European Union Rule of Law Mission (EULEX)
Ministry of Justice, Kosovo and UNMIK
Assembly of Kosovo and United Nations
The Republic of Kosovo

The Judiciary in the Newly Established Municipalities in the Republic of Kosovo

EULEX Judicial Mission

March 2002

EULEX Publications
The Judiciary of the Republic of Kosovo

Japan International Cooperation Agency (JICA)
Ministry of Mines, Energy and Hydraulics (MMEH)
Agency of Senegalese Rural Electrification (ASER)
The Republic of Senegal

The Study on Photovoltaic Rural Electrification Plan in the Republic of Senegal

PV System Manual

March 2002

KRI International Corp.
The Institute of Energy Economics, JAPAN

Currency Exchange Rate

(February 2002)

US$＝¥ 133.74

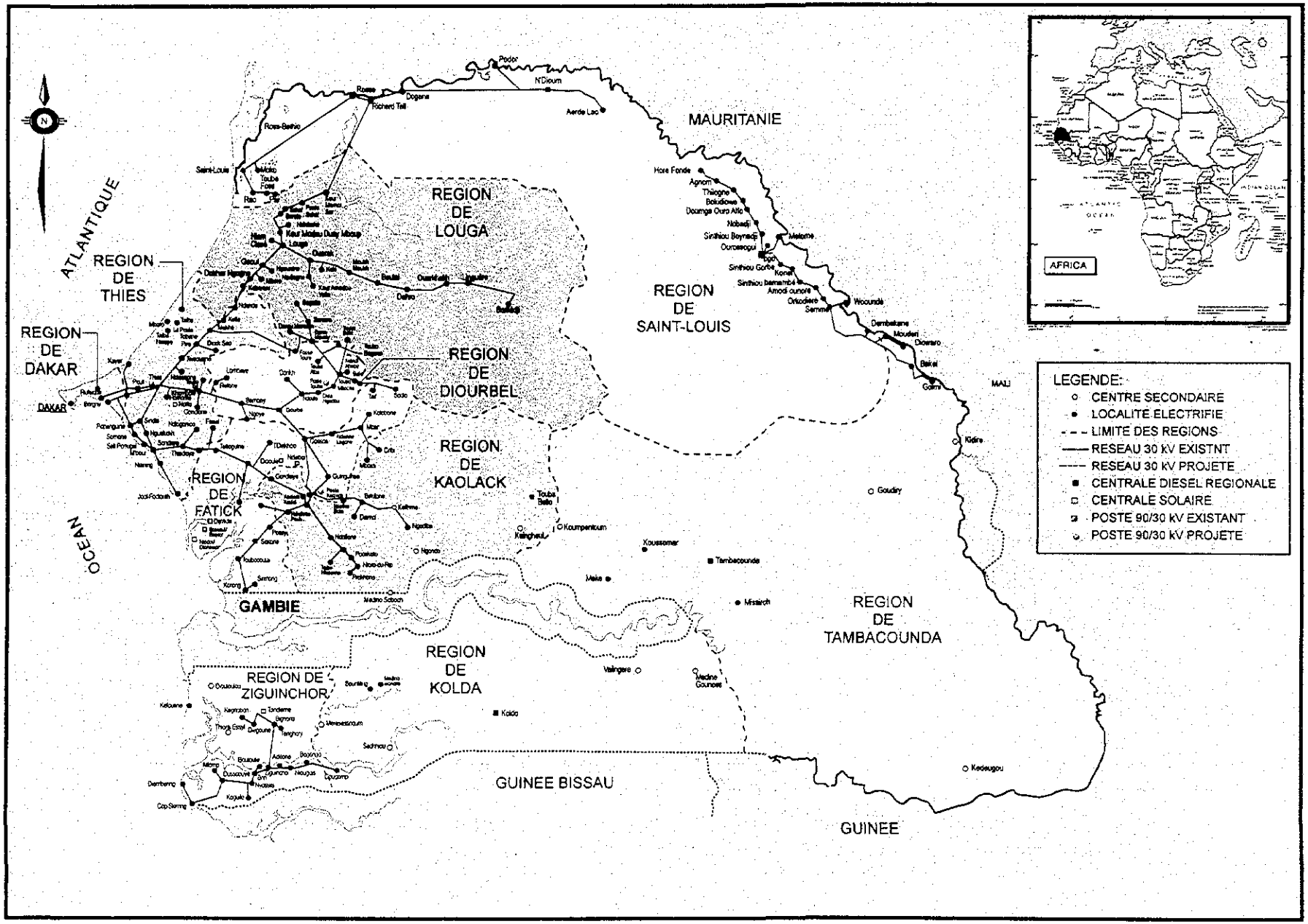
US$＝7.54 FF

Euro＝US$ 0.87

(Euro＝6.56 FF)

