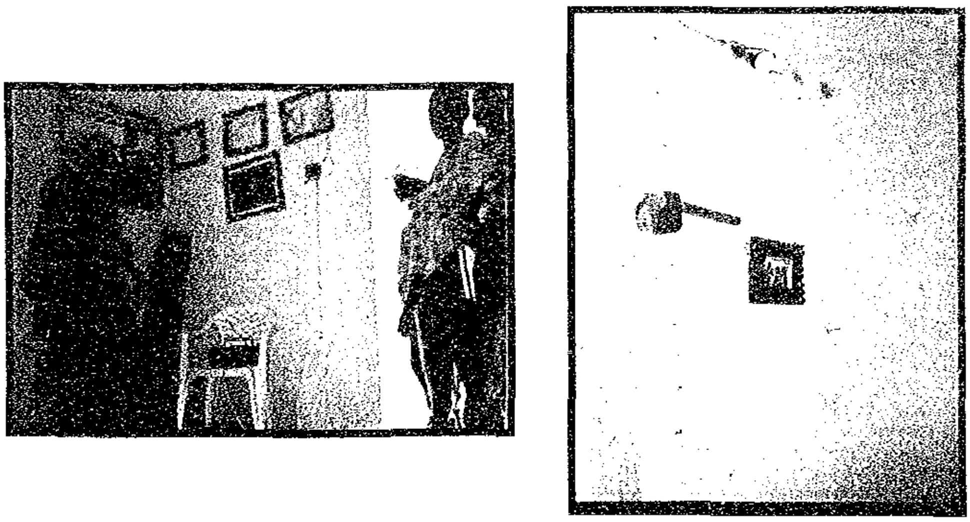


Figure 5.5 Interior Components (Outlets for Radio and LED Lamp)

(6) The Point of the Inspection 3, Installation of PV module and its Support Structure

The study team checked if the PV module installed in appropriate place to optimize the solar radiation and in the right direction (true south). It was difficult in some place to find out an appropriate place for installation because of grown trees. In such situation, the study team and the installer discussed and determined the best place to fix the PV module in order to maximize the irradiation and to optimize the indoor wiring.

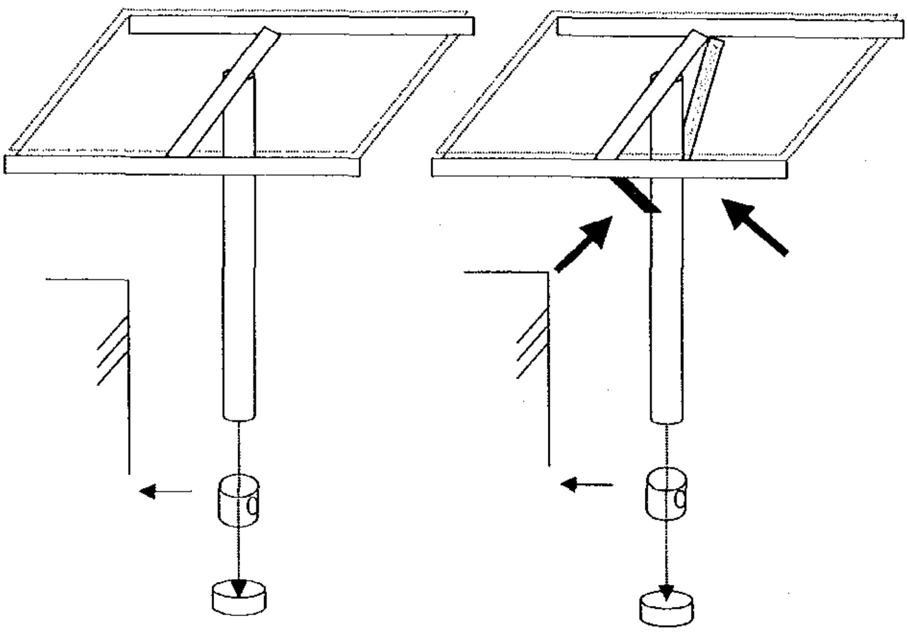


Figure 5.6 Reinforcement of Support Structure for PV module

In order to maximize the irradiation to the PV array, the support structure needs to have proper inclination; it is 15 degree at the site. This proper inclination varies according to the latitude of the site. Generally, the value of inclination to maximize the irradiation onto the PV array is set for the same value as the value of latitude. In the region between latitude 15 degree South and 15 degree North, that value is generally fixed between 10 to 15 degree considering the drainage of rain and natural wash of PV array by rain. Hence, the inclination of PV array at the pilot project site is 15 degree. There was no difficulty of giving the PV array the appropriate inclination because the support structure was designed to have fixed inclination originally.

The support structure was made with rust preventive metal. Before the installation, the study team found that the support structure was not strong enough to resist against a strong wind. The study team told the supplier to add support structure reinforcement and paint it with rust preventive (see Figure 5.6).

Because the support structure pierced the wall when it was set on the wall, the installer was requested to pay enough attention to the water infiltration through the hole. Thus the installer filled up the holes of bolts and cable with silicone or cement.

(7) The Point of the Inspection 4, Initial Charge of Battery

It is very important to charge the battery fully before it is put into service in order to make the battery live long. The study team checked the density of electrolyte and the terminal voltage before putting the system into service in order to confirm if the initial charge of battery is surely carried out. The installer carried out initial charge of batteries with PV module installed. In this process, the battery was connected directly to the PV module. Main concern about the initial charge of battery was:

- if the electrolyte density was over 1.25 kg/l
- if the terminal voltage was 14.5 V

The study team directed the installer to check and record data above after charging battery with PV module.

Although general lead-acid batteries are delivered with dry charged condition, they still need the initial charge before being put into service. When the battery is charged with PV module, it is necessary to know how long the battery should be connected to the PV module. In order to estimate the initial charging period with PV module, it is useful to estimate the battery state of charge (SOC).

The SOC can be estimated by measuring electrolyte density.

$$Q = \left\{1 - \frac{D_0 - D_{20}}{K}\right\} \times 100$$ **Eq. 5. 1**

$$D_{20} = D_t - 0.0007 \times (T - 20)$$ **Eq. 5. 2**

Where,

- Q: Battery State of Charge (SOC) [%]
- D_0: Electrolyte Density at Full Charge [kg/l]
- D_{20}: Measured Electrolyte Density that is converted to that at 20 degree [kg/l]
- D_t: Measured Electrolyte Density at T degC [kg/l]
- T: Measured Electrolyte Temperature [degC]
- K: Proportional Coefficient

The coefficient K is described as a change rate of electrolyte density that changes in proportion to SOC. This is described as:

$$K = D_0 - D_z$$ **Eq. 5. 2**

where,

- D_z: Electrolyte Density at 100% Discharge

Typically, the density of electrolyte at the point where a battery discharge 100 % of its capacity is 1.08 –1.10 kg/l. Though the electrolyte density of fully charged battery varies with the Type of battery, the density of delivered battery is 1.25 kg/l at fully charged condition. Therefore, the K value is estimated as 0.15 – 0.17.

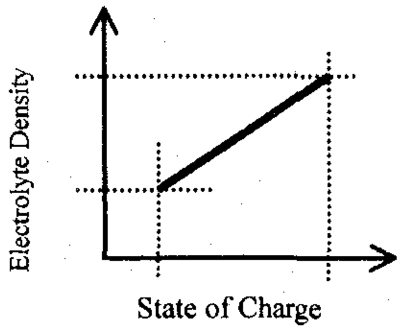


Figure 5.7 Typical Relationship Between Electrolyte Density and SOC

Initial density was measured 2 hours after filling up the electrolyte. The average electrolyte density measured was 1.22. Although the installer was directed to measure electrolyte temperature when they measure the density, they didn't obey. Herein, let us suppose the temperature as 30degC. The electrolyte density at 20 deg.C. can be calculated as 1.213 by equation 5.9. Thus, with equation 10.5.8, the initial SOC can be estimated as 75 to 78 %.

The delivered battery capacity is 120Ah at 20-hour rate; accordingly the battery capacity after filling electrolyte can be estimated as 90 to 94Ah. As a result, it became obvious that 26 to 30Ah of electricity should be charged to fill the battery with electricity.

A 55Wp PV module generates around 3A of electric current at its peak power. Let us suppose 5 kWh/m2/day of irradiation, and then 15Ah/day of electricity can be charged with a PV module. This value tells us the necessary number of days for charging delivered battery is at least 2 days (30/15=2).

Considering the charging loss and fluctuation in irradiation and other losses, the study team directed the installer to carry out initial charge for 3 days.

Every Battery was put into a battery box that was locked in order to keep the battery away from users reach. The study team left the key to the local technician for maintenance.

(8) Disposal of Wastes

Since Senegal has no laws and regulations about the waste of industries, the installer didn't pay any attention on wastes of installation (bottles of electrolyte, plastics and other waste materials). Children are interested in these unfamiliar things like plastic bottles and cardboard boxes. Empty bottles of electrolyte do serious harm on human because of toxic acid. The study team directed the installer to collect all empty bottles and dispose them in appropriate way. The installer collected all empty bottles and burned them in Mar Island.

(9) Installation of Datalogger

The study team installed datalogger with the assistance of a local expert. Although 3 sets of data-logger system were supposed to be installed one by each proposed type of system at the beginning, 1 set of data-logger was installed for a house who applied for Type1 and each of the rest was installed for a house who applied for Type 3 because there was no subscription of Type 2 (TV oriented system) at the moment when the study team installed data-logger. The house building to install data-logger was chosen by the criteria below at the site.

