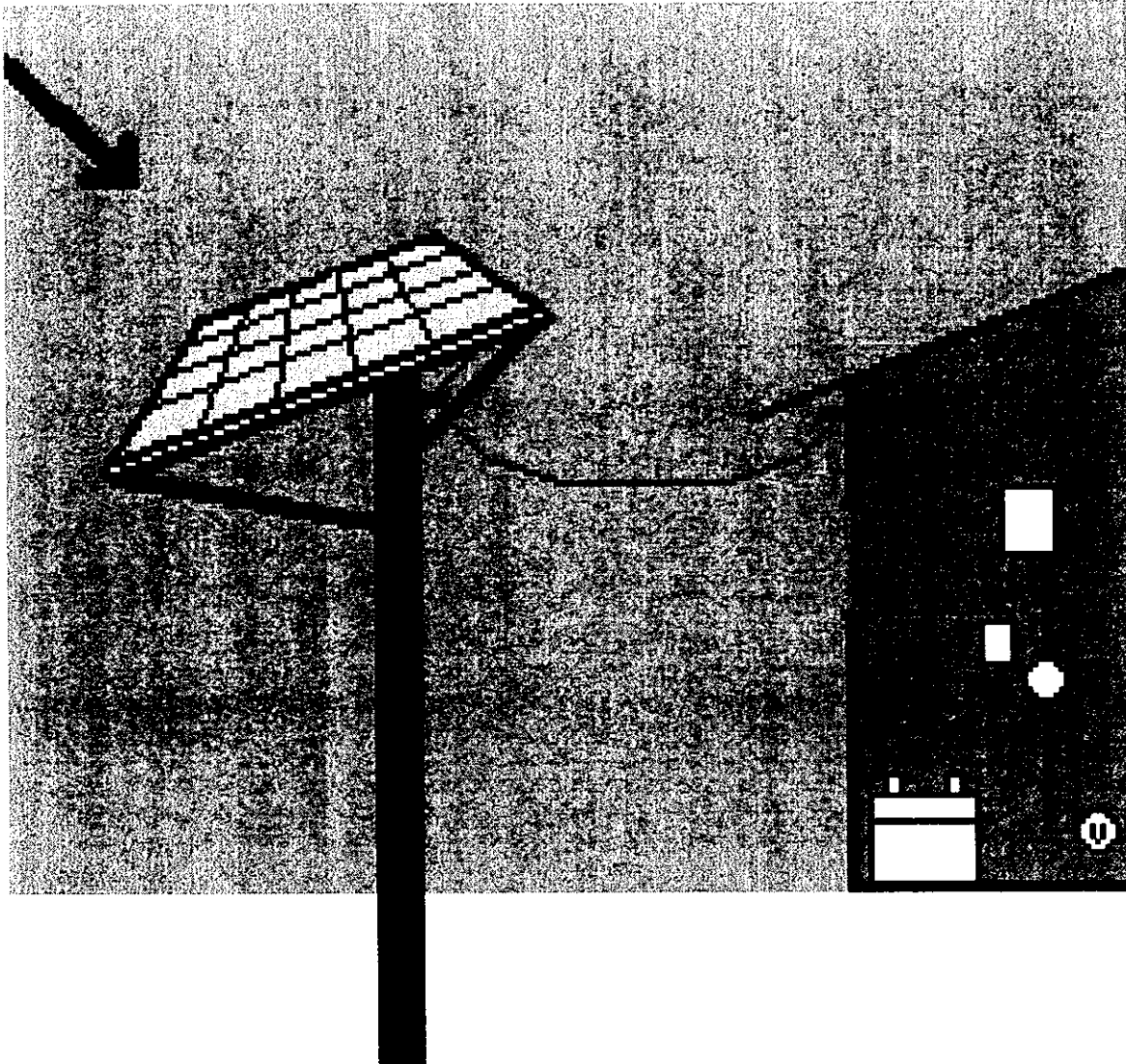
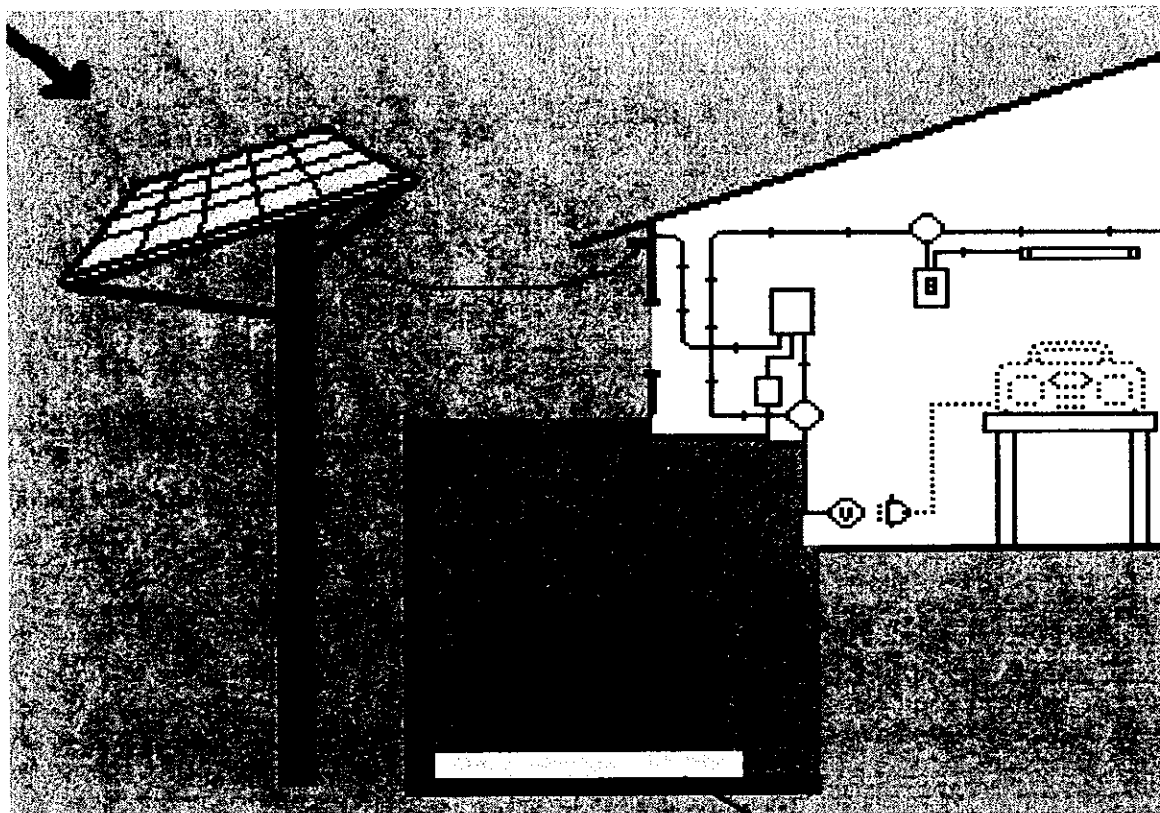


## **Solar Panel = Photovoltaic**



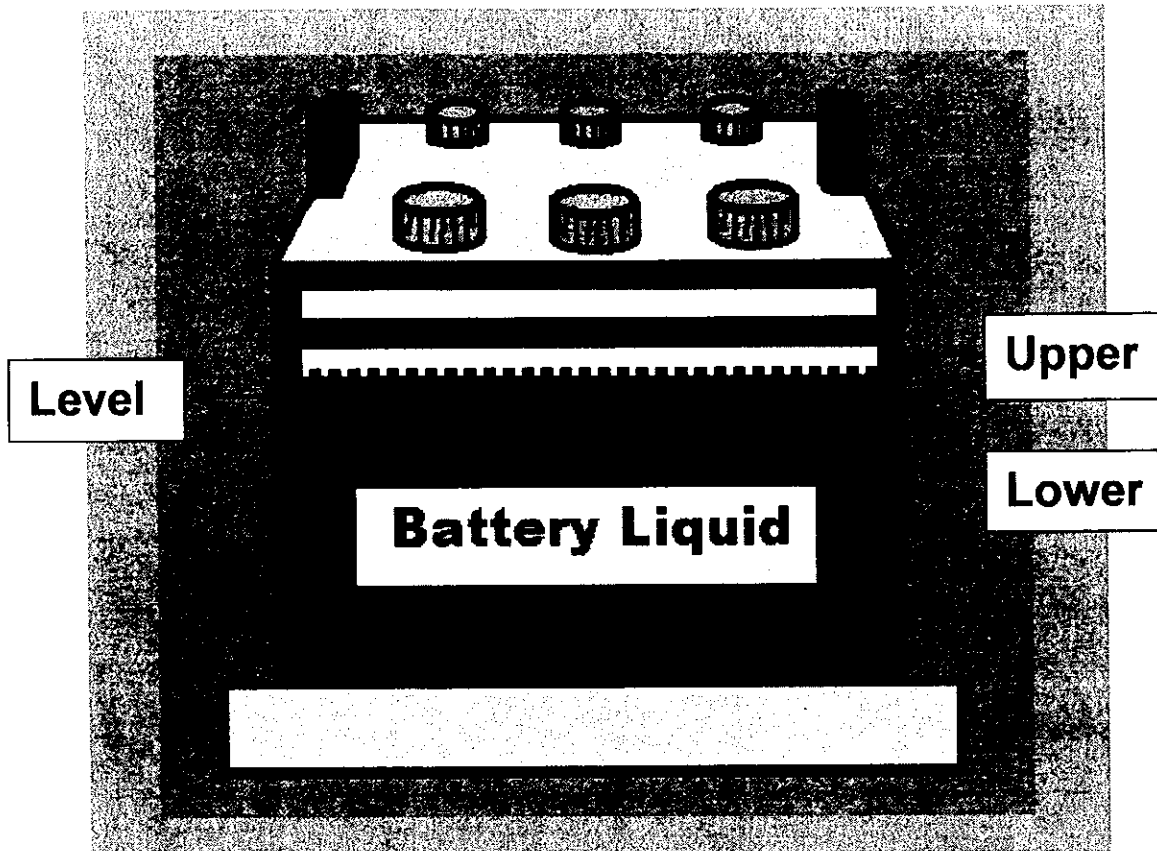
- 1. Do not remove the panel**
- 2. Do not throw stones at the Panel**
- 3. Do not hang anything on the cable**