FF＝100 CFA (FF: French francs)

CFA＝¥ 0.177



LOCATION MAP

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Abbreviation

AC	:	Alternative Current
ADER	:	Association Senegalaise pour le Development de l'Electrification Rurale
ASER	:	Agence Senegalaise d'Electrification Rurale
BCEAO	:	Banque Centrale des Etats de l'Afrique de l'Ouest
CERER	:	Centre d'Etudes et Recherches sur les Energies Renouvelables
		Center of Study and Research on Renewable Energy
CFL	:	Compact Fluorescent Light
CMS	:	Senegalease Mutual Credit Fund
CNCAS	:	Caisse Nationale de Credit Agricole
CNES	:	Confederation Nationale des Employeurs du Senegal
CNQP	:	Centre National de Qualification Professionelle
CR	:	Communaute Rurale
CRSE	:	Commission de Regulation du Secteur de l'Electricite
DAST	:	Scientific and Technical Affairs Delegation
DC	:	Direct Current
DFI	:	Decentralized Financing Institutions
DFS	:	Decentralized Financing Systems
D/G	:	Diesel Generator
ERIL	:	Electrification Rurale d'Initiative Locale
ESCO	:	Energy Service Company
FAO	:	Food and Agriculture Organization
FEM	:	Fonds de l'Environnement Mondial
F/L	:	Fluorescent Light
FOPEN	:	Federation des Organisations pour la promotion des Energies Nouvelles
		Federation of Organization for Promotion of New Energy
GDP	:	Gross Domestic Product
GIS	:	Geographical Information System
GPS	:	Geographical Positioning System
GTZ	:	Deutsche Gesellschaft fur Technische Zusammenarbeit GmbH
HVD	:	High Voltage Disconnection
IDA	:	International Development Agency
IEA	:	International Energy Association
IPP	:	Independent Power Producer
ISN	:	Institute of Senegal National Standard

LV	:	Low Voltage
MMEH	:	Ministere des Mines, de l'Enegie et de l'Hydraulique
NGO	:	Non Governmental Organization
ODA	:	Official Development Assistance
OJT	:	On the Job Training
O&M	:	Operation & Maintenance
PASER	:	Plan d'Action Senegalais d'Electrification Rurale
PCM	:	Project Cycle Management
PDM	:	Project Design Matrix
PLE	:	Plan Locale d'Electrification (LEP)
PPER	:	Programme Prioritaire d'Electrification Rurale
PPMC	:	Pilot Project Management Committee
PTIP	:	Programme Triennal d'Investissements
PV	:	Photovoltaic
RESCO	:	Regional Energy Service Company
ROE	:	Return on Equity
SEMIS	:	Services de l'Energie en Milieu Sahelien
SFD	:	Systemes Financiers Decentralises
SHS	:	Solar Home System
SPF	:	System Photovoltaique familial
UCAD	:	University of Dakar
UNDP	:	United nations Development Program
VUA	:	Village Users Association
WB	:	World Bank
WHO	:	World Health Organization

Unit

mm	:	millimeter
m	:	meter
km	:	kilometer
El.m	:	Elevation in meter
l/s	:	liter per second
m/s	:	meter per second
m^3/s	:	cubic meter per second
mm^2	:	square millimeter

km^2	:	square kilometer
mg	:	milligram
ton, t	:	metric ton
V	:	Volt
W	:	Watt
kW	:	kilowatt
MW	:	Megawatt
Wp	:	Watt peak
kWp	:	kilowatt peak
GWh	:	Gigawatt hour
kWh	:	Kilowatt hour
MVA	:	Megavolt ampere
KVA	:	Kilovolt ampere
Ah	:	ampere hour
Hz	:	Hertz
RPM	:	Revolution (revs) per minute
%	:	Percentage

Currency Unit

CFA	:	Senegalese Currency
US$	:	US Dollar
M.US$	:	Million US Dollar
Euro	:	European Currency
Yen	:	Japanese Currency

CHAPTER 1 MANUAL FOR PV SYSTEM MANAGEMENT

1.1 Objectives and Constrains

The objective of this chapter is to provide a manual for implementation of rural electrification in Senegal using PV technology as a means of electrification.