- Irradiance Condition
  - There is no object that shades the PV module on higher above the roof around the house building.
- Condition of the House

  A household that has:
  - Enough space to place data-logger box
  - A strong structure of a building (solid pillar and wall)
  - A space where no rainwater comes
  - A house building which enables people to climb up to the roof for the maintenance of PV
  - A space where the sun does not shine directly on the data-logger system
  - A space that is not flooded above the floorboards
- User's Condition
  - A household which bring electricity to its family for the first time
  - A household that is installed only one system

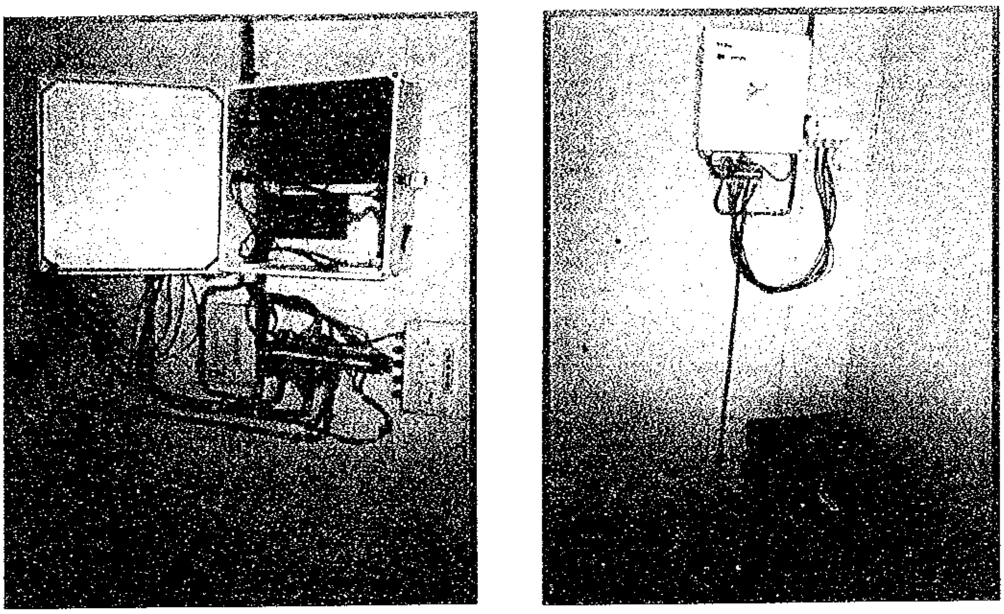


Figure 5.8 Datalogger

The data to be recorded are:

- Total Solar Irradiance

  A thermopile Type of pyranometer was used to measure the solar irradiance. The inclination of pyranometer was adjusted at the same as that of PV array. Hence, the total solar irradiance was observed. The range of measurement is from $0W/m^2$ to $2,000W/m^2$.

- Ambient Temperature

  A platinum resistance thermometer (PT100) was adopted. The measurement range is from –50degC to +100degC. The capture is covered in a shelter to prevent rainwater and direct solar irradiance.

- Voltage of the PV Module and Voltage of the Battery

  Voltage is measured directly after the input signal is converted into 1/10 of the voltage. The measurement range is from 0 to 25V.

- Charging and Discharging Current of the Battery and Consumed Current by the Load

  Electric current is measured after being converted to voltage signal with a shunt resistant. The measurement range is from 0 to 20A.

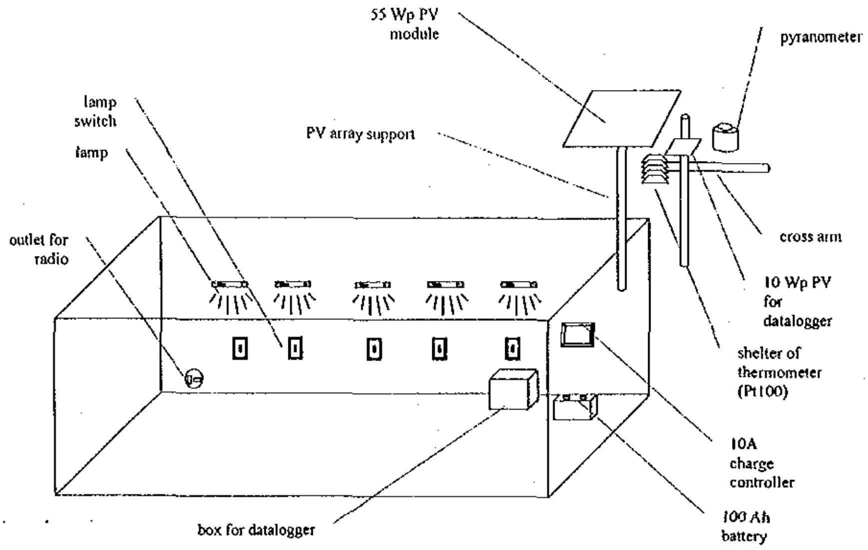


Figure 5.9 Sample Layout of Datalogger

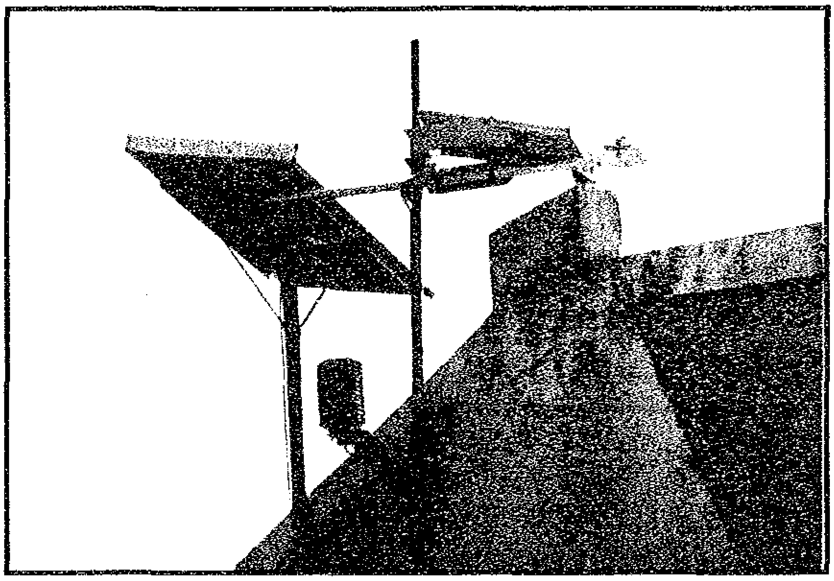


Figure 5.10 Installed Pyranometer and Temperature Sensor

(10) Distribution of User's Manual

User's manual was prepared as pictures to describe the matters to be paid attention on (See Figure 5.11). The supplier and the study team discussed again and again what kind of information about usage and maintenance was necessary for users under the principle of "Fee for Service". The system is to be maintained by the local technician under the initiative of the operator, and users are not allowed to give any unauthorized change or any special use of the system. Therefore, the user's manual should indicate users how to care the system to take the maximum efficiency of system and what is the signal of unusual. On the top of that, the user's manual should be prepared as pictures because many users do not have literacy. Based on this concept, the user's manual shows recommendations and prohibitions as pictures. These pictures were covered with plastic case and nailed on the wall next to the charge controller for all system so that users can refer to them anytime.

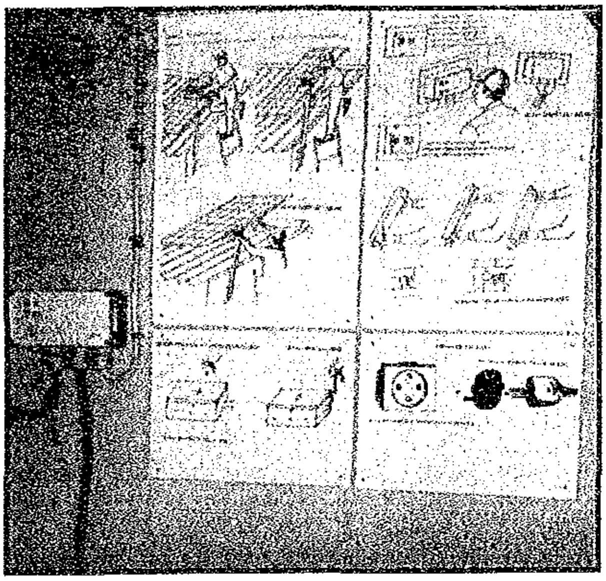


Figure 5.11 User's Manual

1) PV module

The user's manual shows how to clean the surface of PV module. It is necessary to keep clean the surface of PV module to use the PV system effectively. The matters to be paid attention on cleaning were also shown in the picture.

2) Charge Controller

Charge Controller is the only device that tells users the state of system. The LED on the controller indicates the system status. The user's manual shows the meaning of LED color and tells users what to do in case of failure.

3) Battery

The battery is put in a locked battery box which keeps users away from the battery. The user's manual shows the undesirable actions that are taken on or near the battery box.

4) Lamps

The user's manual shows the way of replacement of bulbs. Since the socket of LED bulbs is compatible with that of Incandescent bulbs, the users are strongly forbidden to use incandescent bulb with the socket in order to prevent waste of energy.

5) Sockets for TV and Radio

The polarity warning is indicated as a picture. 5.3.11 Installation of Isolation Amplifier

Because of fluctuation with the signal from shunt resistances for current measurement, accurate data couldn't be obtained at the time the datalogger was installed. It became obvious through the test in CERER that the data would be obtained well by isolating the signal from the shunt resistance (Through the kindness of the local expert, the study team was able to test how the datalogger work by putting an isolation amplifier into the system). An isolation amplifier was prepared in Japan and brought to the site. In order to cut the noise, the isolation amplifier was installed into the datalogger system. Although it is said that isolating all signals to the datalogger is preferable to be absolutely sure for accurate data acquisition, it was not necessary to isolate the signal of voltage this time.