# Battery



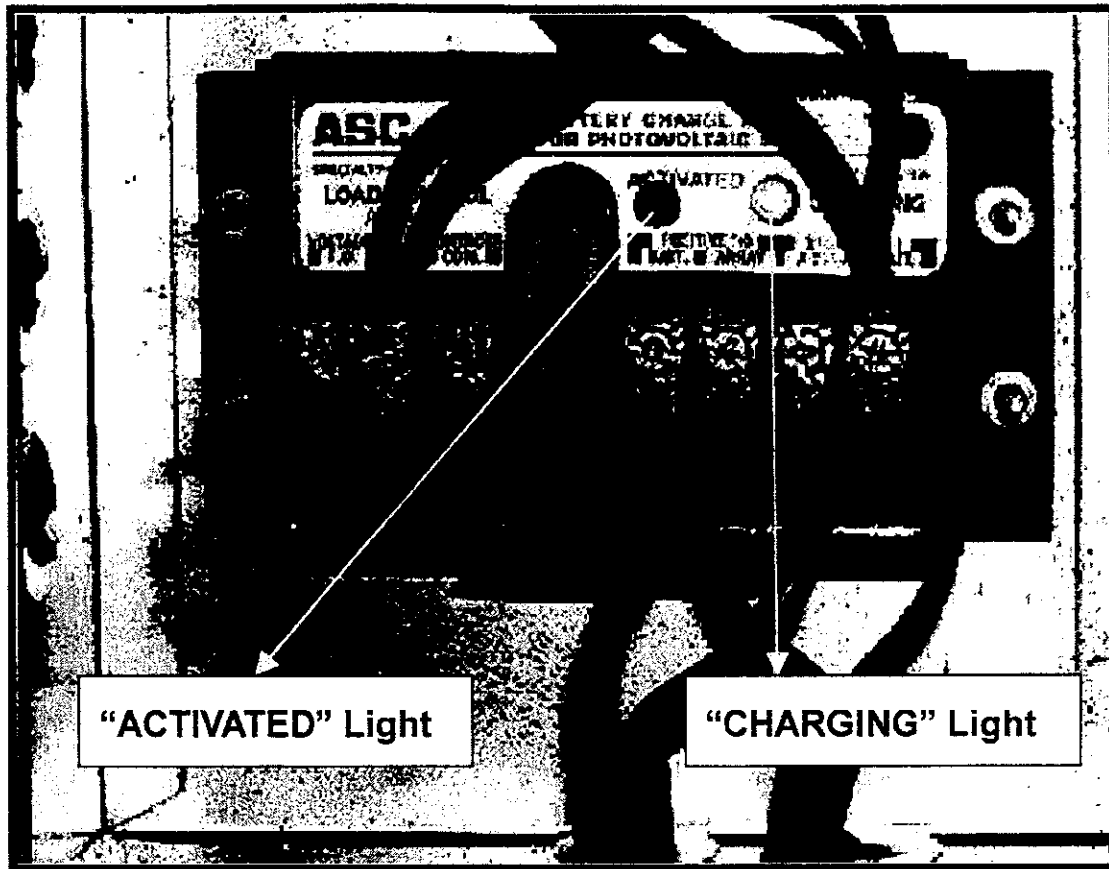
- 1. Put the Battery on flat base (wood or brick)**
- 2. Battery contains harmful acid liquid**
  - **Open the window above the battery**
  - **Never let children close to the battery**
  - **Never keep livestock in the room**
- 3. Do not touch nor move battery**
- 4. Do not put anything on the battery**
- 5. Do not put fire nor heat near the battery**
- 6. Do not use the battery for other purposes**

## Battery Check



1. Check the level of electrolyte on the vessel
  - The level should be between two lines
2. If the level is under lower line, stop using the Power and ask Operators to fill distilled water.

# Controller



## 1. CHARGING Light

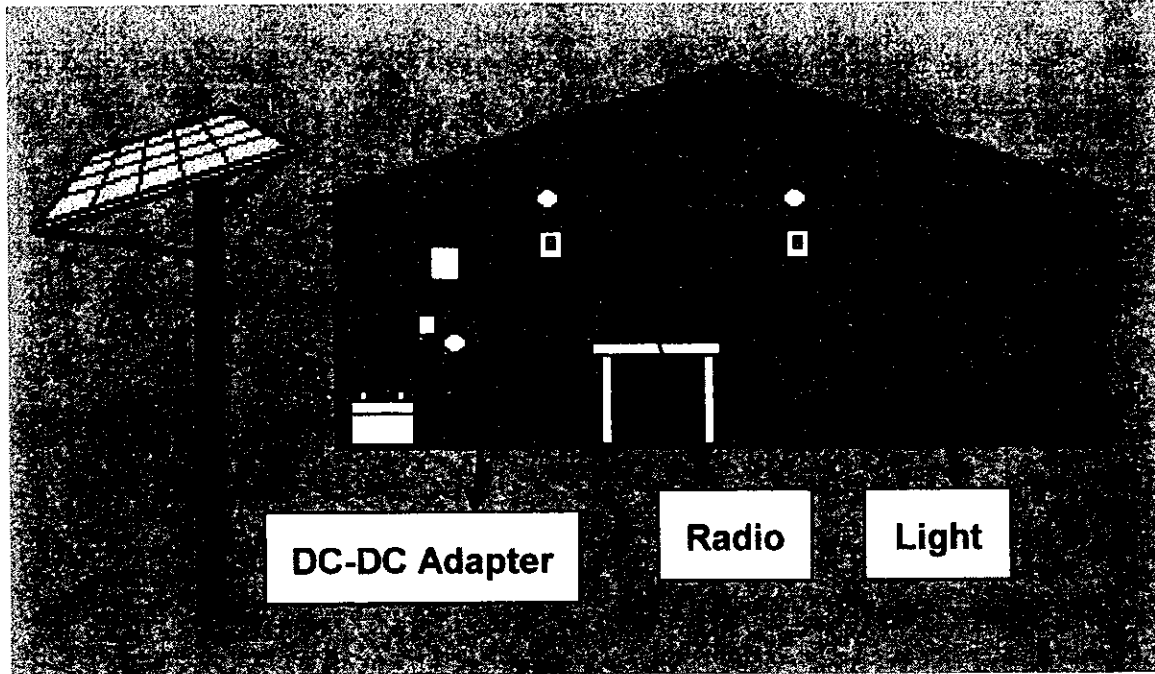
**ON : The battery is charging**

## 2. ACTIVATED Light

**ON : The battery is at a Low Voltage**

**: User can not use ANY LOAD at all.**

## Load

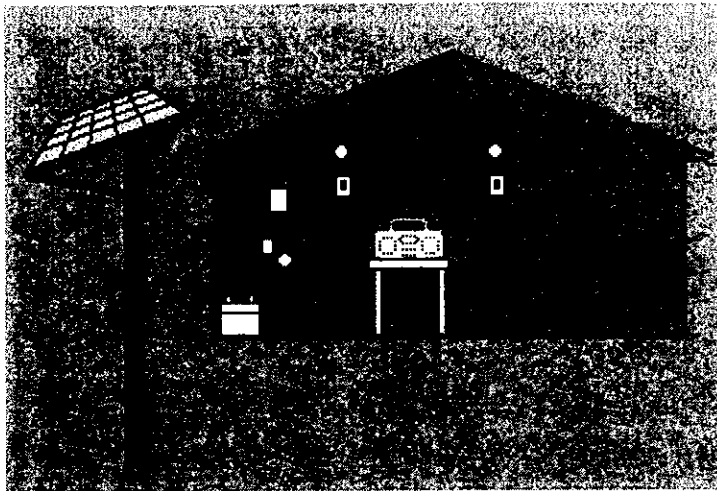


**Loads must be 12V / DC. Not 240V / AC**

**Connect plug properly :  
Use supplied plug & DC-DC Adapter only**

- 1. Bulbs to be clean**
- 2. Broken bulbs to be replaced**
- 3. In case of replacement of the lights and purchase of Radio / TV, ask Operator's advices for specification to purchase**

# Load Pattern



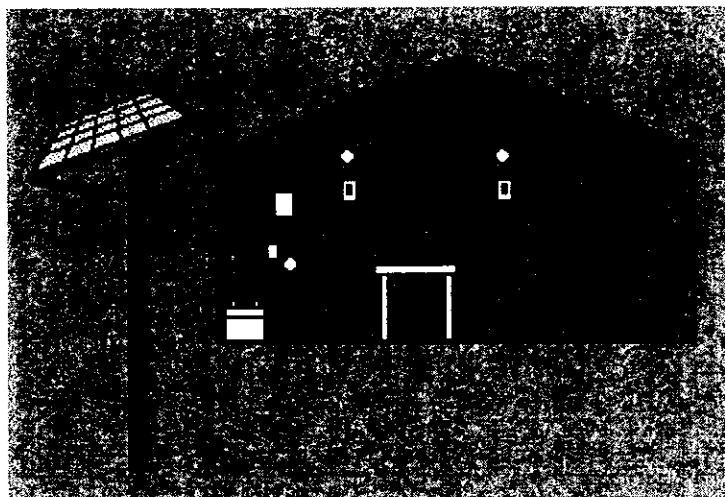
## Light

### Daily Use

One Light : 7 hours

Two Lights : 4 + 3 hours

Tree Lights : 3+2+2 hours

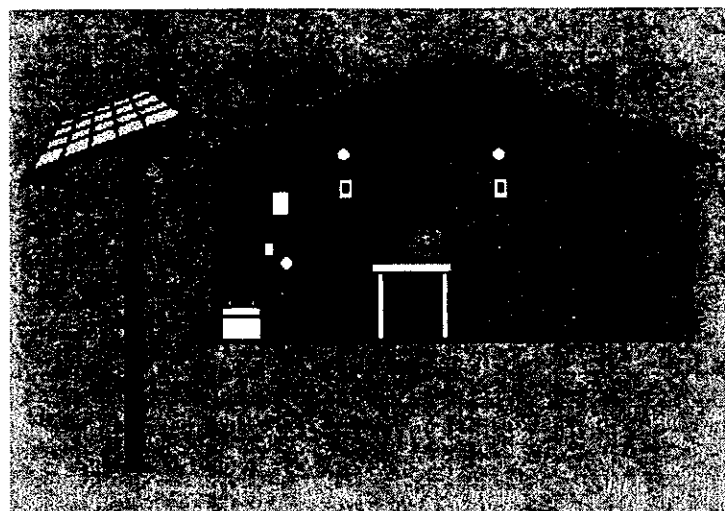


## Light + Radio

### Daily Use

Two Lights : 3 + 2 hours

Radio : 2 hours



## Light + B/W TV

### Daily Use

Two Lights : 3 + 2 hours

B/W TV : 1 hour

## General Rule for Users

- Careful & Appropriate Manners for daily use
- Payment duty
  - Initial payment Bs 700 / Total
  - Monthly charge Bs 22 or 30/ Month

### Do

- Keep using PV System all the year in the same level of use (Battery must be charged constantly)
- Observe liquid level on the battery indication
- Keep the hours in use along to the following table

LIGHT : 15 W  
 RADIO : 15 W / Max. 2 hrs  
 BW TV: 20 W / Max. 1 hr.