The manual to be provided are (i) for Users, (ii) for Enterprise of electrification or Project Operator and (iii) for Governmental Organization.

At present, the government of Senegal has changed their policy to implement rural electrification from conventional national electricity organization SENELEC to private enterprises by licensing the right of concession of electrification divided the un-electrified area of Senegal. Expecting the vitality of private organization.

The ASER was established as an implementing organization and manuals for the ASER to execute the rural electrification are provided and publicized.

According to this manual, ASER consider three basic electrification methods such as, (i) the extension from MV grid, (ii) stand-alone diesel generator with LV distribution line and (iii) PV (SHS), but electrification program based on the PV dissemination does not provided.

The target number of electrification is described in PASER (Action program for rural electrification in Senegal). It is shown as follows:

Table 1.1 Target of PASER

Type of Service	Present (2000)	First Phase (2005)	Second Phase (2015)
Extension of MV line	27,000	58,000 (+31,000)	80,000 (+22,000)
Diesel + LV network	—	26,000 (+26,000)	120,000 (+94,000)
SHS (PV)	3,000	20,000 (+17,000)	70,000 (+50,000)
Total	30,000	104,000 (+74,000)	270,000 (+166,000)
Rural household	600,000	696,000	810,350
Electrification ratio	5%	15%	33%

Total number of electrified household by 2015 is targeted as 240,000, by the extension of MV line is expected as 53,000(22%), Diesel/LV network is 120,000 (50%) and by SHS is expected as 67,000 (28%), the expectation for SHS is pretty high.

The number of concession will be set around 20 in whole Senegal. Each concession will electrify around 10,000 households then around 3,000SHS could be introduced.

What type of SHS to be introduced or what type of system to distribute SHS are leave to the concessionaire's discretion

ASER provided another type of electrification plan other than concession program. ERIL is an electrification project of limited zone or area by the initiative of local community. ERIL (Local Initiative Rural Electrification)

Under those situation, JICA study team formulated the pilot project in Mar Island to install 95 SHS and entrusted private operator to manage them as "fee for service" mode to prove the feasibility of ESCO system in Senegal.

This pilot project will be an example of ERIL type project or implementation model project in PV introduction of concession type electrification (PPER).

The manuals will be provided here are mainly based on the experience and results of the pilot project for:

1) Manual for customer: Based on the user manual provided for the pilot project, such as a recommendation of "how to use SHS systems" introduced in the "fee for service" scheme.
2) Manual for Enterprise of electrification or Project Operator: Based on the process to formulate and operate the pilot project in such as "fee for service" scheme.
3) Manual for Governmental organization: Based on the provided ASER manual, from the view point of implementation of PV dissemination, providing the evaluation of application document for ERIL project and method for investigation and monitoring of implementation of ERIL project.

CHAPTER 2 MANUAL FOR CUSTOMER

2.1 Principle of Solar Photovoltaics (PV)

Principle of solar photovoltaics is simply said; the PV module receives the solar light energy and converts it as electricity so it can generate electricity during only the sun is shinning.

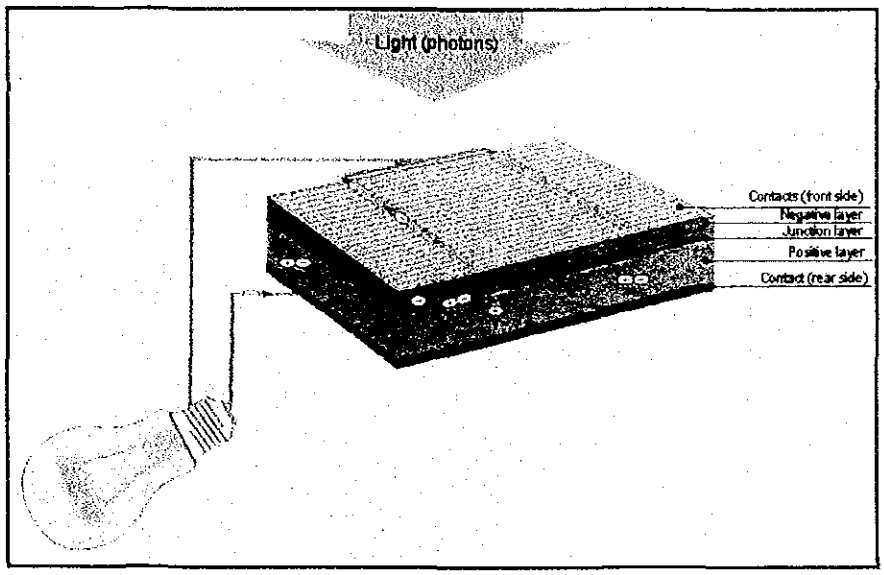

Figure 2.1 Photovoltaic Power Generation (IEA PVPS Home Page)