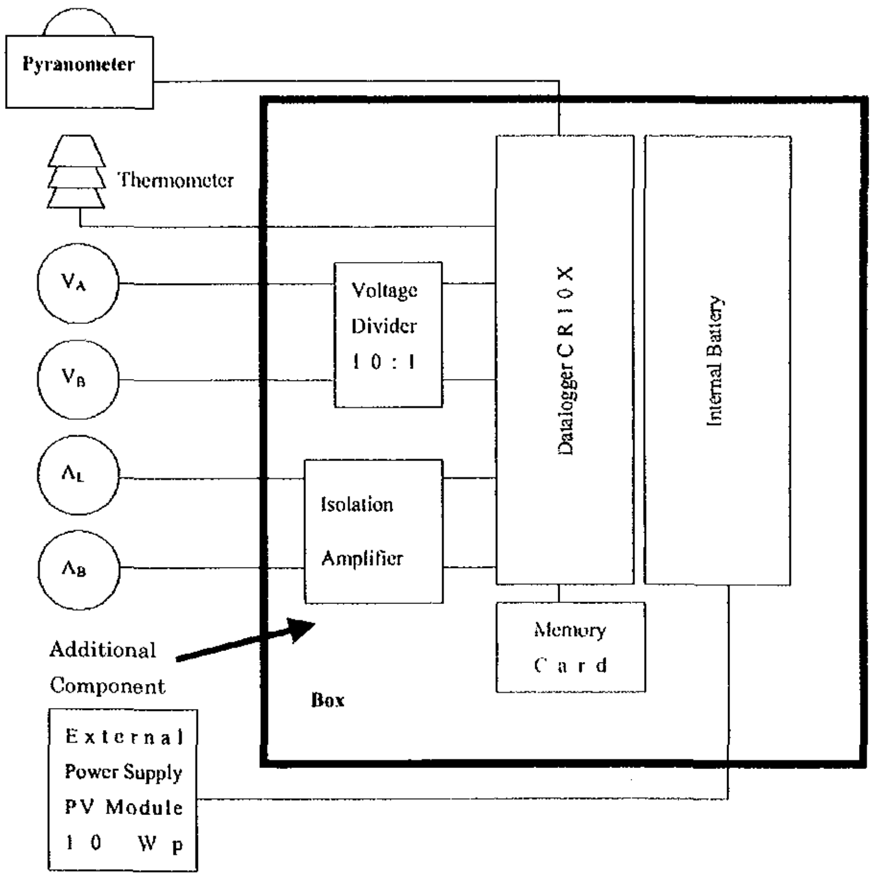


Figure 5.12 Block Diagram of Datalogger System

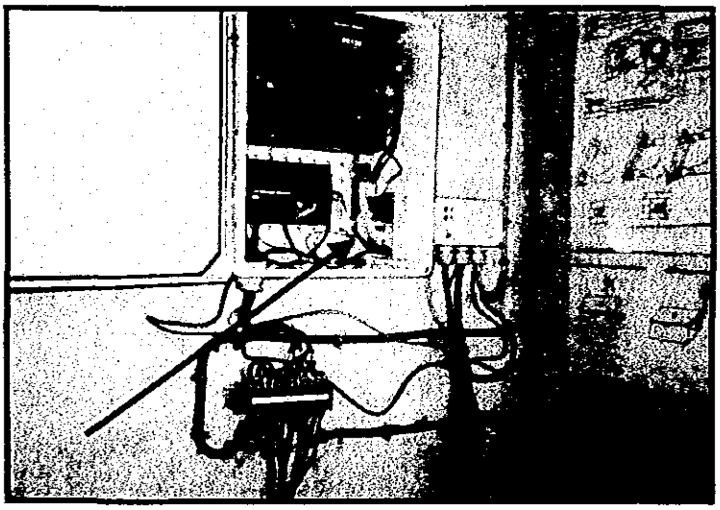


Figure .5.13 Isolation Amplifier Apearatus

(12) Data Collection

Through the kindness to the local expert, a set of isolation amplifier had been borrowed until the study team prepared another one and installed at one site in Mar Fafaco. Here is shown the data acquired at the site over 3 months since the installation to show the operating condition. The datalogger scans all data every 5 seconds. The scanned data is processed to make average every 20 minutes and then the result is stored.

1) Computation of Generation and Consumption

Figure 5.14 shows the point of capturing basic data. The data shown in Table 5.6 and 5.7 was calculated with those basic data.

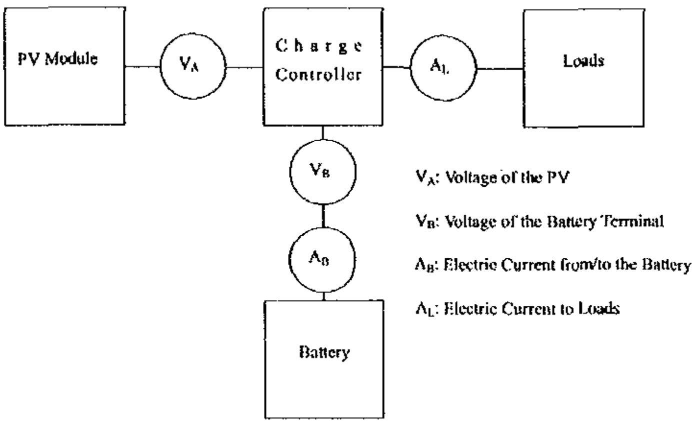


Figure 5.14 Data Capturing Point

Watt-hours are calculated by multiplying the current and voltage and cumulating the result. VB was applied on calculating watt-hours based on the assumption that there is no voltage drop between the capturing points. Current from PV is calculated with AL and AB (See Figure 5.14). When sign of AB is positive, the current goes to the battery (charge). When it is negative, the current comes from battery (discharge).

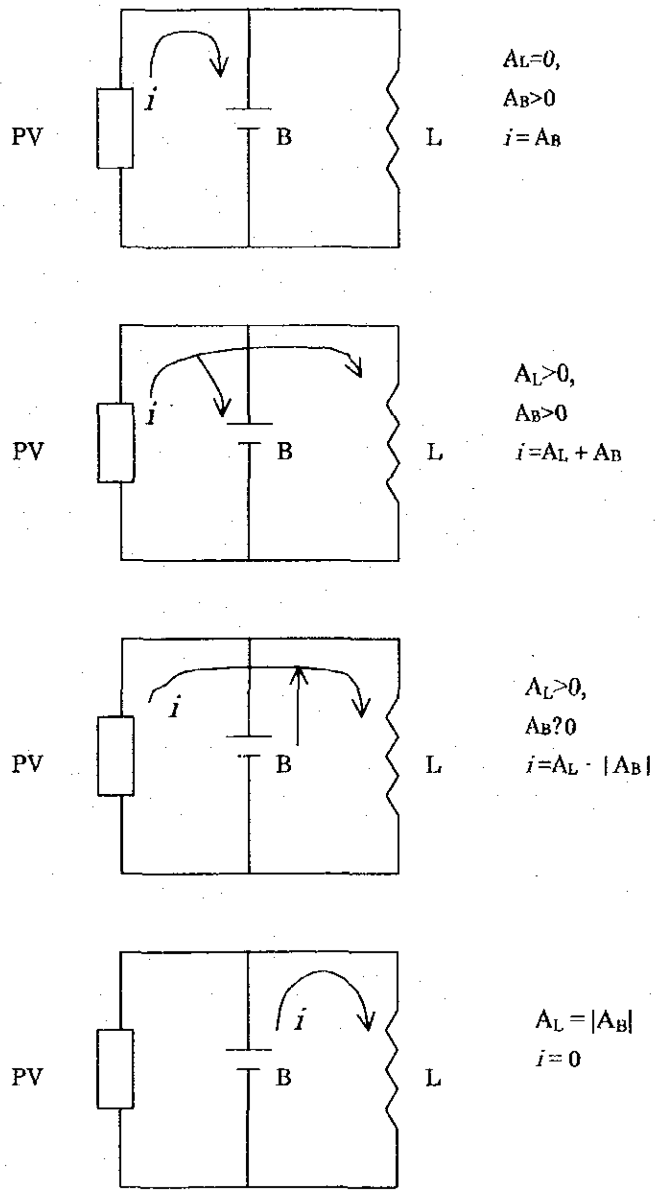


Figure 5.15 Determination of PV Current

Table 5.6 and 5.7 shows cumulative power generation and consumption by users. Since this system was put into service since November 28, 2000, here the value in November 2000 was omitted. The values in March are cumulative from 1st to 12th of the month.

Table 5.6 Generation and Consumption [kWh] in Term

	Irradiation [kWh/m²/term]	PV Generation [kWh/term]	Battery Charge [kWh/term]	Battery Discharge [kWh/term]	Consumption [kWh/term]
Dec-00	176.84	2.583	2.574	1.426	1.255
Jan-01	195.77	2.249	2.219	1.606	1.489
Feb-01	154.23	2.222	2.195	1.489	1.414
Mar-01 (1st–12th)	83.15	1.269	1.240	0.956	0.942
Total	609.99	8.32	8.23	5.48	5.10

Table 5.7 Generation and Consumption [Ah] in Term

	Irradiation [kWh/m²/term]	PV Generation [Ah/term]	Battery Charge [Ah/term]	Battery Discharge [Ah/term]	Consumption [Ah/term]
Dec-00	176.84	185.88	185.70	114.43	100.79
Jan-01	195.77	162.37	160.66	129.03	119.57
Feb-01	154.23	161.73	160.20	119.45	113.38
Mar-01 (1st–12th)	83.15	92.37	90.64	76.82	75.58
Total	609.99	602.35	597.20	439.73	409.31

(13) Verification of Generation

The expected energy output of the system is given by the equation below.

$$E_O = P_M \left(\frac{R_A}{G_S} \right) K \qquad \textbf{Eq. 5.11}$$

Where,

E_O: Expected Energy Output [Wh/day]
P_M: Nominal Power of PV Module [Wp]
R_A: Irradiation [kWh/m²/day]
G_S: Irradiance at Standard Testing Condition [1000 W/m²]
K: System Loss Factor

The power output of the system was estimated about 180 Wh/day (what about 5.4 kWh/month) with the assumption below.