**Pattern of Loads Use**

LOADS USE	LIGHTS			LIGHT+RADIO	LIGHT+TV
	ONE	TWO	THREE		
POWER (W)	15	15+15	15+15+15	15+15+15	15+15+20
USE (hours)	7	4+3	3+2+2	3+2+2	3+2+1
TOTAL (Wh)	105	105	105	105	95

- Using loads too much may cause inconvenience of load disconnected by controller at any time.
- Report the trouble to Technical staff and Chief of Community to inform to Operator

## **Do not**

- Do not touch and move anything except lights and switches
- Do not let children go closer to the battery
- Do not touch anything especially in case of trouble
- Do not come close to any part of the total system in case of the thunder lighting

## **Punishment**

- To remove the PV System in case of inappropriate Use

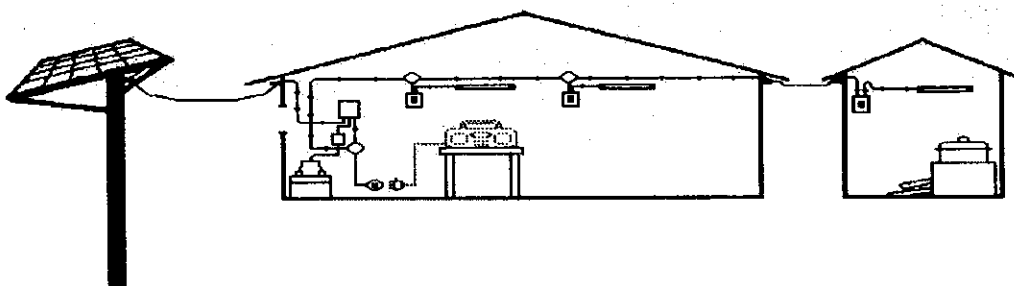
## **System Transfer**

- The system to be removed on the Prefecture's responsibility with Grid line connected



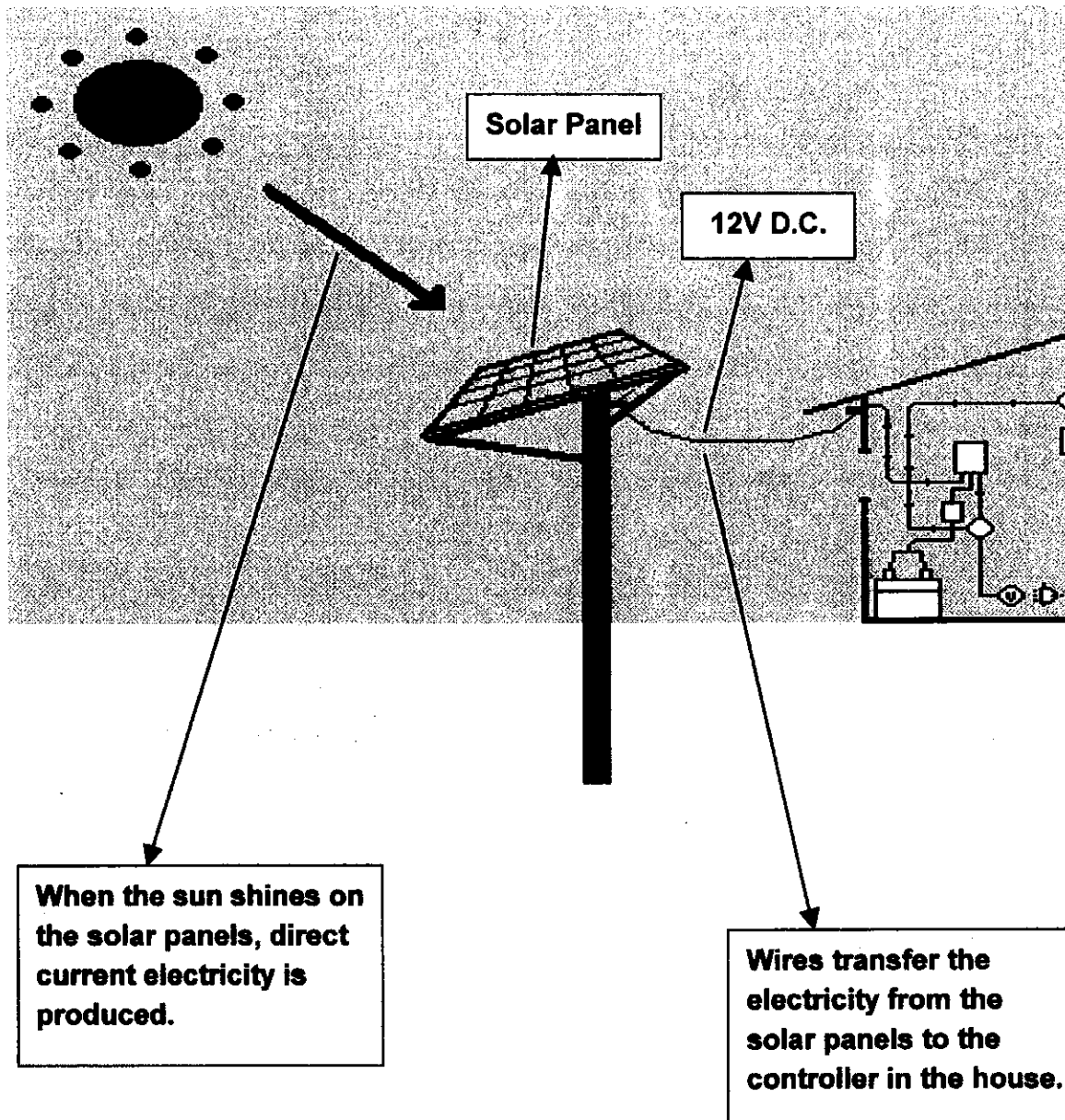
**JAPAN INTERNATIONAL COOPERATION AGENCY**  
**THE STUDY**  
**ON**  
**RURAL ELECTRIFICATION IMPLEMENTATION**  
**PLAN BY RENEWABLE ENERGY**  
**IN**  
**THE REPUBLIC OF BOLIVIA**

**Maintenance Manual**  
**for**  
**Solar Home System**

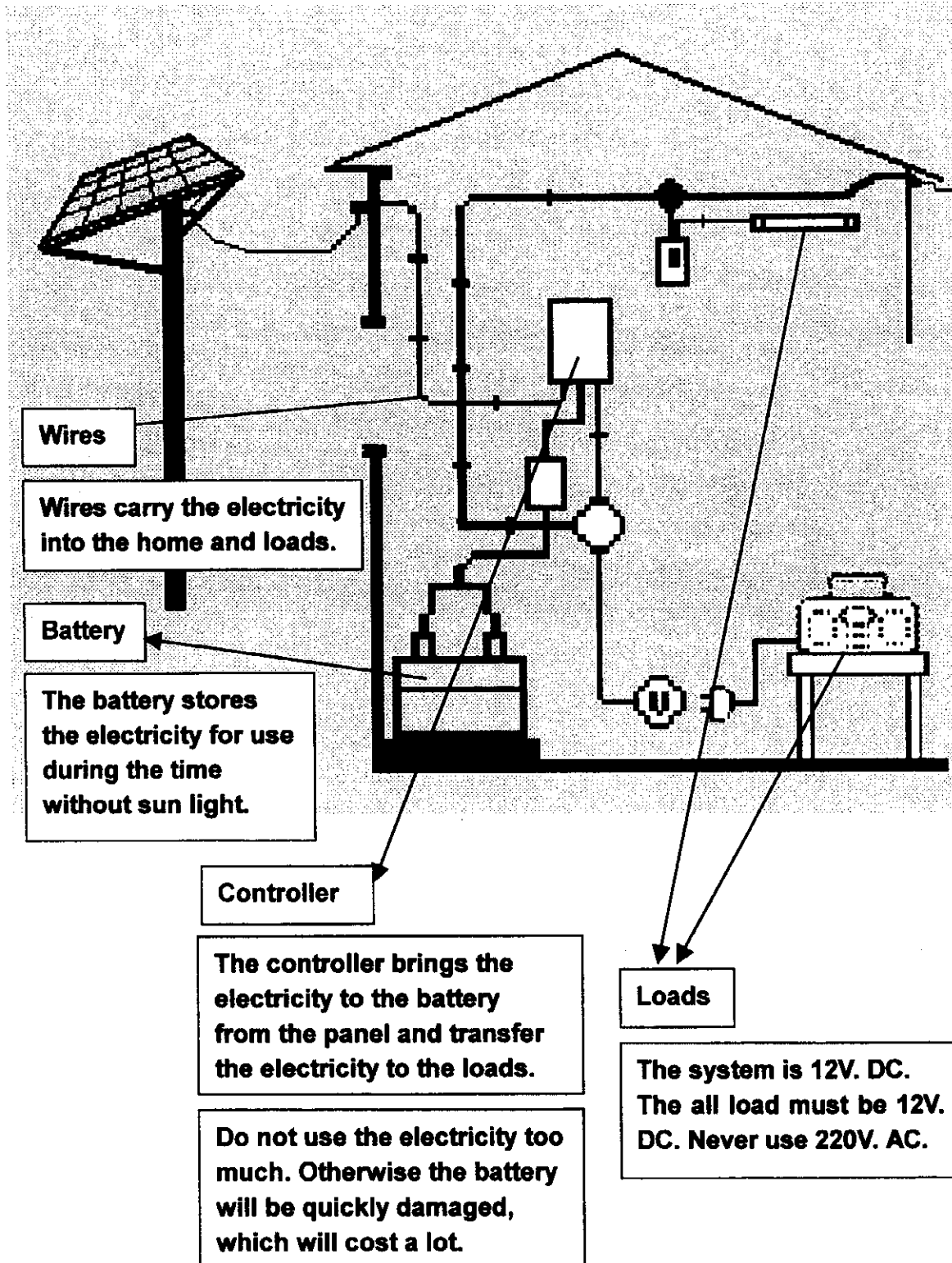


Revised on June 10th 2000

# Solar Electric Power



# Functions of main appliances



# Maintenance Schedule

## Weekly : By Users

- Observe battery water level

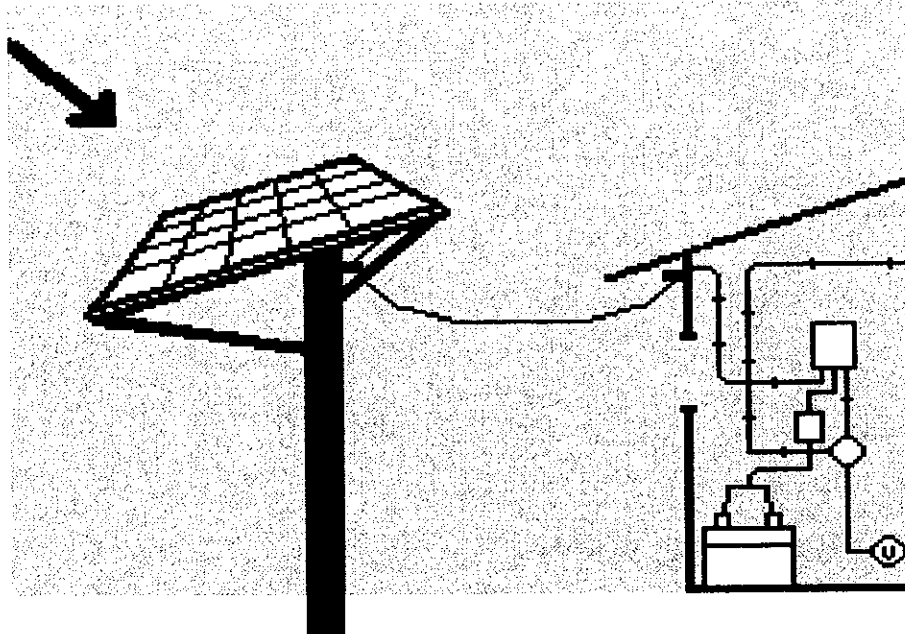
## Monthly :