2.2 Solar Photovoltaics System

PV module generates only the sun is shining but electricity is necessary after the sun downs such as for illumination. For this purpose the electricity generated during the sun shines should be stored in battery. To use the battery work well, the charge controller is necessary. Then solar PV system is consisted from PV module, battery, charge controller and load appliances.

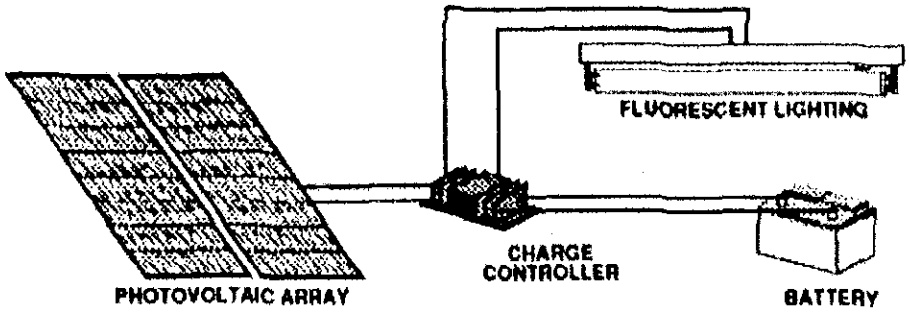

Figure 2.2 Photovoltaic System

(1) PV module (PV panel)

PV module is consisted from PV cells to take enough voltage to charge battery and current to utilize electricity. Usually the voltage is 15 to 18V and generated power is 30 to 200W per module. People want much power it is possible to connect PV modules as much as they need.

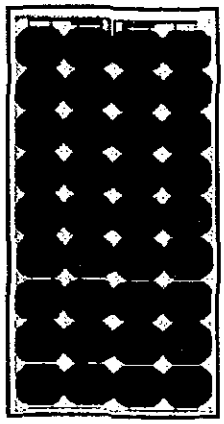

Figure2.3 PV module (PV panel)

(2) Battery

Battery stores the generated electricity. There are many kind of battery but most popular type is lead-acid type (lead as electrode and sulfuric acid as electrolyte).

The life of battery is affected by use condition, customer should follow the direction of battery supplier or project operator.

The charge controller controls battery by setting voltage for the each type of battery so when needs to renew battery it is recommended to purchase same grade of used one.

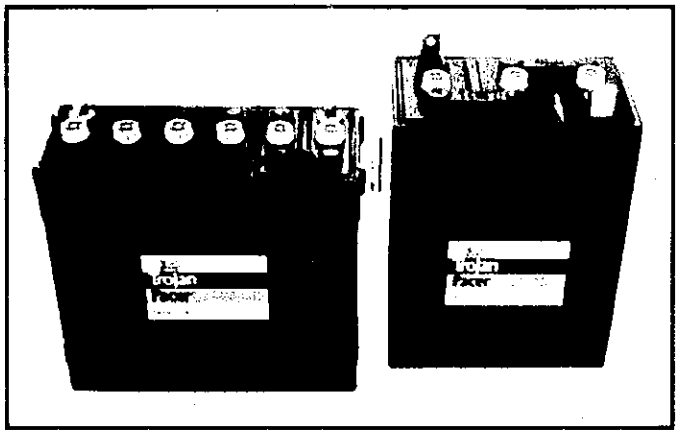

Figure 2.4 Battery

(3) Charge controller

Charge controller is to prevent over charge and over discharge to extend the life of battery. When charging battery, the voltage reaches the upper limit then cut off the current from PV module to prevent over charge and decomposition of water. When discharging, the lower limit voltage is detected, it cuts off the supply of electricity to loads to prevent over discharge and damage of electrode.

Usually charge controller equipped the indicating function like LED to see the state of charge and possible to judge the utilize condition.