PM: 55 [Wp], RA:5 [kWh/m^2/day], K: 0.65

Table 5.8 Actual Consumption and Expected Energy Output

	Irradiation [kWh/m^2/term]	(A) Actual Consumption [kWh/term]	(B) Expected Energy Output [kWh/term]	(A)/(B)
Dec-00	176.84	1.255	6.32	0.198
Jan-01	195.77	1.489	7.00	0.213
Feb-01	154.23	1.414	5.51	0.256
Mar-01 (1st–12th)	83.15	0.942	2.97	0.317

Expected energy output calculated with actual irradiation and estimated system loss factor is shown in Table 5.8. Actual consumption is 20 to 30 % of the expected energy output. Because of this small consumption of energy by users, the battery did not run so much as to be charged with the maximum performance of the PV module. The reason of this small consumption is considered that the user does not use loads other than lamps.

Table 5.9 Actual Daily Average Irradiation and Power Generation of the PV Module

	Irradiation [kWh/m^2/day]	PV Generation [Wh/day]
Dec-00	5.705	83.31
Jan-01	6.315	72.54
Feb-01	5.508	79.36
Mar-01 (1st–12th)	6.929	105.75

Table 5.9 shows actual irradiation and power generation of the PV module in average of each month. This table shows that the PV module didn't work in its full performance while the irradiation was higher than expected.

(9) Monitoring of Battery Charge and Discharge

Table 5.10 Battery Circuit Efficiency

	E_A PV Generation [kWh/term]	E_{BI} Battery Charge [kWh/term]	E_{BO} Battery Discharge [kWh/term]	E_{BO}/E_{BI} Battery Circuit Energy Storing Efficiency	E_{BO}/E_A Battery Circuit Correction Factor
Dec-00	2.583	2.574	1.426	0.554	0.552
Jan-01	2.249	2.219	1.606	0.724	0.714
Feb-01	2.222	2.195	1.489	0.678	0.670
Mar-01 (1st--12th)	1.269	1.240	0.956	0.771	0.754

There are two factors for Monitoring of Battery Charge and Discharge. Each factor is defined as follows.

$$\eta \equiv \frac{E_{BO}}{E_{BI}} \qquad \textbf{Eq.5.12}$$

$$K_B \equiv \frac{E_{BO}}{E_A} \qquad \textbf{Eq.5.13}$$

Monitoring these factor allows to assess the efficiency of battery charge and discharge. When the factor decreases significantly, the battery may be going to die. However, it has to be totally determined with other parameters like battery terminal voltage, electrolyte density after equalization charge, rapid decrease of electrolyte level (high amount of water filled), if the battery has used up.

(15) Consumption by Users

Figure 5.16 shows daily irradiation and daily cumulative energy generated by the PV module, charged to the battery, discharged from the battery and daily cumulative energy consumed by users since the first operation. For the day missing data observed because of maintenance of data-logger, the cumulative data was omitted. For the first few days, generated power by PV module and charged energy to the battery decreased day by day, despite of small energy discharge of the battery and energy consumption by the user. This is to compensate a shortage of initial charge of the battery.

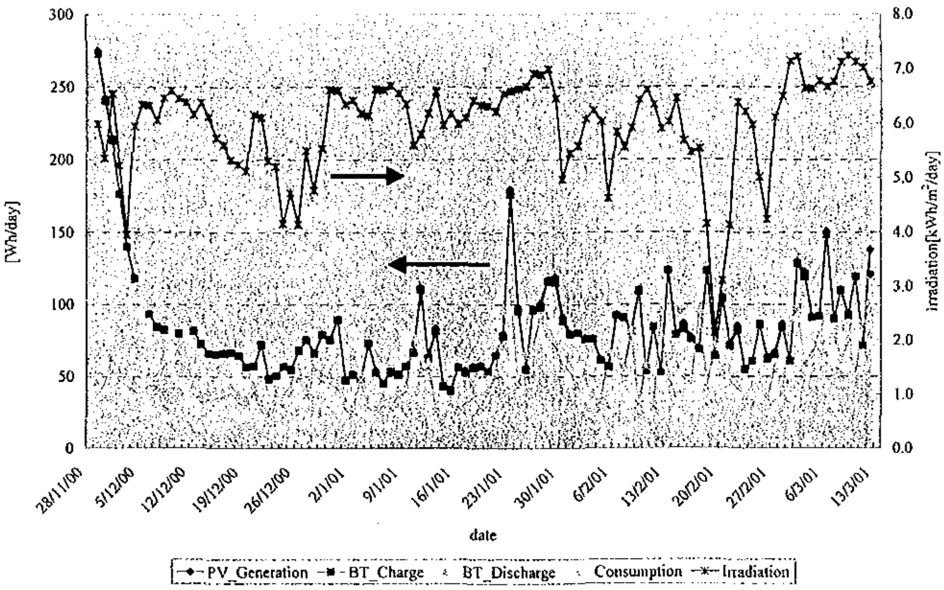


Figure 5.16 Daily Trend of Energy and Irradiation

After the battery was charged sufficiently, PV energy generation moved along with the fluctuation of energy consumption.

In order to see the energy consumption tendency of the user, monthly average of consumption at each sampling time (every 20 minutes) is shown in Fig 5.17. The peak current of consumption increased every month from November to March. Moreover, the time range of consuming energy got broader and broader as time passes.

The loads of the user are two 8W of fluorescent lamps and four 0.7W of LED lamps (Type-3). In addition, there are two outlets; one is for TV and the other is for radio. One fluorescent lamp can be assumed to consume about 0.7 – 0.9 Amps, taking into consideration of the efficiency of its ballast inverter. As for a LED lamp, it would be 0.06 Amps. Considering over this current consumption of each lamp, the user seems to have used only one fluorescent lamp for 3 hours from around 7 to 10 pm in the evening on November and December in average. Since January, the user seems to have started using 2 fluorescent lamps in the same time slot of the day. The reason why the current in January and February is around 1.2 Amps, which does not correspond to the total value of 2 fluorescent lamps consumption, is considered that there were both days 2 lamps were used and days only one lamp was used.

Every day, the user seems to have used one LED lamp all through the night.

There can be seen another peak in the early morning on November and March. This phenomenon may be because of religious reason. About this reason, further socio-economic survey is expected.

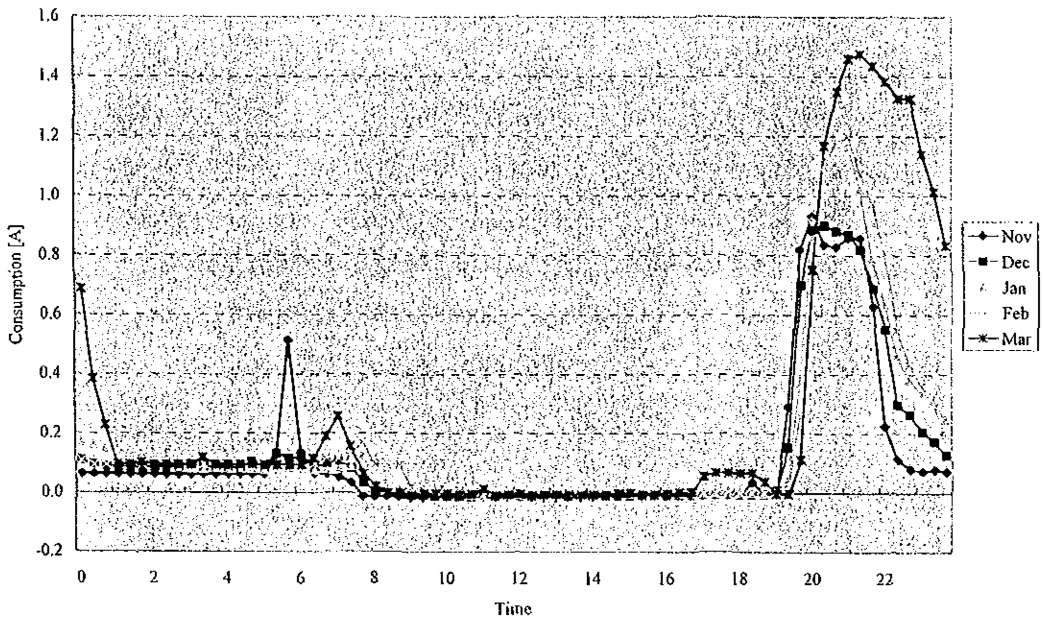


Figure 5.17 Monthly Average of Every 20 Minutes Trend of Consumption

(16) Battery Condition

The trend of current flow into/from the battery is shown in Figure. 5.18 and the battery voltage trend is in Figure 5.19. These trends are monthly average of each sampling time (every 20 minutes). The battery discharge current went higher and the discharging time spread out wider as time passes since the beginning; consequently, the user got familiar with the system as mentioned above. However, the current charged to the battery stopped around noon even in March when the user started using more energy. This means the battery was charged fully by around noon everyday.

Table 5.11 Threshold Voltage of the Controller

	SOC	Voltage (Reference)
Load Disconnection	<30 [%]	11.1 [V]
Load Reconnection	>50 [%]	12.6 [V]
Final Voltage of Charge Normal		13.7 [V]
Cycle		14.4 [V]
Equalization		14.7 [V]
Temperature Compensation		-4 mV/K/cell

Source: SLR1010 Installation and Operation Instruction Manual, Uhlmann Solarelectronic GmbH

The charge controller watches the amount of electric current to/from the battery to prevent overcharge and over discharge. It is said that the best way for charging battery nowadays is "three step" charging method. Each step is defined as follows.