- Wipe bulbs with dry cloth
- Inspect panel for broken
- Wash panel surface
- Check and add water to the battery electrolyte
- Wipe top of battery
- Equalize batteries in case that Specific Gravity difference seen between cells
- Inspect controller for proper light indication

## Annually :

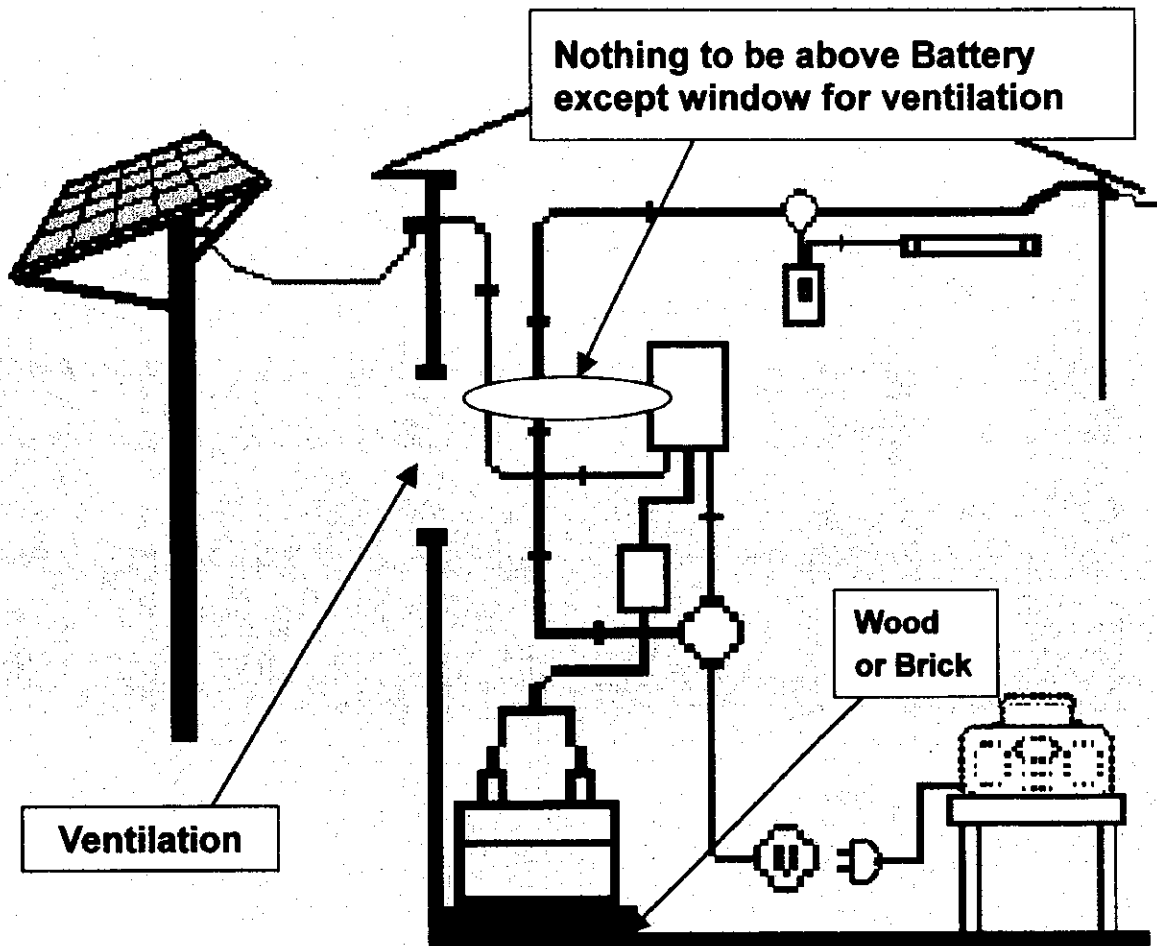
- Check array wiring for physical damage, mounting hardware for tightness
- Inspect wiring for poor connections
- Inspect battery terminals for corrosion. Clean and put grease as needed

## Solar Panel

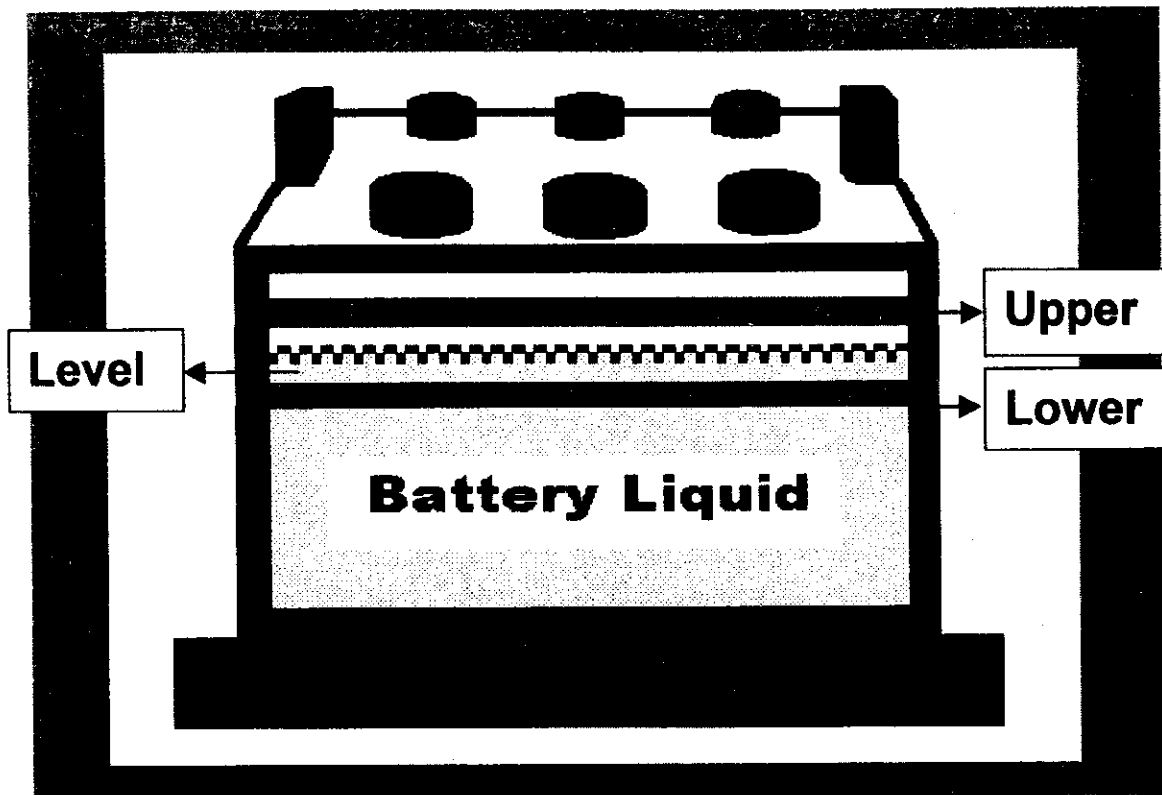


1. Check the glass on the PV is not broken
2. Wash module surface as needed using soft cloth and pure water
  - Clean in early morning or evening when the sun is below the horizon
3. Check that all bolts are secure and that the structure is well attached to pole
4. Examine all wiring connection for corrosion or looseness
  - Clean and tighten
5. Check that junction boxes are covered
6. Inspect module for cells condition

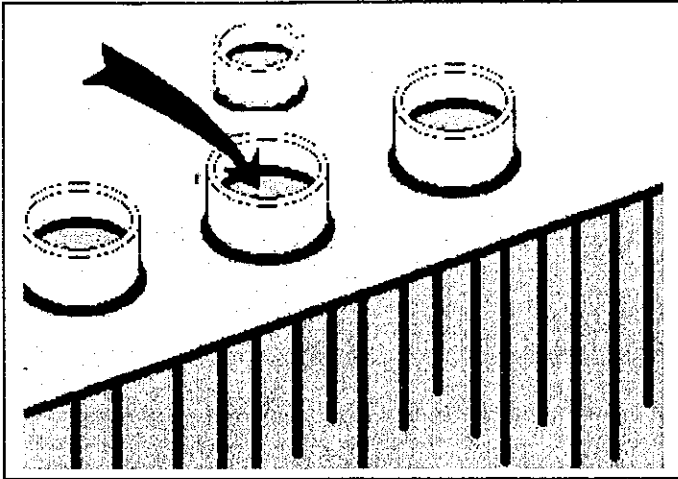
# Battery



1. Check the base to be under the battery. If not, tell and assist users to fix wood or brick
2. Make sure nothing to be above the battery
3. Check the ventilation function above the battery



- 4. Check the level of electrolyte**
  - The level should be between two lines
  - Switch off all load in case of the level below the low line
- 5. Inspect terminals for corrosion and loosened cable connections**
- 6. Clean and tighten as necessary**



#### **Caution**

- Do not get liquid on clothes, skin or eyes
- Wash any exposed skin or eyes with water for at least 10 minutes and see a doctor
- Do not wear metallic jewelry
- Do not sparks
- Do not bring burning materials (including cigarettes)

#### **7. Check battery every month**

- Select a calm day to prevent dust getting into battery
- Time is late morning on a sunny day