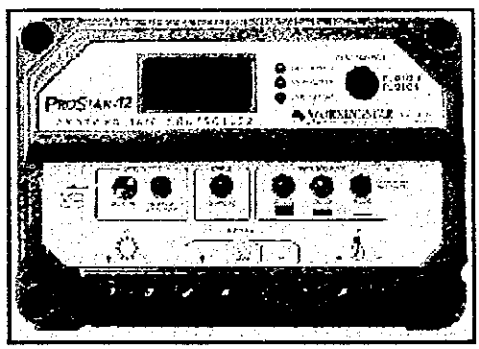

Figure 2.5 Charge Controller

(4) Load appliances

As load appliances for PV system are mainly lighting, radio, radio-cassette and TV (B/W) and most of them should be for direct current use. The supply of electricity is limited then the efficiency of appliances is better to be high.

For lighting, small fluorescent light is popular and recently compact type is become to use. To watch TV, usually black and white TV is possible but recently the request to watch color TV is strengthening but the electricity consumption is large and difficult by small capacity system.

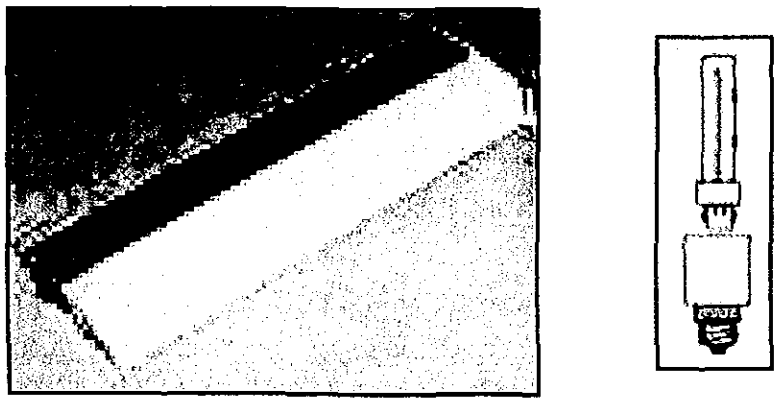

Figure 2.6 Fluorescent lamp

2.3 User Manual

Here is introduced "the user manual" that prepared for the customer of the pilot project. Objective of this manual is to show customers how to use the electricity from the PV system in "Fee for Service." scheme

(1) Introduction

According to the "Fee for Service" method, the service that users receive is served as the compensation of the fee collected by the operator. The operator guarantees providing electricity with SHS as far as the user respects the contract about user's responsibility to maintain the system.

The user is not allowed to touch to any part of the system or to change the wiring without permission of the operator.

(2) Cleaning of PV module

Senegal has only two seasons (dry and rainy season) and small precipitation can be expected (Hot and Semi-Arid climate). Because of this small amount of rainfall, it is rarely expected that the rainfall clean the PV module naturally.

Moreover, objects outside is likely to be covered with sands carried with the wind from Sahara. Considering this situation, the user of SHS in Senegal is strongly recommended to clean the surface of PV module at least once a week in order to maximize the power generation of PV module. The cleaner surface of PV module is, the greater the expected output of PV module is.

The user has to pay attention on the items below when they carry out the cleaning;

- To avoid pulling the wiring when the cleaner climb on the roof for the cleaning.
- To avoid putting the cleaner's weight on the PV module.
- To use soft cloth when the cleaner clean the PV module.

It is more preferable to wash the PV module with enough amount of water, if possible