- 1st Step – Bulk Charge
  In this step, the battery is charged with a rated amount of electric current until the voltage of the battery reaches at the gassing voltage (normally 14.4 V for a 12V system).

- 2nd Step – Absorption Charge
  In this stage, the charge controller keeps the battery voltage constant and starts to decrease the current to the battery. The battery is charged fully through this step.

- 3rd Step – Float Charge
  When the electric current reaches at the preset amount or when a constant period of time has passed, the charging step switches to the 3rd step called "Float Charge Mode". The controller keeps the battery voltage at the float voltage. During this mode, some amount of electron is charged to the battery in order to keep the battery SOC full.

It can be observed that the installed charge controller regulates following the charging method mentioned above. The current to the battery goes up to around 2 [A] just before the noon and kept at around 0.3 [A] until the sunset. This trend is due to the function of charge controller to charge the battery completely.

All through this monitoring period, the battery voltage has never fallen down lower than the load disconnection voltage. The lowest battery voltage observed was 12.33 [V] in fact.

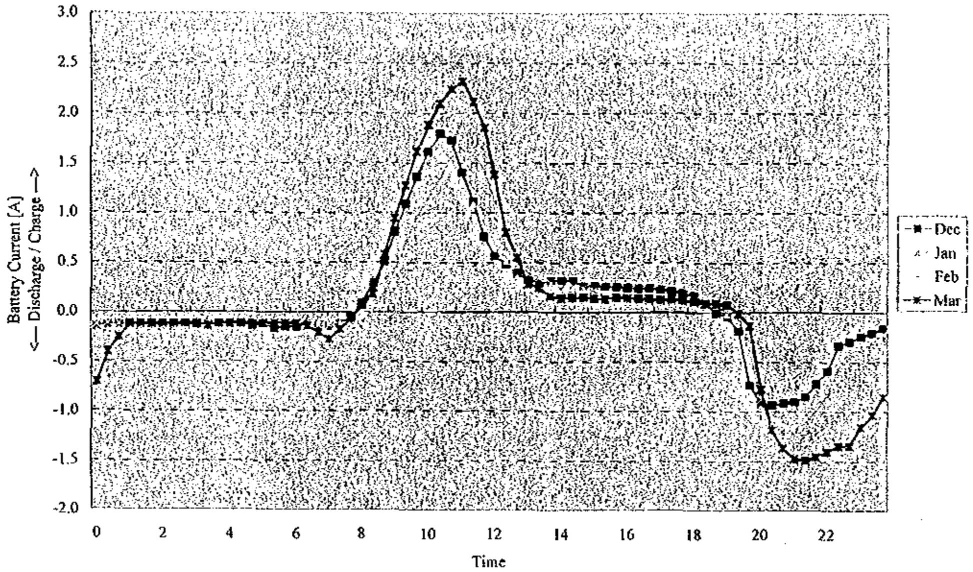


Figure 5.18 Monthly Average of Every 20 Minutes Trend of Charge/Discharge of the Battery

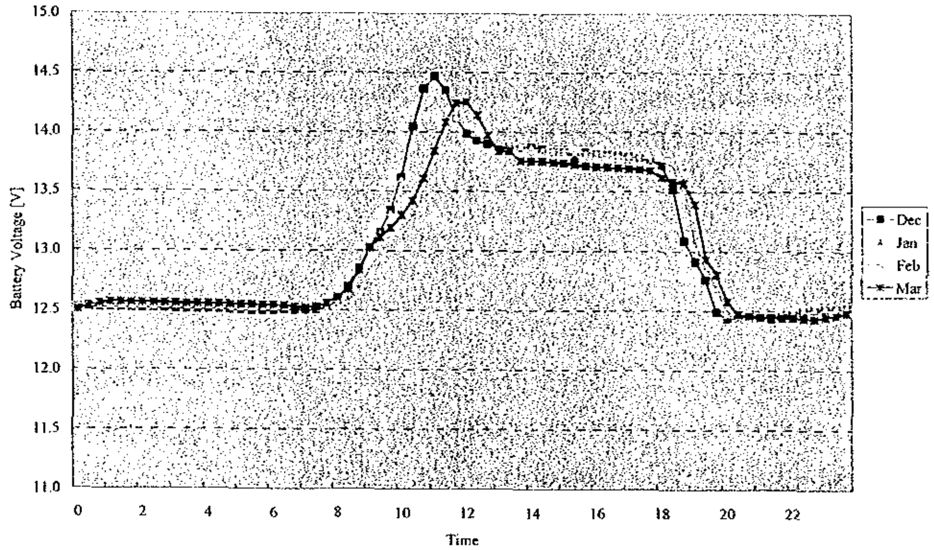


Figure 5.19 Monthly Average of Every 20 Minutes Trend of the Battery Voltage

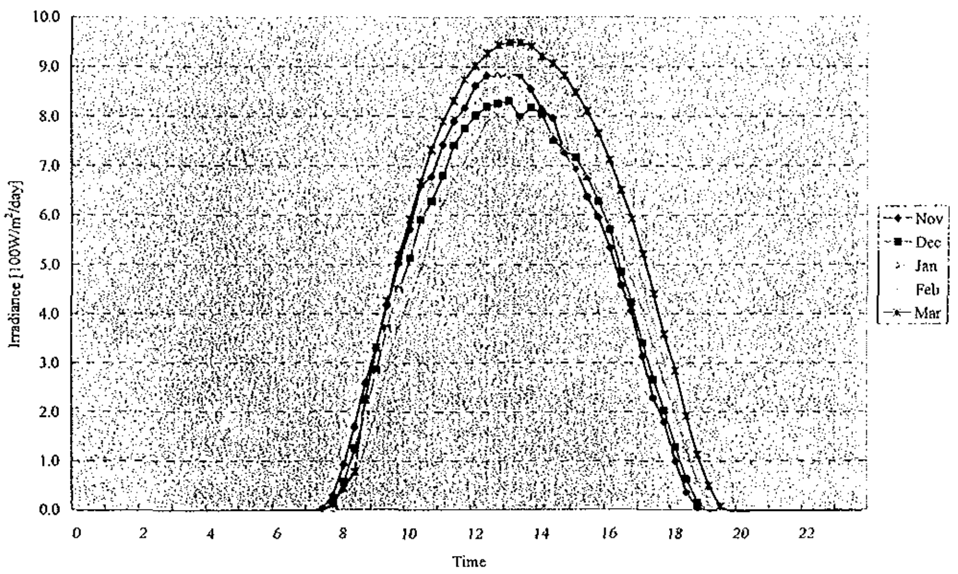


Figure 5.20 Monthly Average of Every 20 Minutes Trend of Irradiance

(17) Conclusion

Despite of sufficient irradiation, the power generation of the PV module was less than expected because the battery was not used full compared to its capacity. The user does not seem to have started using loads other than lamps so far. However, the user started using lamps longer hours as they got familiar with the system. The charge controller won't start regulating power until the user starts using another loads like TV and radio. It is expected the user will start learning how the system behaves after the charge controller begin regulating power when further consumption is added.

6. Selection of the Operator

The selection of the pilot project operator has been made through the limited tendering under the major conditions of "Fee for Services" in Pilot Project on Mar Islands as follows:

Four (4) candidates for this purpose were chosen by the representatives of PPMC from among the companies capable of performing this task

Major Conditions of "Fee for Service" in Pilot Project on Marl Islands

Payment Method

1. Initial payment	10,000 FCFA at registration 35,000 FCFA before installation
2. Regular payment	Fee for service shall be paid as follows; Monthly 3,700 FCFA every month (Definite month should be proposed by users in cases of bi-monthly and semi-annually)

The regular payment will be reviewed every two years.

Service period

The service period is 20 years, however the renewal of the contract be made every 5 years.

Guarantee Clause

Any equipment and materials shall be fixed or replaced by the Pilot Project Operator when the system doesn't work, as far as the end-users follow the instruction of the Pilot Project Operator. The reason and causes will be

investigated with cooperation of the end-users of the system in problem jointly by the technician trained and the experts nominated by the Pilot Project Operator. The battery, charge controller, module, etc. shall be taken care of by the Pilot Project Operator. However, consumable materials such as bulb shall be bought by the users themselves.

Maintenance Supporting System

The fixing and replacement shall be made within 3 days in minor case and 1 week in major case after malfunctioning of the equipment.

Collection Method

Bill collection will be made by the person to be nominated by the Pilot Project Operator.

Cash Management of Collected Fee

The fee to be collected, in the form of initial payment and regular payment, will be deposited and secured in the reliable bank. Bank A/C will be opened for current expenses for administrative activities and for equipment replacement/renewal purposes. These funds shall be properly managed by the Pilot Project Operator.

Removal of the System

The system shall be removed in case that the regular payment is not paid or more than the period mentioned in the contract.

Indicative Replacement Period

PV module	20 years
Charge controller	10 years
Battery	4 years

(For reference, distilled water is advised to be refilled into batteries with 0.5 liter/battery/month.)

The nominated candidates were requested to submit the proposal for management of the pilot project located in Mar Islands, with the components;

1. Organization of the operation, inclusive of nominated persons and their residence
2. Method of operation & maintenance
3. Method of communication between the management office and the site operation office
4. Proposal of the cost in terms of CFA/month required to manage the PV system
5. Method of fee collection and cash management

The schedule of the tendering is as follows;

Date of visiting Mar Islands	October 12-13
Date for explanation of the proposal	October 10 at ASER
Date of submission	10:00 am of October 20 at ASER

Finally, MATFORCE, which is a contracted supplier of the PV Equipment & Installation, was selected as a Pilot Project Operator.