#### **8. Battery must be serviced only after charging and the acid inside is bubbling**

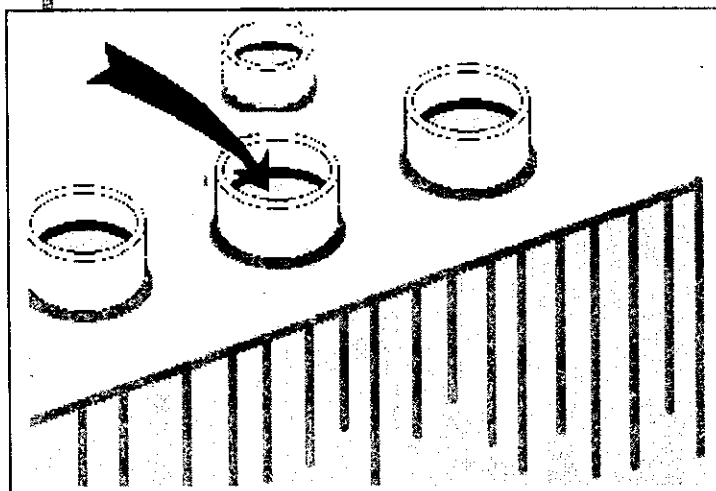
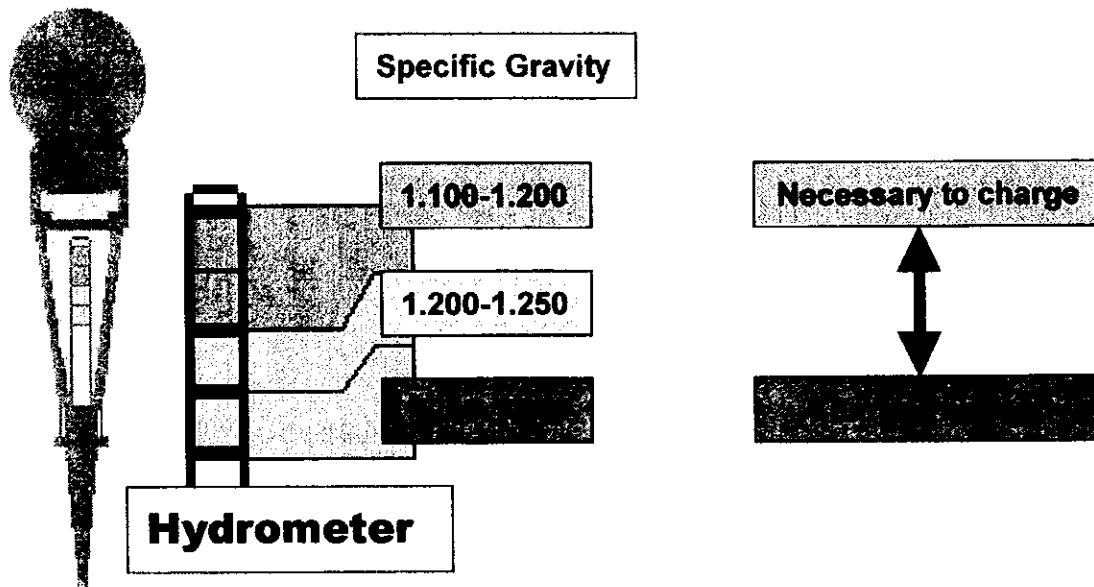
- Wear gloves & eye protector
- Turn off breaker
- Carefully remove battery cap

#### **9. Add the distilled water to the cells as needed**

- Filling up to the inside ring marked in red above
- Use distilled water only
- Replace battery cap

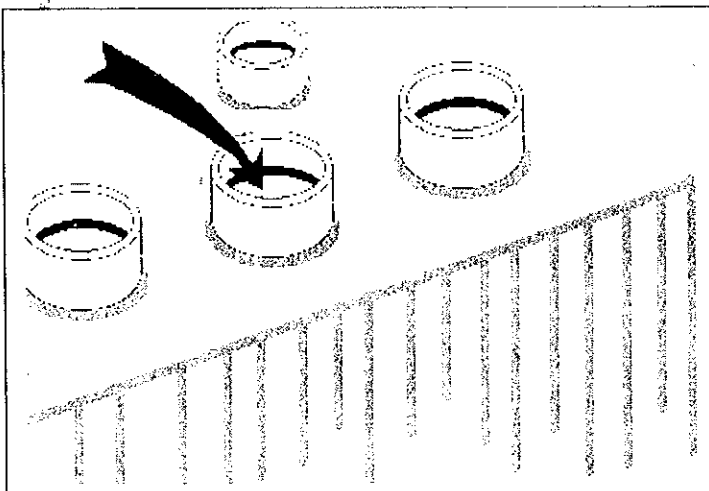
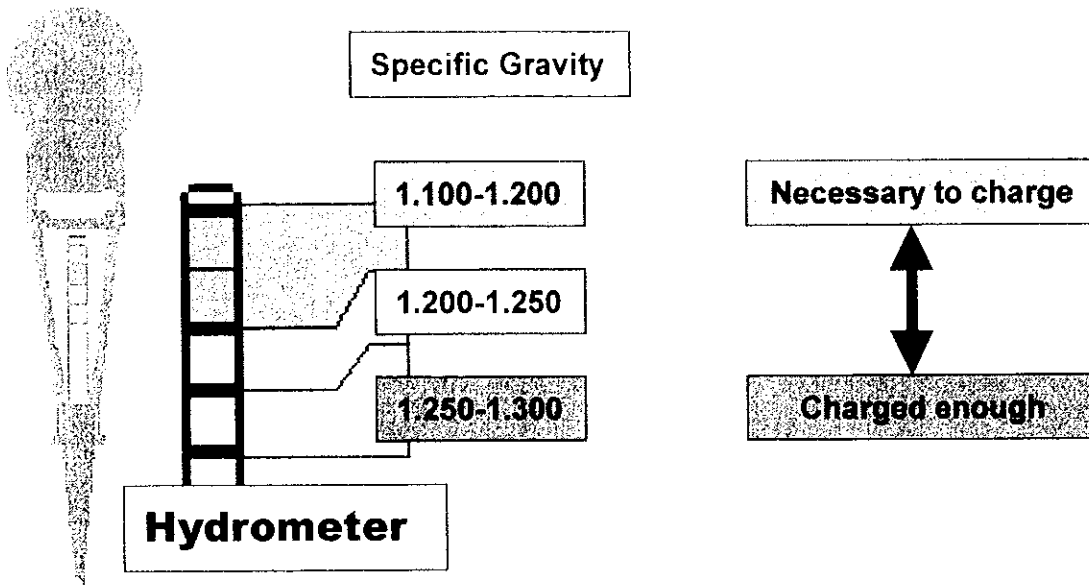
#### **10. After filling the water anti-oxidant grease to expose wire and terminals**





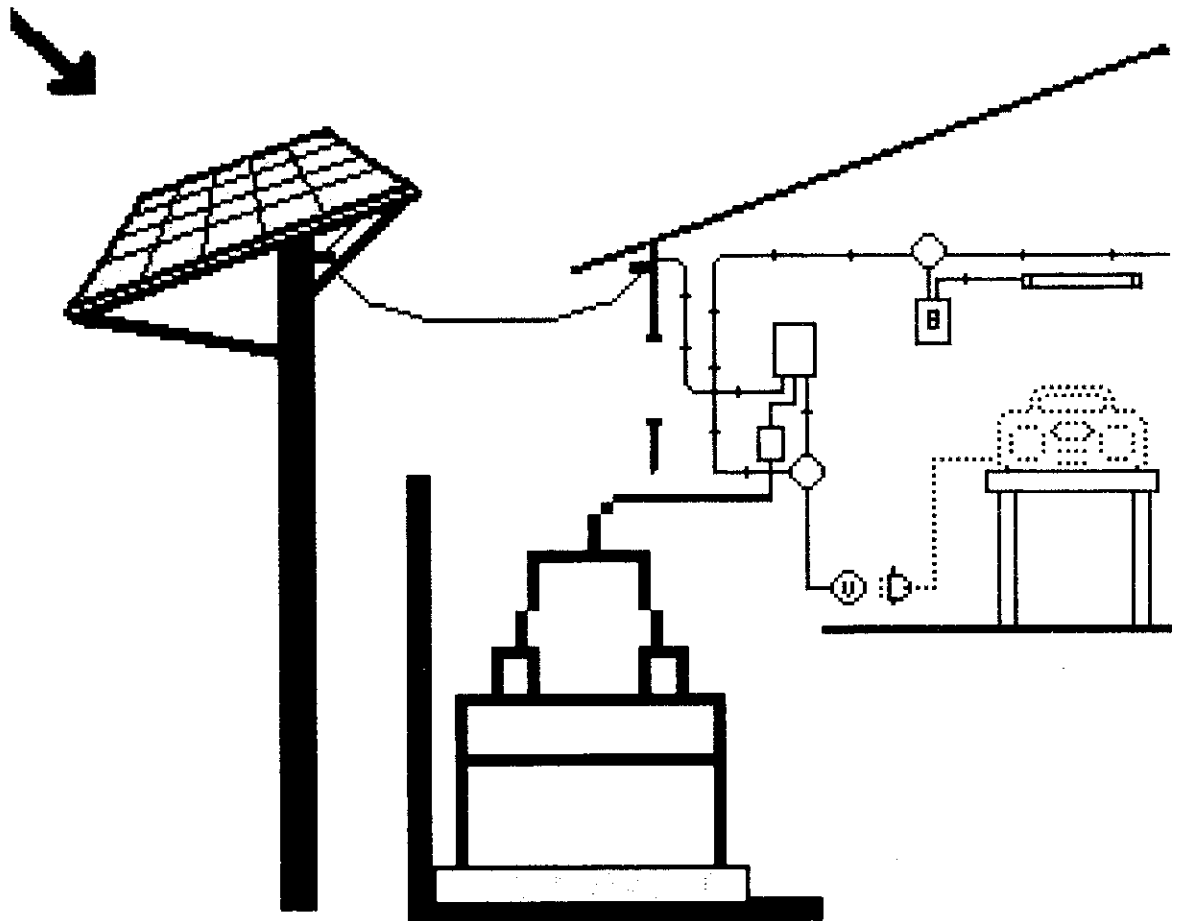
**11. Measure specific gravity of all cells using hydrometer**

- **Specific Gravity**  
1.100-1.200 : Necessary to charged
- **Specific Gravity**  
1.250-1.300 : Charged enough
- **Equalize batteries in case that Specific Gravity difference seen between cells**



**11. Measure specific gravity of all cells using hydrometer**

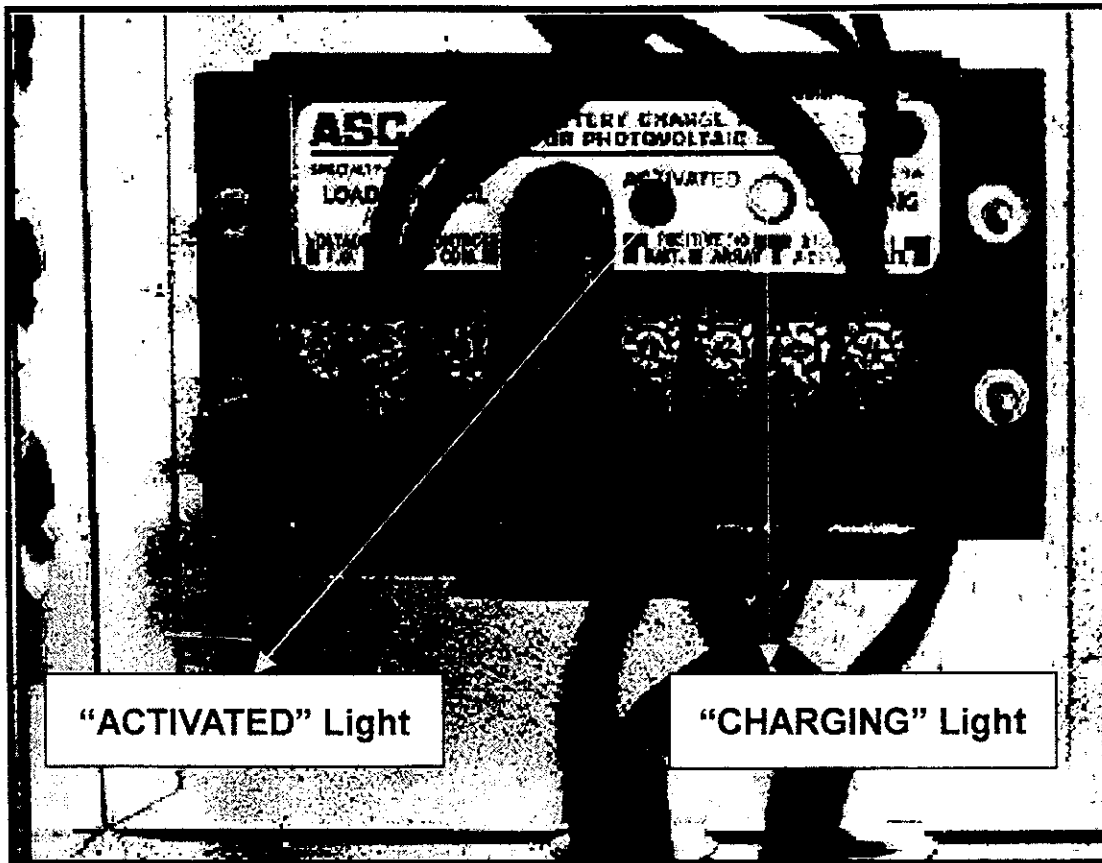
- **Specific Gravity**  
1.100-1.200 : Necessary to charged
- **Specific Gravity**  
1.250-1.300 : Charged enough
- **Equalize batteries in case that Specific Gravity difference seen between cells**