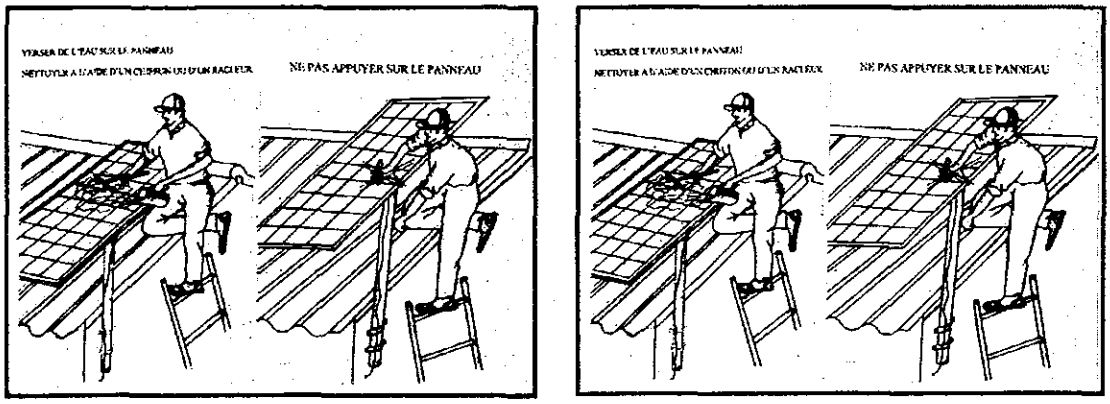

Figure 2.7 Cleaning Instruction of PV Module

(3) Checking the Charge Controller

The user does not need to check inside of the charge controller. All the user have to do is to see the LED color to confirm the charge controller works well or not.

There are 2 LEDs on the charge controller to show the operation status. The upper LED is "Information Display" and the lower one is "State of Charge Display."

When the system works well the information display blinks green. If the LED blinks in another color like yellow or red, the user has to stop use the system and call the local technician.

The state of charge display informs of the battery state of charge. The LED changes its color according to the battery voltage and users can know the state of charge.

GREEN: The battery is full. The system is ready for use.

YELLOW: The battery is losing its capacity. Not necessary to stop using the system but charging is needed.

RED: The battery is empty. The user has to stop using the system until the LED changes its color green.

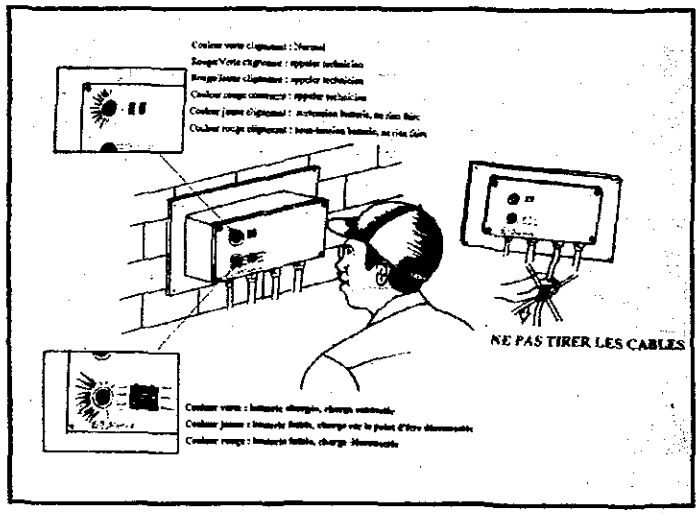

Figure 2.8 The System Status Indication of Charge Controller

(4) Battery Box

The battery emits flammable gas, hydrogen, when it is fully charged. The battery box bears the hole to exhaust the gas produced. The user has to make it sure that there is no flames nearby the box and there is no obstacles on the hole of the box. It is not allowed for

users to touch the battery itself. The local technician keeps the key of battery box to keep away.

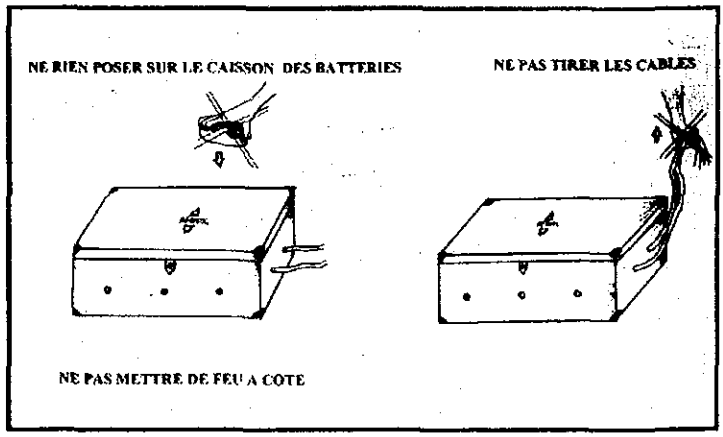

Figure 2.9 Preservation of Battery Box

(5) How to Change the Bulb of Lamps

The bulb of lamps is out of service for the fee. Users need to change bulbs by their own expense when the bulb has broken.

1) Fluorescent Lamp

The cover needs to be removed pinching top and bottom together to unlock the cover when users want to change the bulb. Twist and pull the dead bulb to remove it from the body. Insert the new bulb in the reverse way. Make it sure to fix the cover again after the replacement of bulbs.