7. Problems and Measures Taken during the Project Period

There were various type of problems occurred during the preparation and implementation periods of the Pilot Project. These problems were solved through the discussion among the organization concerned such as PPMC, supplier, operator and users. Measures of the problems regarding procurement and installation of equipment were drawn up through the discussion with the PPMC and supplier. Regarding the problems during the implementation stage were confirmed through the interview and questionnaire surveys with users and the Operator. Draft measures for these problems were drawn up through the discussion between the PPMC and Operator. The drafts of measures were explained to users when the seminars were held, then finalized after investigating feasibility of the draft of measures.

Main problems and measures during the preparation and implementation periods are shown on Table 7.1. On the other hand, contents of seminars were shown on Chapter 8.

Table 7.1 Problems and Measures (1/3)

[Preparation Stage]

No.	Problems	Measures	Notes
1	Down payment for CFA 45,000 per unit was set up for subscribing the Project. However, many villagers couldn't afford to pay this amount. In addition, some subscribers who subscribed more than 1 unit also paid only CFA 45,000 for their down payment.	The PPMC extended the application period, and advised villagers to start the installment saving for the down payment. Regarding the subscribers who applied more than 1 unit but paid for only a unit, the PPMC re-explain the regulation for applying, and requested them to pay for additional units.	One of the purposes to require the down payment was to estimate the financial affordability of individual subscribers. However, many villagers depend on pension and remittance for their income source in the rural arias. The appropriateness of this measure should be examined in this financial situation.
2	Some subscribers canceled their reservation, due to the suspicion about project implementation (delay of installation).	New subscribers were recruited. Because large number of households received remittance on November, initial payment was collected smoothly in this time.	
3	Some villagers subscribed for 2 to 3 sets of SHS. On the contrary, there were many villagers who couldn't subscribe for SHS, due to shortage of it.	This problem was caused by fluctuated number of subscribers during the preparation period. Many subscribers cancelled their orders just before the installation (after purchasing the components). Because the number of new subscriber didn't expected, the PPMC didn't set any roles regarding available number of SHS per person.	The limitation of available unit number per subscriber should be clarified before the subscription started.
4	Some subscribers requested to change their option at the end of application period. This change would be a cause of the spare parts shortage.	PPMC explained that all of the SHS units were purchased based on the selection by the subscribers. Therefore, subscribers should use their selected system at first. If any problems are clarified, appropriate measurements will be prepared at mid term evaluation.	Appropriateness of each option and satisfaction of user should be surveyed at mid term and final evaluation.
5	The tender conducted only JICA side and there was no chance to attend it for MMEH/ASER. MMEH/ASER also pointed out the importance of selection criterion by technical viewpoint.		To select the better quality component, possibility to adapt the technical selection criterion should be considered. Because MMEH is supposed to be held the tender for rural electrification by themselves in near future, possibility of the participation of Senegalese counterparts to tender procedure also should be considered.

Table 7.1 Problems and Measures (2/3)

[Installation Stage (1/2)]

No	Problems	Measures	Notes
6	The SHS units were planed to install from September in the initial schedule. However, installation started from mid of November due to the delay of procurement of goods.	This delay was known in June 2000. PPMC informed user of this delay through the meetings in June and July. However, this delay caused that user suspected of project implementation.	
7	Some 3 sets of PV panel, battery, fluorescent tube with ballast, charge controller were investigated by CERER. The delay of the procurement was resulted not only installation schedule of SHS, but also the investigation of the components.	PPMC decided to start the installation before receiving results of the investigation. If not, the Project would has been postponed until June, due to the assignment schedule of JICA Study Team.	The result of investigation was submitted on March 2001. It was confirmed that battery and ballast of the fluorescent tube weren't satisfied the required specifications.
8	Because the insufficient brightness of LED lamp, some subscribers requested to replace it to the normal light bulb when installation started.	Based on the request from subscribers, an angle of LED lamp to wall was adjusted.	Because LED lamp hasn't introduced in this area, villagers couldn't image the brightness of LED lamp when PPMC held the public consultation. When this kind of new product is introduced, an actual good should be shown to subscribers. User's satisfaction of LED lamp this measurement should be surveyed at mid-term evaluation.
9	SHS system was designed on the assumption that capacity of radio-cassette recorder was 5W. However, some subscribers used radio-cassette recorder more than 12W, which didn't match the specification of SHS. Because of this difference, users who selected this option can't use radio-cassette recorder required higher voltage.	The PPMC prepared additional option which use higher voltage DC/DC converter. However, this option can supply the electricity shorter period than the option 1. After explanation of this measurement, PPMC carried out questionnaire survey to users to define the options.	In general, user's demand is surveyed through a questionnaire survey. Some questions aim to actual required power of electric appliances should be included in this questionnaire. Ex: Required size and number of dry sells for radio / radio cassette recorder at a time.
10	The original design of the Project covered to socket, but plugs wasn't included. However, it was identified that procurement of plugs which fit the installed socket was very difficult for user side when installation was started..	The PPMC requested the Installer to provide appropriate type of plugs, and the Installer accepted it.	

Table 7.1 Problems and Measures (3/3)

[Implementation Stage]

No	*Problems*	*Measures*	Notes
11	The PPMC set up the first fee collection day on early in January. However, some users who have the remittance once or twice a year couldn't afford to pay it on schedule.	Based on the request from user side, the operator postpones first payment of some users for 6 months.	Due to change the project design and schedule several times, a notification of payment schedule to user side was also delayed.
12	Many users required more powerful SHS at the mid-term evaluation. Some users were eager for using color TV (AC 220V) and refrigerator.	The PPMC recommended to use DC 12V color TV which was available in Dakar (see ANNEX 2). The capacity of SHS was designed based on the experience of GTZ project, demanded capacity for prioritized objective of SHS (lighting purpose), balance of cost/benefit.	There is a tendency to increase the required power demand in proportion to electrification experience. However, power demand of users was lower than power supply (seeChap 9.2).
13	Some of installed components, namely battery and ballast-inverter of the fluorescent tube weren't satisfied the required specifications. Abnormal short life span of fluorescent tube which supposed to be caused by the ballast was recognized at mid-term evaluation.	PPMC officially requested the installer to replace ballast of the fluorescent tube, and the installer agreed this request. As of October 2001, 57 fluorescent lamps were replaced to integrated type. Hereinafter, modular type fluorescent lamps will be gradually replaced from the lamps which occurred abnormal short life span of fluorescent tubes.	This abnormal short life span of fluorescent tube was recognized at mid term evaluation. Meanwhile, users whose fluorescent tube was out of order purchased new light for CFA 2,000. It is said that there is an affinity between devices from different manufacturers. Therefore, careful investigation is required when the equipment such as ballast inverter and fluorescent tube are selected.
14	Cost of integrated type is more expencive than modular type. Therefore, there is some possibility that present financial plan couldn't cover the replacement cost for equipment.	The Operator agreed to supplement a part of market price from the deposit of electricity fee when users purchase integrated type.	The modular type is cheaper than integrated type, but there is some possibility to broken down. On the other hand, integrated type is worked without trouble, but comparatively high in price. Deeper investigation is required when SHS is designed.
15	Fee collector went to Mar Island from the Operator's office in Dakar in the initial stage of the project. This trip was very costly because it took more than 2days.	New fee collection system that VUA collects fees from each users before Fee collector arriving from Dakar was introduced. This new system decreased cost for fee collection about CFA 25,000/time.	The VUA in Mar Fafaco is very cooperative, and new fee collection system worked well by obtaining the cooperation of them.. On the other hand, the VUA in Mar Lothie has the lower sense of participation, and the Local Technician assists fee collection in the village. It would be better to introduce some kind of activities for building up villager's capability is required.

8. Seminars

8.1 Objective and Method

Seminars for the Pilot Project were held for explaining the purpose and contents of the project, grasping the user's opinion from and discussing the subjects to be solved. These seminars were held at initial stage (12th and 13th, December 2000), mid-term (25th and 26th, June 2001) and final stage 15th and 16th, October 2001) of the project period..

The opinions and existing condition, such as utilization condition of electricity, were surveyed through the questionnaire surveys conducted in cooperation with VUAs in Mar Lothie and Mar Fafaco. The issues confirmed through the surveys were discussed among the members of the PPMC and the Operator. The measures proposed from user side through the questionnaire surveys also discussed in this meeting, too. Then the PPMC proposed measure for each subject to users at the seminars. These proposed measures were finalized through the discussion between the PPMC and users.

Each seminar was held both in Mar Lothie and Mar Fafaco. Because the first seminar was simultaneously held with the opening ceremony of the Project, all of the subscribers and many other villagers attended. The attendance for second seminar was limited to only SHS users. The list of attendance was shown on Table 8.1.

The subjects discussed at the seminars were as follows;

8.2 Subjects Discussed at the Seminars

(1) First Seminar

The first seminar was simultaneously held with the opening ceremony of the Project. All of users made contracts with the Operator after the explanation of the content of contract, utilization method of SHS and role of the Operator. A series of meeting with subscribers preceded the first seminar on 29th to 30th, November and 12th to 13th, December 2000. These meeting aimed to establish the mutual understanding for role of each stakeholder, namely the PPMC, the Operator, VUAs and users, and also for the contents of contract between the Operator and users. The Operator requested VUAs assistance for fee collection, too.

The questions and answers in the meetings and seminars were as follows.

Q1: Some users who requested option including LED lamp wanted to change their option, due to the of LED lamp was unexpectedly not bright enough for users.

A1: Brightness of LED lamp would be adjusted to change the angle of lamp in this period. If there were still some problem, this subject would be discussed again at the mid-term evaluation period.