## 12. Check followings

- Never let children close to the battery
- Never keep livestock in the room
- Do not move battery
- Do not put anything on the battery
- Do not put fire nor heat near the battery
- Do not use the battery for other purposes

# Controller



## 1. CHARGING Light

**ON :** The battery is charging

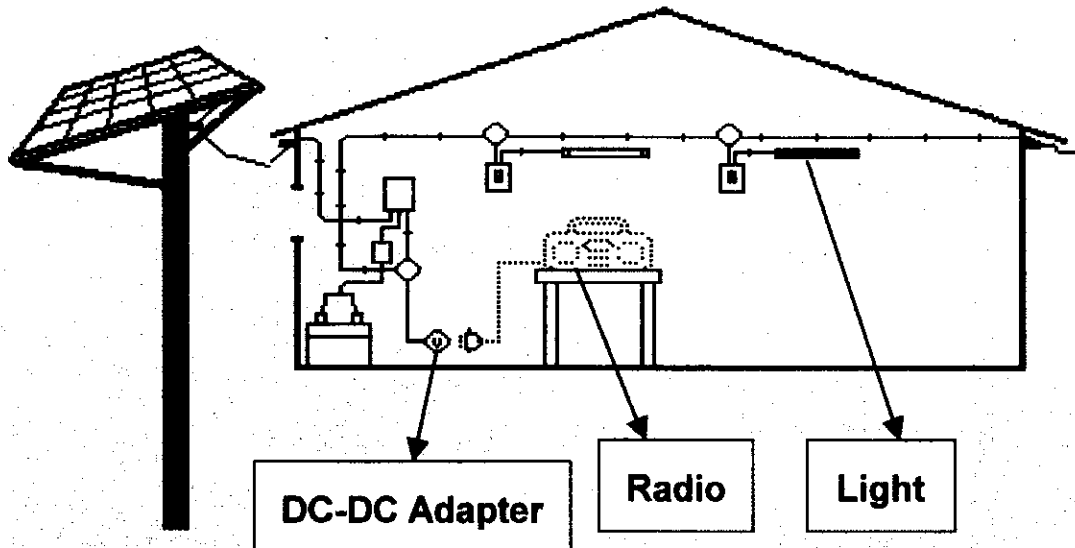
**Check the battery is charging**

## 2. ACTIVATED Light

**ON :** The battery is at a Low Voltage

**: Users can not use ANY LOAD at all**

## Load



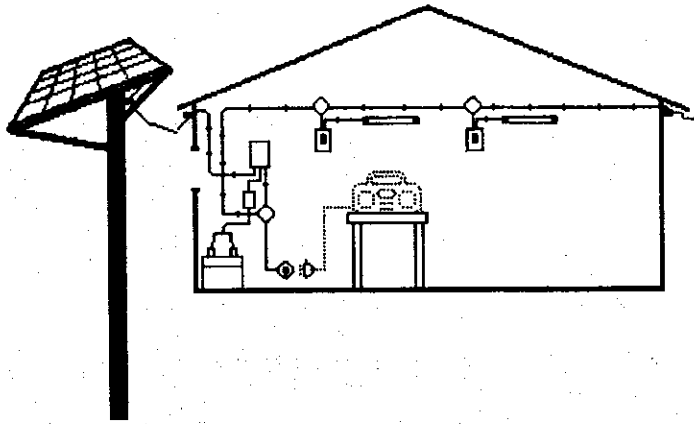
**Loads must be 12V / DC. Not 240V / AC**

**Connect plug properly :**

**Use supplied plug & DC-DC Adapter only**

- 1. Bulbs to be clean**
- 2. Broken bulbs to be replaced**
- 3. In case of replacement of the lights and purchase of Radio / TV, ask Operator's advices for specification to purchase**

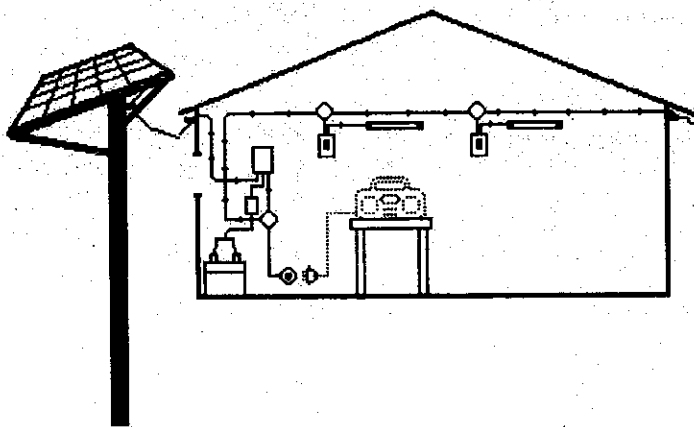
# Load Pattern ( Recommendation to users )



## Light

### Daily Use

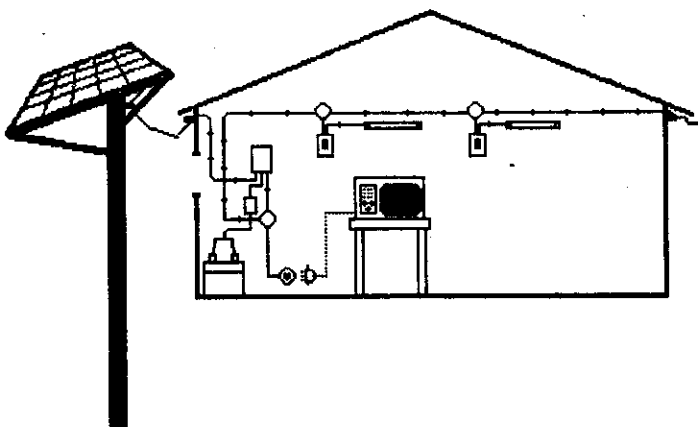
- One Light : 7 hours
- Two Lights : 4 + 3 hours
- Tree Lights : 3+2+2 hours



## Light + Radio

### Daily Use

- Two Lights : 3 + 2 hours
- Radio : 2 hours



## Light + B/W TV

### Daily Use

- Two Lights : 3 + 2 hours
- B/W TV : 1 hour

# Wiring & Fixtures

## Checking Points

- All appliances remain as the original
- Wiring connection for corrosion
- Wiring connection fastened tight
- Wire covering in normal
- Breakers function
- Switch function

## To be done

- Remove
- Clean
- Fasten
- Taping
- Repair or Replace
- Repair or Replace

## General Rule for Users

- Careful & Appropriate Manners for daily use
- Payment duty
  - Initial payment Bs 700 / Total
  - Monthly charge Bs 22 or 30/ Month

## Do

- Keep using PV System all the year in the same level of use (Battery must be charged constantly)
- Observe liquid level on the battery indication
- Keep the hours in use along to the following table

LIGHT : 15 W  
 RADIO : 15 W / Max. 2 hrs  
 B/W TV: 20 W / Max. 1 hr.

### Pattern of Loads Use

LOADS USE	LIGHTS			LIGHT+RADIO	LIGHT+TV
	ONE	TWO	THREE		
POWER (W)	15	15+15	15+15+15	15+15+15	15+15+20
USE (hours)	7	4+3	3+2+2	3+2+2	3+2+1
TOTAL (Wh)	105	105	105	105	95



- Using loads too much may cause inconvenience of load disconnected by controller at any time.
- Report the trouble to Technical staff and Chief of Community to inform to Operator

## **Do not**

- Do not touch and move anything except lights and switches
- Do not let children go closer to the battery
- Do not touch anything especially in case of trouble
- Do not come close to any part of the total system in case of the thunder lighting

## **Punishment**

- To remove the PV System in case of inappropriate Use

## **System Transfer**

- The system to be removed on the Prefecture's responsibility with Grid line connected

**PV SYSTEM SERVICE CONTRACT**

**INITIAL PAYMENT**

**RESIDENTIAL CATEGORY**

Let it be clearly understood by the present Private contract that with the simple signature reconnaissance it will be able to be raised to public instrument and is subscribed between **PREFECTURA DE LA PAZ** represented by \_\_\_\_\_, who from this point will be called simply "**PREFECTURE**" and the subscriber Sr. \_\_\_\_\_ who from this point will be called "**USER**" declare and agree the following:

**FIRST.** - General Conditions of Equipment Supply. -

**PREFECTURE** will provide PV panel, pole and holder of PV panel, charge controller, battery, cable and related fixtures, which belong to the "**PREFECTURE**", the maintenance for this equipment will be of the "**ADMINISTRATOR**" responsibility, "**PREFECTURE**" will also provide with three fluorescent lamps, cable and fixtures to be set inside the house, for which the "**USER**" will pay an "**INITIAL PAYMENT**" of Bs. 700

The items to be paid (three fluorescent lamps, cable and fixtures inside the house), belong to the "**USER**", and the care and maintenance of them are his responsibility.

**SECOND.** - Payment conditions.-

Payment of Bs. 700 will be done by the "**USER**" to the "**PREFECTURE**", according to the following schedule:

First Payment	on April 30, 2000	Bs. ....
Second Payment	on December 30, 2000	Bs.....
Third Payment	on April 30, 2001	Bs. ....

**THIRD** - Technical Assistance. -

The 55W Siemens SM55 PV System, Polarized Cable #10, the ASC Charge Regulator for PV Systems and the TOYO Battery will all be of entire responsibility of the "**ADMINISTRATOR**" regarding its maintenance. The "**USER**" will be responsible for the internal installations and must comply with the technical recommendations established by the "**ADMINISTRATOR**".

**FOURTH.** - Payment method. -

The "**INITIAL PAYMENT**" will be carried out in national currency at the "**PREFECTURE**" office or at the account available for such purpose.