2) LED amp

The bulb of LED lamp is screwed into the socket. When users want to remove the dead bulb, they need to screw it out turning anticlockwise. Then, screw the new bulb into the socket.

Although the socket of LED lamp is compatible with that of incandescent lamp, incandescent bulbs are not allowed to use with the socket of LED lamps to prevent inefficient energy consumption of the system.

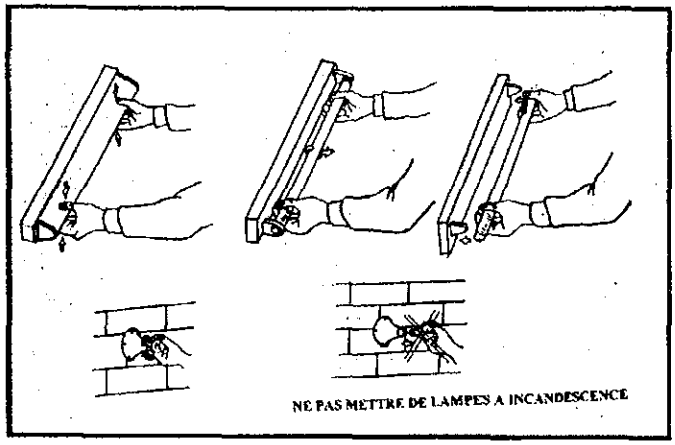

Figure 2.10 Introduction of Replacement of Bulbs

(6) Outlets for TV and Radio

Outlets for TV and Radio have special shape to avoid adapting the adaptor in reverse polarity. The supplier provides the adaptor. All users who want to use radio and TV must ask the local technician to make wiring for the adaptor.

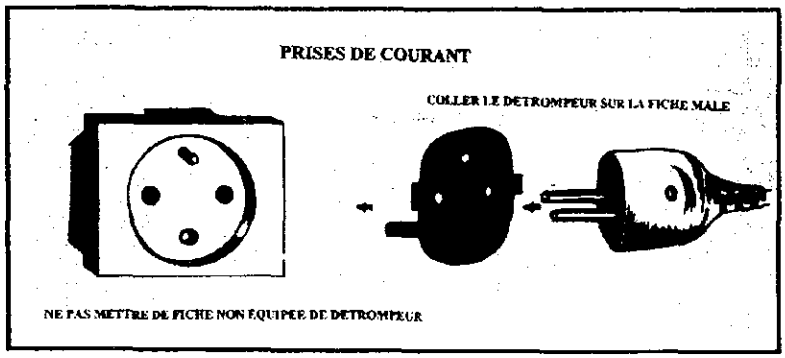

Figure 2.11 Instruction of Polarity of Socket for TV and Radio

(7) Energy Management by Users

Because the amount of energy supplied to users is limited in SHS, the users need to learn how the system behaves in what kind of usage in order to recognize effective energy management.

The system of the pilot project is expected to supply 180 Wh/day. This means that the user can watch TV of 30W for 6 hours. Instead, any other appliance other than TV won't be available during the same period. To use TV and lamps at the same time, the user has to

control the time of watching TV. For example, if TV of 30W is on for 3 hours, the rest of available energy will be 90 Wh. If the user uses an 8-W lamp, the lamp will be available for about 11 hours. If the user uses five 8-W lamps, each lamp will be available for about 2 hours.

User should remind that 180W/day could charge only on sunny days, cloudy days and rainy days the generated electricity will be reduced. But battery stores around for three days use without any additional charge. If battery discharge more than that, controller cut the supply of electricity to the load until enough electricity charged from PV module in sunny days.

Here is shown a model of usage.