Q2: A part of users used radio cassette recorders which demand higher voltage than SHS provide. They eager use these radio cassette recorders by SHS.

A2: The PPMC informed users that any users who want to use these appliances required high voltage could replace the DC/DC converter. The installer would do this replacement after confirming the users needs through the interview survey.

Q3: Who will collect the fee?

A3: The Operator dispatch fee collector every month.

Q4: The first payment is supposed to be collected on January. Due to no advance notification, many users couldn't afford to pay it on time.

A4: As the result of discussion between the PPMC and the Operator, the Operator agreed to postpone first payment based on the request from users.

Q5: There are many additional subscribers for SHS in both villages. VUAs already prepared waiting lists for the Project. Is it possible to add the subscribers for the Project?

A5: The PPMC couldn't accept any more subscribers, because the number of installed SHS was already fixed based on the application from villagers. The PPMC is reporting ASER that there are still many villagers want to participate the Project.

(2) Second seminar

The second seminar was held during the mid-term evaluation period on June 2001.

The PPMC confirmed several constraints on the management system for the Pilot Project through the field survey and questionnaire survey. These constraints were classified broadly into two categories, one was malfunction of fee collection system, and the other was demand of SHS modification.

Member of the PPMC, namely ASER, MMEH and JICA Study Team, and the Operator agreed the following conclusions.

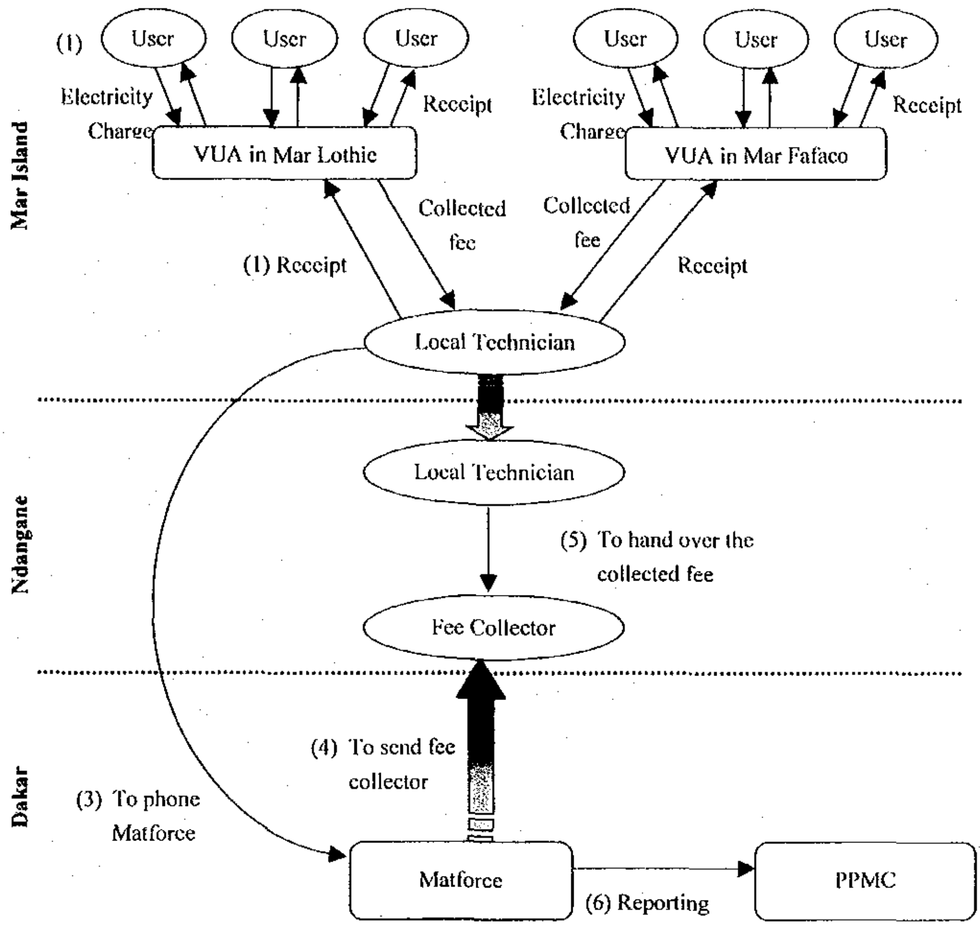
1) Improvement of Fee Collection System

Based on the agreement concluded on December 2000, the Operator dispatched a money collector to Mar Island every month. However, it was confirmed that expense for this dispatch accounted for about 25 percents of total expenditure since December 2000. Therefore, it was necessary to modify the existing fee collection system for reducing its expense. In addition, delay in issuing the receipt to individual user was also recognized.

The PPMC and the Operator agreed to modify the fee collection system as follows.

1. Village Users Associations (hereafter referred as to "VUA) in each village, namely Mar Lothie and Mar Fafaco, collect the electricity charge from individual users in cooperation with the Local Technician. VUAs also give individuals a receipt for the electricity charge.
2. The Local Technician receives collected fee from VUAs, and gives VUAs receipts for total amount of the collected money.
3. The Local Technician gets in touch with the Operator after receiving the electricity fee from VUAs.
4. The Operator dispatches fee collector to Ndangane to receive the electricity fee. The fee collector also delivers the salary for the Local Technician too.
5. The Local Technician deliver over the electricity fee to money collector in Ndangane.
6. The Operator submits a record of electricity charge collection to the PPMC every month. PPMC audits the submitted record, and instruct the Operator, if necessary. All of financial reports submitted by the Operator should include related materials such as receipt and invoice.

Flow of the New Fee Collection System



2) Modification of the SHS

Based on the experience since December 2000, some users requested to modify a part of SHS components, such as LED light, TV socket and inverter. The PPMC and the Operator approve the modification of SHS under the following procedure. In principle, necessary cost for modification is paid by the user.

1. User submits request for modification to the Operator.
2. The Operator examines technical feasibility of the modification. At the same time, the Operator estimates the necessary cost for modification.
3. The Operator notifies the user of the cost estimation, if the request is approved in the technical examination.

4. The Operator modifies the SHS, if user agrees to pay for the cost estimated.
5. The Operator should report any modification to the PPMC.

These measures were explained to the users at the second seminar. Regarding the fee collection system, both VUA agreed to assist the fee collection, and VUA in Mar Fafaco set up the collection day of the month. There were some users depended their income on pension which was paid on every 10th of month. Considering this fact, fee collection day was set up on every 15th of month. In case of users who selected *semi-annual* payment, fee is collected whenever user come back to Mar Fafaco (These users usually work away from home). The fee collection day of Mar Lothie wasn't fixed in the seminar. It would be decided thought the VUA meeting.

Then discussion period was taken between PPMC and users after the explanation. Main questions and answers were mentioned as below.

Q1: Many users were eager for using color TV. There were also some users want to use refrigerator, too. Is it possible?

A1: The PPMC explained that the modification of SHS for watching color TV is technically possible. However, this modification is very costly when they use regular type color TV of AC V220 powered, and this modification would cause too many loads to the SHS itself. Therefore, the PPMC recommend to use DC 12V color TV which was more suitable for SHS, and available in Dakar. The PPMC also advised users to consult with the Operator for its technical possibility prior to purchase DC 12V color TV or any modification.

Regarding the possibility for using refrigerator, the capacity of SHS installed in this time was too small to use refrigerator. The PPMC also explained about possibility of the refrigerator unit with PV panel, although it was very expensive.

Q2: The abnormal short life span of fluorescent tube which supposed to be caused by poor performance of the ballast-inverter was recognized at some SHS units. In addition, malfunction of some charge controllers was also reported.

A2: The PPMC explained that this subject was under negotiation with the Operator. The result of negotiation would be informed of VUAs.

Q3: VUA appealed that there were many villagers who have an earnest desire to install SHS.

A3: The PPMC explained that the Government of Senegal is also concerned with this matter. The PPMC also explained that it would take a long procedure for establishing a new project.

However, during the seminar in Mar Lothie, the Director General of ASER announced that ASER intended to prepare the new project for electrifying Mar Island using not only SHS, but also surplus power of the autonomous generator for water pump.

Q4: There were also some technical questions for using/replacing electric appliances.

A4: The PPMC answered that they had to consult the Operator first. The PPMC and external technician of the Operator also explained some basics theory of the capacity of SHS. In addition, the PPMC advised users that users have to consult with the Operator about the feasibility of using electric appliances before they bought it.

Besides of the question and answer mentioned above, the PPMC pointed out that the request for replacing fluorescent light in the health post was postponed. The PPMC and users agreed that responsibility of replacement and payer of necessary cost should be clarified through the discussion with the Operator.

(3) Third seminar

There were three subjects discussed at the third seminar, namely malfunction of ballast inverter, work schedule of local technician, and unpaid monthly fee of the health post in Mar Lothie.

1) Replacement of fluorescent light

The SHS unit introduced by the Pilot Project adopted modular type fluorescent light which were assembled individual parts such as ballast inverter and fluorescent tube. The unexpected short life span of fluorescent tube has been reported to PPMC since June 2001. Based on the agreement between PPMC and Operator, Operator agreed to replace the modular fluorescent lamp with the integrated type fluorescent lamp which was integrated with fluorescent tube and ballast inverter.

Based on the agreement between User and Operator, this replacement would be done free of charge (users should pay the necessary cost from second replacement). Although Operator agreed to replace all of the fluorescent lamps, this replacement would be conducted gradually when the fluorescent tube of the modular lamp is burnt out. Based on this agreement, 20 sets of modular fluorescent lamp were replaced to compact fluorescent lamp on 5 to 6, October 2001, and another 37 sets of compact fluorescent lamp were kept in the Island as spare parts.