**FIFTH.** -Responsibilities. -

The "**ADMINISTRATOR**" will not assume any responsibility for the internal installations of the "**USER**", and if the "**USER**" performs alterations or defective connections that can cause harm to the equipment that is responsibility of the "**ADMINISTRATOR**" he will be able to remove the equipment definitely from the household and will impose fines and sanctions established according to the law.

**SIXTH.** - Payment delay. -

If the "**USER**" doesn't pay, within 30 days of date, it will be in Delay without requirement by part of the "**ADMINISTRATOR**" and he will suspend the electrical energy supply without notice, removing at once the installations with all its accessories, which will remain to the disposition of the "**ADMINISTRATOR**" to be installed in other household that can comply with the acquired obligations, and will be able to initiate legal action for the debt, by the coercive way.

**SEVENTH.** - Validity. -

The present contract will come into force from the subscription date, being the "**USER**" able to demand the cancellation of the contract with an official notice to the "**PREFECTURE**" with at least one month of anticipation, leaving the "**PREFECTURE**" free of the obligation to reestablish the service again.

**EIGHTH** -Acceptation. -

As a signal of acceptance of all the clauses stipulated in this contract; we sign as the representatives authorized from the "PREFECTURE" and the "USER".

**Prov. Aroma Dpto. La Paz, September 14, 1999**

**EMPRESA DE LUZ Y FUERZA AROMA  
PV SYSTEM SERVICE CONTRACT**

User..... Tariff.....RESIDENTIAL ACCOUNT.....  
ID..... Telephone.....  
Address.....

.....RESIDENTIAL.....  
Energy Usage

.....  
"USER"

.....  
**PREFECTURE REPRESENTATIVE**

**PV SYSTEM SERVICE CONTRACT**

**POWER TARIFF**

**RESIDENTIAL CATEGORY**

Let it be clearly understood by the present Private contract that with the simple signature reconnaissance it will be able to be raised to public instrument and is subscribed between **EMPRESA DE LUZ Y FUERZA AROMA S.A.** represented by its General Manager Ing. Lutgardo Alvarez Garay, who from this point will be called simply "**ADMINISTRATOR**" and the subscriber Sr. \_\_\_\_\_ who from this point will be called "**USER**" declare and agree the following:

**FIRST.** - General Conditions of Energy Supply. -

The "**ADMINISTRATOR**" will take care of all maintenance works on the PV system that supplies electrical energy at the "**USER**" point of consumption, which is enabled for such purpose. The energy supply will be 12V continuous current.

The energy supply will be continuous, except when power down occurs for reasons beyond of the "**ADMINISTRATOR**'s" control, or when the "**ADMINISTRATOR**" considers that it is necessary to perform operations, maintenance or replacements in the installations.

The Power that is available to the "**USER**" is limited to three 15W lamps, one power outlet for a TV and/or radio, having the user to economize the energy when it is unnecessary. Before connecting any additional load to the PV System, the "**USER**" will have to consult the "**ADMINISTRATOR**" and it will be approved if there is enough power available from the system.

**SECOND.** - Limitations. -

The service under this category, is destined to users of residential type for PV Systems.

**THIRD.** -Measurement. -

The energy consumption is limited solely by the installed equipment capacity and the "**User**" shall pay a fixed tariff that is initially fixed at Bs. 30.00 (Thirty 00/100 Bolivianos.)

**FOURTH.** - Technical Assistance. -

The 55W Siemens SM55 PV System, Polarized Cable #10, the ASC Charge Regulator for PV Systems and the TOYO Battery will all be of entire responsibility of the "**ADMINISTRATOR**" regarding its maintenance. The internal installations will be responsibility of the "**USER**", and the user must comply with the technical recommendations established by the "**ADMINISTRATOR**".

**FIFTH.** - Tariff. -

As indicated in the third clause of the present contract, the fixed monthly tariff that the "**USER**" shall pay will be Bs. 30.00 (00/100 Bolivianos.)

This tariff can be readjusted annually according to the inflation registered in the Country.

**SIXTH.** - Payment method. -

The monthly payment will be carried out in national currency at the "**ADMINISTRATOR**" office or at the account available for such purpose.

If there is disagreement with the invoice, the "**USER**" must first pay before he can demand, establishing a 90-day period for the reception of the demand at the administrative office of the "**ADMINISTRATOR**" in Patacamaya.

**SEVENTH.** -Responsibilities. -

The "**ADMINISTRATOR**" will not be responsible for power downs of the electrical energy supply caused by fortuity reasons that are out of his control.

The "**USER**" will have to check its protection in the main feeder.

The "ADMINISTRATOR" will not assume any responsibility for the internal installations of the "USER", and if the "USER" performs alterations or defective connections that can cause harm to the equipment that is responsibility of the "ADMINISTRATOR" he will be able to remove the equipment definitely from the household and will impose fines and sanctions established according to the law.

**EIGHTH.** - Payment delay. -

If the "USER" doesn't pay the monthly service invoice, within 30 days of the invoice emission date, it will be in Delay without requirement by part of the "ADMINISTRATOR" and he will suspend the electrical energy supply without notice, removing at once the installations with all its accessories, which will remain to the disposition of the "ADMINISTRATOR" to be installed in other household that can comply with the acquired obligations, and will be able to initiate legal action for the debt, by the coercive way.

**NINTH.** - Validity. -

The present contract will come into force from the subscription date, being the "USER" able to demand the cancellation of the contract with an official notice to the "ADMINISTRATOR" with at least one month of anticipation, leaving the "ADMINISTRATOR" free of the obligation to reestablish the contract again.

**TENTH.** -Acceptation. -

As a signal of acceptance of all the clauses stipulated in this contract; we sign the representative authorized of the "ADMINISTRATOR" and the "USER".

**Prov. Aroma Dpto. La Paz, September 14, 1999**

**EMPRESA DE LUZ Y FUERZA AROMA  
PV SYSTEM SERVICE CONTRACT**

User..... Tariff.....RESIDENTIAL ACCOUNT.....  
ID..... Telephone.....  
Address.....

.....RESIDENTIAL.....  
Energy Usage

.....  
"USER"

.....  
**ELFA S.A. REPRESENTATIVE**

Para JICA STUDY TEAM

FECHA: 01 / 11 / 2000

MENSUAL

## Monitoreo para O. / Mantenimiento

Hoja de Monitoreo - Formulario A-b (REC)

Reporte para el CER: CALTECA

Hecho por: Operador (ELFA S.A.) Nombre: Tec. Antonio Llusco

Revisado por: Prefectura (La Paz) Nombre: Ing. Carlos Lopez

### Inspeccion del Sistema y Artefactos

Problema: Adjuntar reporte detallado

Sistema	Inspeccion	AGO	SEP	OCT
A : FV	Problema/ Inspeccion total	0/10	0/10	0/10
B : Controlador	Problema/ Inspeccion total	0/10	0/10	0/10
C : Bateria	Problema/ Inspeccion total	1/10	0/10	2/10
D : Poste y Sujetador	Problema/ Inspeccion total	0/10	0/10	0/10
<b>Artefactos</b>				
A : Luz	Problema/ Inspeccion total	1/10	0/10	1/10
B : Luz	Problema/ Inspeccion total			
C : Luz	Problema/ Inspeccion total			
D : Radio	Problema/ Inspeccion total	1/10	1/10	1/10
E : R. Cassette	Problema/ Inspeccion total	0/10	0/10	0/10
F : B/N TV	Problema/ Inspeccion total			

Adjunto para JICA STUDY TEAM

FECHA: 01 / 11 / 2000

**Monitoreo para O. / Mantenimiento**

MENSUAL

Reporte de Problemas – Formulario A - c

Nombre de la familia: Quispe Tola Miguel (Numero del Sistema: CL-S-007)

CER/ Canton / Comunidad: CALTECA / CALTECA / CALTECA

Revisado por: Operator (ELFA) Nombre : Tec. Antonio Llusco

Checked by: Prefecture (La Paz) Nombre : Ing. Carlos Lopez

Problema: Fecha del problema : 14 / 08 / 2000

Con el Sistema ( Item : \_\_\_\_\_ )

Con los artefactos ( Item : \_\_\_\_\_ )

Situacion	Motivo	Accion
Usual Instalation	Low level battery's water	Increase water

Adjunto para JICA STUDY TEAM

FECHA: 01 / 11 / 2000

MENSUAL

**Monitoreo para O. / Mantenimiento**

Reporte de Problemas – Formulario A - c

Nombre de la familia: Quispe Vera Felix (Numero del Sistema: CL-S-012)

CER/ Canton / Comunidad: CALTECA / CALTECA / CALTECA

Revisado por: Operador (ELFA) Nombre: Tec. Antonio Llusco

Checked by: Prefecture (La Paz) Nombre: Ing. Carlos Lopez

Problema: Fecha del problema : 14 / 08 / 2000

Con el Sistema (Item : \_\_\_\_\_)

Con los artefactos (Item : A: Luz)

Situacion	Motivo	Accion
One lamp work no good (on and off)	The ballast is no good	Change the ballast



Adjunto para JICA STUDY TEAM

FECHA: 01 / 11 / 2000

MENSUAL

**Monitoreo para O. / Mantenimiento**

Reporte de Problemas – Formulario A - c

Nombre de la familia: De la Cruz Tola Juan (Numero del Sistema: CL-S-002)

CER/ Canton / Comunidad: CALTECA / CALTECA / CALTECA

Revisado por: Operador (ELFA) Nombre : Tec. Antonio Llusco

Checked by: Prefecture (La Paz) Nombre : Ing. Carlos Lopez

Problema: Fecha del problema : 24 / 10 / 2000

Con el Sistema ( Item : \_\_\_\_\_ )