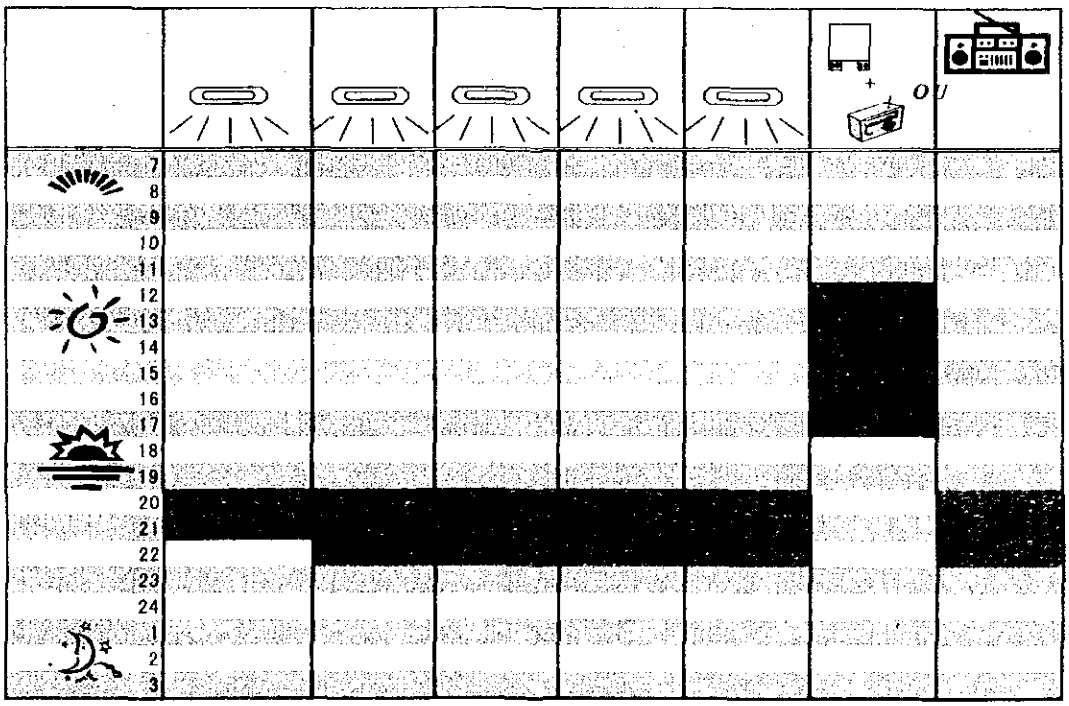

Figure 2.12 Sample of Usage, Type 1

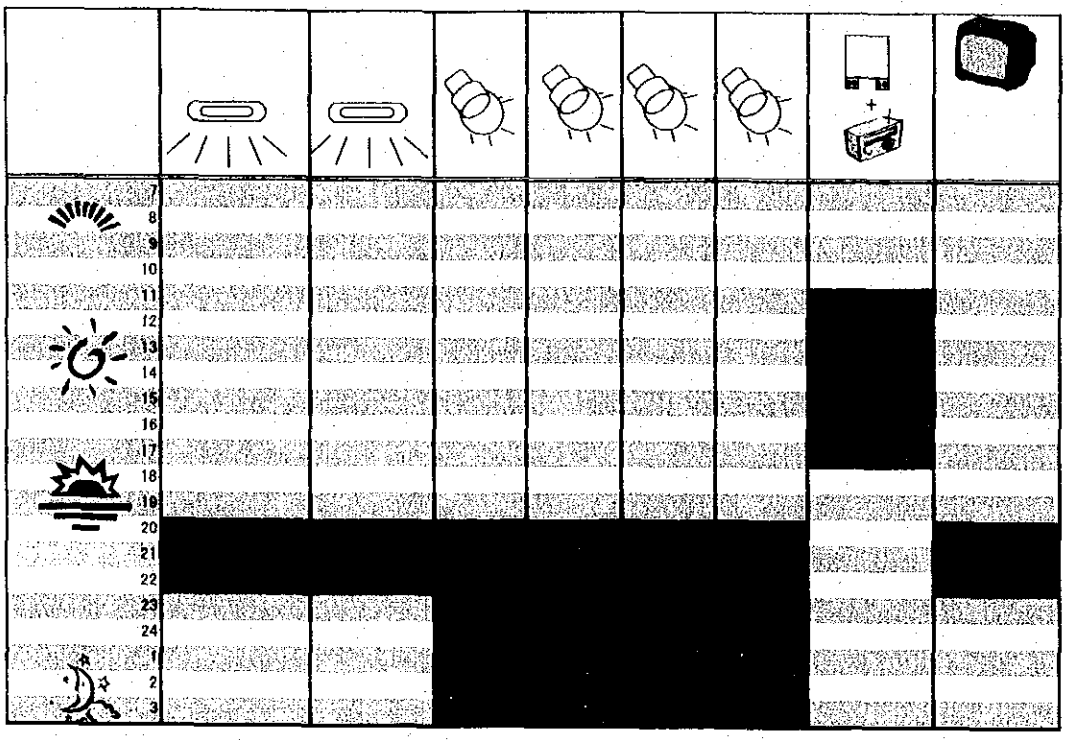

Figure 2.13 Sample of Usage, Type 3