The outline of explanation was as follows;

1. The replacement to the integrated type conducts gradually when the fluorescent tube of the modular lamp is burnt out.
2. Operator keeps 50 sets of integrated type fluorescent lamp in the Island as spare parts.
3. All of the modular type fluorescent lamps are the target of this replacement. 。
4. Users ought to submit the burnt out fluorescent lamp to Operator through the local technician when the lamp is replaced. Any replacement would not be done without submitting the burnt out lamp

The contract provides that the necessary cost for the replacement of ballast inverter is paid from the deposit of monthly fee, although replacement cost for consumable items such as fluorescent tube should be paid by users. The PPMC and the Operator agreed that the necessary cost from the second replacement would be shared by the user and deposit of monthly fee managed by the Operator. The second replacement is supposed to conduct more than three years from the first replacement. Therefore, sharing rate of the replacement cost for user couldn't fixed, because the price of integrated type fluorescent lamp is uncertain at this period.

2) Revision of the work plan for the local technician

According to local technician, his workload has been increased because of frequent call from users in Mar Lothie and Mar Fafaco. From the user's point of view, there were some difficulties to contact to local technician, because the work areas of local technician are scattered around the two villages.

Regarding this matter, the PPMC recommends that local technician should fix the days of the week to work at Mar Lothie and Mar Fafaco. This scheduling expected to make easier for routine works. Users in Mar Lothie and Mar Fafaco accepted this recommendation.

3) Unpaid monthly fee of the Health Post in Mar Lothie

The Health committee applied two units of SHS for the Health Post in Mar Lothie. However, installed position of the equipment was instructed by a health nurse, due to the absence of the representative of Health committee. As the result, the Health committee refused to pay the monthly fee for one unit of SHS, because the lamps weren't installed to correct places where the Health committee planned. The Health committee requested the Operator to transfer some fluorescent lights free of charge.

This problem wasn't solved to September 2001, although the PPMC expected VUA to solve this problem. Therefore, the PPMC held the meeting with supplier of SHS, a representative of the Health committee and deputy village leader before the third seminar. The PPMC proposed following measures to the Health committee.

1. User should obey the contents of user contract. User couldn't refuse to pay electricity fee as long as using SHS. The PPMC approves of continues use of SHS, if the Health committee pay the outstanding fee for past 10 months (CFA 37,000) at the fee collection period on October. The PPMC remove one SHS from the Health Post, if CFA 37,000 is not paid by the appointed day.
2. Regarding the transfer of lamps requested by the Health Committee corresponds to the "Modification of SHS" explained at the second seminar on June 2001. Therefore, necessary costs for modification are basically charged on the health committee. However, this problem was caused by inappropriate works of both the health committee and Installer at the installation period. Therefore, The PPMC charges the health committee for a part of necessary costs (CFA 26,000). The modification will be done when the health committee pays CFA 26,000.

The health committee didn't make any decision for the measures mentioned above, because these decisions should be done through the village meeting. Therefore, the PPMC informed users of these situations. The representative of health committee and deputy village leader spoke that they take the consequences to discuss this matter with villagers.

Then discussion period was taken between PPMC and users after the explanation. Main questions and answers were mentioned as below.

Q1 Working condition would be improved, if working days for each village are fixed. It is very difficult to get in touch with local technician in present condition. We must realize this idea.

A1 Concerning the above speech, the Operator proposed to set up the maintenance record book for each user's house. Following items were accepted by all of the participants through the discussion.

- The Operator set up the maintenance record book for each user's house.
- The local technician describes the maintenance record on the record book.
- Each record is collected and reported to the Operator every two to three months.

Q2: Dose the PPMC have any idea to start the new projects in other area after closing the JICA project? How dose the PPMC intend to cope the additional subscribers for the SHS project?

A2: The PPMC which is composed of MMEH and ASER undertake the project activities on their own responsibility. As mentioned at the second seminar on June 2001, ASER gave the priority to Mar Island for rural electrification, and new project is preparing. Although the project preparation was delayed, due to the reorganization in governmental sector, the Government of Senegal still prioritizes the electrification of Mar Island. However, Senegal couldn't request JICA for further assistant, because the JICA project is terminated.

Q3: The PPMC explained that the electrification for productive activities will be realized. We would like to know the future plan?

A3: This Pilot Project aimed lighting oriented electrification which located in initial stage of electrification. The Government of Senegal intends to draw up next project based on the experience of the Pilot Project. ASER already apply to the the Government of Senegal for the additional project explained at the second seminar.

Q4: Will the monthly fee increase?

A4: A part of the monthly fee is saved for replace cost of the devices. Because of new policy, PV equipment also is imposed a tax. Therefore, present monthly fee should be revised. Although the PPMC strive for subsidy from the government, it seems very difficult to get it.

Q5: What is the difference between integrated type fluorescent light and modular type? According to the PPMC, replacement cost from second time charges on user side. We would like to know the actual price. Is it possible to replace integrated type to modular type, if we can't afford to pay the cost for integrated type?

A5: Due to malfunction of some parts of modular type fluorescent light, all of modular type are replaced to integrated type. The integrated type is expected longer life span. However, integrated type is comparatively high in price. Therefore, users can choose which type of fluorescent light they use, if the lamp work correctly.

Besides of the question above, there were a lot of technical questions regarding the modification of SHS. Engineers from the PPMC answered some question, and remaining technical questions would be discussed and answered by engineer dispatched by the Operator.

Table 8.1 Attendance List of the Seminar in Mar Island (1/3)
(Contractors in Mar Lothie)

Contractor		Date of Seminar		
		Dec. 00	June 01	Oct. 01
1	ABDOU KHADRE NDIAYE	○	○	○
2	ABDOU MATA DIOUF	○	○	○
3	ABDOUL AZIZ THIOR	○		○
4	ABDOULAYE DIOM	○	○	○
5	ABLAYE DEBE GNING	○		○
6	ADAMA FAYE	○	○	○
7	AGNES	○	○	
8	ALIOUNE SENGHOR	○	○	○
9	BIRAMA NDIAYE	○	○	
10	DISPENSAIRE	○	○	○
11	DOUDOU LAMINE DIOM	○	○	
12	EL HADJ COUMBA NDIAYE	○	○	
13	EL HADJ DOUDOU DIOM	○	○	○
14	MAMAU THIOR	○		○
15	ETIENNE DOGUE	○	○	○
16	FABIRAMA BOP	○		○
17	FALLY FAYE	○		○
18	IBRAHIMA NDIAYE	○	○	○
19	ISSA DIOP	○	○	○
20	JOSEPH NDIOGOYE	○	○	○
21	JULIENNE DOGUE	○		○
22	KHADY NDIAYE	○	○	○
23	MADABA THIOR	○	○	○
24	SALIFOU NDAYE	○	○	○
25	MAMADOU KANGOU NDIAYE	○	○	○
26	MAMOUR THIARE	○	○	○
27	MARTINE CLAUDIN	○	○	○
28	MICHEL NDONGUE	○		○
29	PAPE LATYR FAYE	○	○	○
30	PAUL NDIOGOYE	○	○	○
31	SABOU THIOR	○		○
32	SIDY FAYE	○	○	○
33	SOULEYMANE ROCKY FAYE	○	○	○
34	THEOPHILE THIOR	○	○	○

Table 8.1 Attendance List of the Seminar in Mar Island (2/3)

(Contractors in Mar Fafaco)

Contractor		Date of Seminar		
		Dec. 00	June 01	Oct. 01
1	ABDOU KALING	O	O	O
2	ABDOU RAMANE BOP	O	O	
3	ABDOU SARR	O		O
4	ABIBOU SARR	O	O	O
5	ALOUINE DIOME	O	O	
6	AMETH FALL	O	O	O
7	ANSOU THIARE	O	O	
8	ARFANG MOUSSA NDONG	O	O	O
9	BAKARY DIOME	O	O	O
10	BIRAMA NDONG	O	O	O
11	BIRAME MAI FAYE	O	O	O
12	DISPENSAIRE	O	O	O
13	EL HADJ ALIOUNE THIAM	O	O	O
14	EL HADJ ALIOUNE THIARE	O	O	O
15	EL HADJ BIRAME FAYE	O	O	O
16	EL HADJ CHEICK THIARE	O	O	
17	EL HADJ LAMINE DIOM	O	O	O
18	EL HADJ MAMADOU BARO	O	O	O
19	EL HADJ OUSMANE DIOP	O	O	O
20	EL HADJ SACOU KALING	O	O	O
21	FABI SENGHOR	O	O	O
22	FALY DIONE	O	O	O
23	FAMARA SARR	O	O	O
24	ISSA KANE	O	O	O
25	ISSA SARR	O	O	O
26	LAMINE MOUSSO NDIAYE	O		O
27	LAMINE DABA DIOM	O		O
28	LAMINE DIOP	O	O	O
29	LAMINE THIOR	O	O	
30	MADY COUMBA FAYE	O	O	

Table 8.1 Attendance List of the Seminar in Mar Island (3/3)
(Contractors in Mar Fafaco)

Contractor	Date of Seminar		
	Dec. 00	June 01	Oct. 01
31 MADY DIOUF	○	○	
32 MADY SARR	○	○	○
33 MADY YAYE FAYE	○	○	○
34 MAMADOU AMADOU SARR	○	○	○
35 MAMADOU BARO	○	○	○
36 MAMADOU KALING	○	○	○
37 MAMADOU MADIANG FAYE	○	○	○
38 MAMADOU NDIAKAL BOPP	○	○	
39 MAMADOU ROGUE SARR	○	○	○
40 MOUSSA DIOM	○	○	○
41 OUSMANE DIOUF	○		○
42 OUSMANE FATOU NDIAYE	○	○	○
43 OUSMANE TAMSIR NDIAYE	○	○	○
44 SAGAR THIAM	○	○	○
45 YAKHAYA SANE SARR	○		○