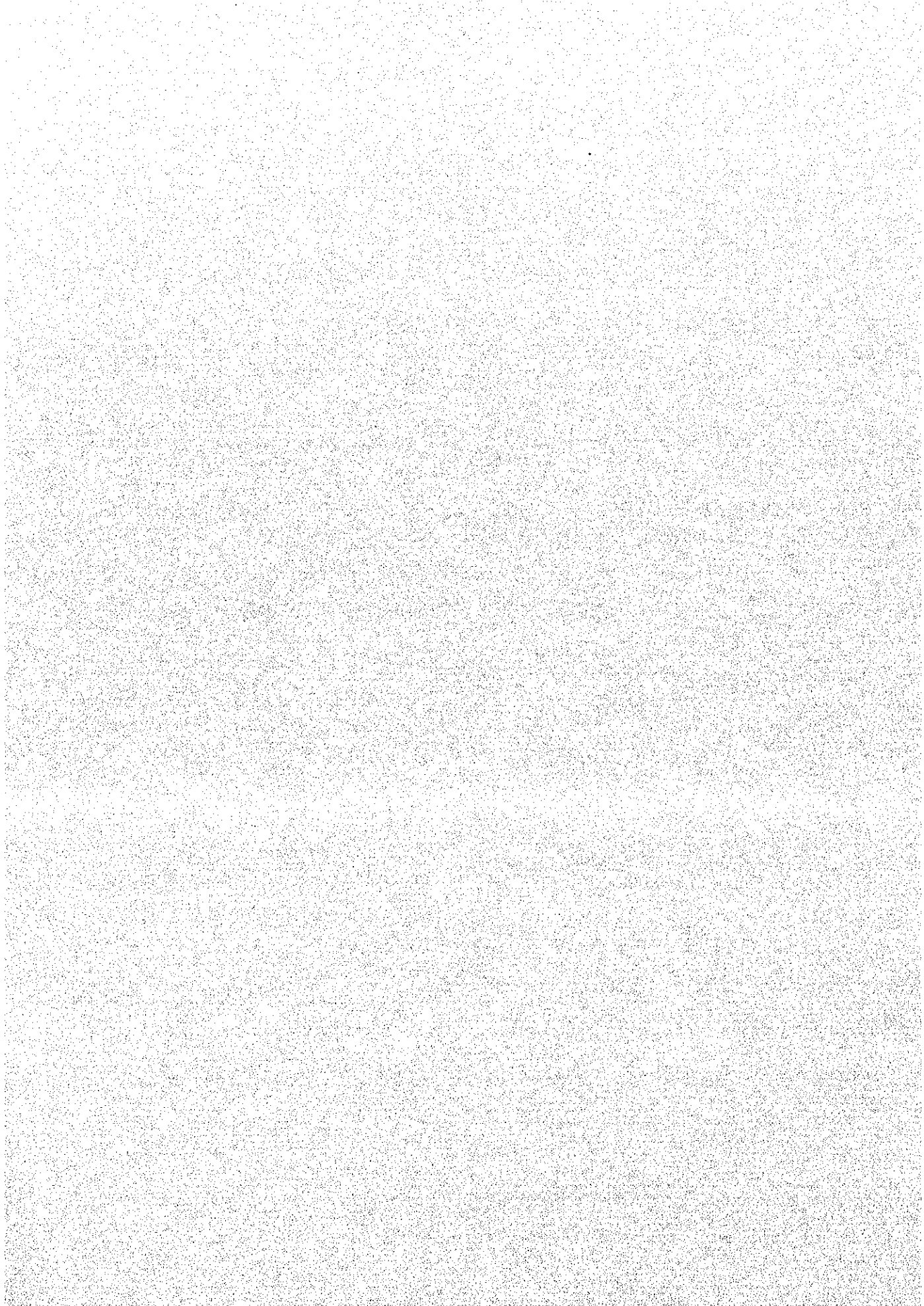
Con los artefactos ( Item : A: Luz )

Situacion	Motivo	Accion
One lamp work no good (The unit was off)	The Lamp is no good	Change the lamp



**APENDICE II**

**ESTUDIO DE PRE FACTIBILIDAD DEL  
PROYECTO DE MICRO CENTRALES  
HIDROELÉCTRICAS**



## **CAPÍTULO 1 INTRODUCCION**

### **1.1 Objetivos del Estudio**

El objetivo de todo del estudio es formular un Plan de Implementación de Electrificación Rural mediante Energía Renovable en La Paz y Oruro. El estudio de las micro centrales hidroeléctricas se ha enfocado en los siguientes aspectos:

- 1) revisar el inventario e identificar el potencial de micro centrales hidroeléctricas;
- 2) identificar lugares prioritarios para micro centrales hidroeléctricas y evaluar la competitividad de los costos. Los proyectos identificados serán incluidos en el Plan de Implementación de Electrificación Rural; y
- 3) seleccionar proyectos de alta prioridad (2 proyectos) para realizar los estudios de pre-factibilidad.

### **1.2 Investigación y Estudio de Campo**

La investigación de campo empezó el 7 de agosto de 1999 y continuo hasta el 7 de septiembre de 2001 de forma continua con las siguientes etapas de investigación:

- 1) primera investigación de campo : 7 de Agosto de 1999 -20 de Septiembre de 1999
- 2) segunda investigación de campo : 5 de enero de 2000-12 de febrero de 2000
- 3) tercera investigación de campo : 15 de mayo de 2000-14 de julio de 2000
- 4) cuarta investigación de campo : 5 de enero de 2001-15 de febrero de 2001
- 5) quinta investigación de campo : 10 de mayo de 2001-8 de junio de 2001
- 6) sexta investigación de campo : 27 de agosto de 2001-7 de septiembre de 2001

La investigación y el estudio conducidos durante el periodo antes indicado, son como sigue:

- Estudio sobre inventario e identificación de lugares para la observación del caudal
- Instalación de las reglas de medición (2 en La Paz y 2 en Oruro)
- Observación diaria del nivel de agua en lugares seleccionados de los proyectos prioritarios
- Selección de proyectos de alta prioridad (1 en La Paz y 1 en Oruro) e ingeniería
- Investigación topográfica y mapeo en los lugares prioritarios seleccionados (2)
- Estudio de Pre-factibilidad de los proyectos prioritarios seleccionados (2) incluyendo Evaluación Inicial del Impacto Ambiental (EIIA)

También se realizó la transferencia de Tecnología al personal de contraparte durante todo el periodo de investigación y a través de tres seminarios llevados a cabo en enero de 2000, junio de 2000 y septiembre de 2001.

## **CAPÍTULO 2 INVESTIGACION DE CAMPO, OBSERVACIÓN DEL CAUDAL Y MAPEO TOPOGRAFICO**

### **2.1 Recolección de Información**

Durante la primera investigación de campo, la recolección de información topográfica, meteorológica, hidrológica, geológica y otros datos relacionados fueron realizados por el Experto de JICA en colaboración con el personal de contraparte de las Prefecturas de La Paz y de Oruro. Los datos de Inventario de las micro centrales hidroeléctricas fueron igualmente recolectados principalmente en el Viceministerio de Energía e Hidrocarburos.

#### **2.1.1 Mapa Topográfico**

Los mapas topográficos fueron obtenidos en el IGM (Instituto Geográfico Militar). Los mapas topográficos obtenidos fueron los siguientes:

- mapa 1/500,000: 6 hojas están disponibles (total 19 hojas), escala 1/250,000.
- mapa 1/250,000: 61 hojas están disponibles (total 85 hojas), escala 1/50,000.
- mapa 1/50,000: 1,657 hojas están disponibles (total 2,349hojas). El mapa escala 1/50,000. Los mapas a escala 1/50,000 no están disponibles para el Norte del Departamento de La Paz.
- mapas a otras escalas: mapa a 1/100,000; solamente 9 hojas disponibles para áreas importantes. El IGM tiene fotos aéreas (escala: 1/10,000 – 1/3,000,000) y mapa digital (CD-Rom).

Las condiciones topográficas de La Paz y Oruro se resumen a continuación.

- 1) El Departamento de La Paz tiene 2 cuencas hidrográficas (Amazónica e interna) y el Departamento de Oruro tiene una sola cuenca hidrográfica.
- 2) Tal como se muestra en el mapa de la cuenca hidrográfica de Bolivia (Figura 2.1), la parte Norte del Departamento de La Paz pertenece a la cuenca del Río Amazonas. Los ríos fluyen de Sud a Norte (la Cordillera Real), cuya elevación varia de mas de 6.000 m. hasta 180 m. La altura máxima del Departamento de La Paz es 6.420 m., que esta ubicada al Sur de la cuenca.

- 3) El área desde el Sud-Occidente del Departamento de La Paz hasta la mitad del área del Departamento de Oruro es de tierras altas llamadas "Altiplano".

Las áreas de alto potencial para la hidroelectricidad en La Paz y en Oruro están ubicadas en los siguientes lugares (Figura 2.2).

- 1) Cadena Occidental de los departamentos de La Paz y Oruro a lo largo de la Cordillera Occidental de Los Andes
- 2) Cadena Oriental del Departamento de Oruro a lo largo de la Cordillera de Azanaques
- 3) Línea Occidental hacia el Sudeste a la mitad del Departamento de La Paz a lo largo de la Cordillera Real

### 2.1.2 Información Meteorológica

La información meteorológica tal como la precipitación pluvial, temperatura, humedad, evaporación, etc. esta siendo recolectada por SENAMHI (Servicio Nacional de Meteorología e Hidrología), en aeropuertos y laboratorios de universidades (UMSA: Universidad Mayor de San Andrés, Instituto de Hidráulica e Hidrología). Durante la primera investigación de campo, se obtuvo la siguiente información.

- SENAMHI Lista de Estaciones de Observación Meteorológica (Tablas 2.1 y 2.2)
- Mapa de Isoyetas en Bolivia (Figura 2.3)
- Temperatura Anual en Bolivia (Figura 2.4)

Tal como se muestra en el Mapa de Isoyetas, las áreas con mayor precipitación están ubicadas en la parte Noreste de La Paz y Cochabamba. La precipitación anual es alta en la cuenca del Río Amazonas de La Paz.

Los bosques cubren el 51 por ciento del territorio boliviano. Los bosques tropicales y subtropicales cubren aproximadamente 37 por ciento del total del territorio. La región amazónica de Bolivia tiene un área de 162,000 km<sup>2</sup> de pastizales. (Área Total de Bolivia =1,098,581 km<sup>2</sup>, Departamento de La Paz=133,985 km<sup>2</sup>, Departamento de Oruro=53,388 km<sup>2</sup>)



La precipitación pluvial anual de estas áreas alcanza el orden de los 2,000 mm/año, alta precipitación pluvial comparada a otras áreas adyacentes de 200~400 mm/año en el Sur de los departamentos de La Paz o de Oruro. La lluvia se concentra durante un corto periodo del verano y la precipitación pluvial es particularmente alta.

De la información meteorológica, se identifican áreas con un alto potencial para la hidroelectricidad en La Paz y Oruro, en los siguientes lugares:

- 1) Parte Norte de la Cordillera Real en el Departamento de La Paz (a lo largo de la Cordillera Occidental de Los Andes),
- 2) Área montañosa alta, y
- 3) Cadena Oriental del Departamento de Oruro (cerca al lado del Departamento de Cochabamba).

### **2.1.3 Información Hidrológica**

Tal como se muestra en el mapa de la cuenca hidrográfica de Bolivia (Figura 2.1), la cuenca hidrográfica esta dividida en tres cuencas, a saber, 1) la cuenca del Río Amazonas, 2) la cuenca del Río de La Plata, 3) cuenca (cerrada) interna.

Información hidrológica como nivel del agua o de caudal en La Paz/Oruro esta siendo recolectada por SENAMHI, la Naval Boliviana, la UMSA-IHH y compañías eléctricas. La Naval Boliviana mide únicamente el nivel del agua para los propósitos de navegación de barcos en el Lago Titicaca o en los ríos mayores. (Además del SIRESE (Sistema de Regulación Sectorial), la Superintendencia de Aguas tiene información de abastecimiento de agua para las áreas urbanas.)

Las estaciones de observación hidrológica del SENAMHI se muestran en la Tabla 2.4 (La Paz) y Tabla 2.5 (Oruro). La información hidrológica recolectada en La Paz y en Oruro por el SENAMHI se resumen en el siguiente cuadro.