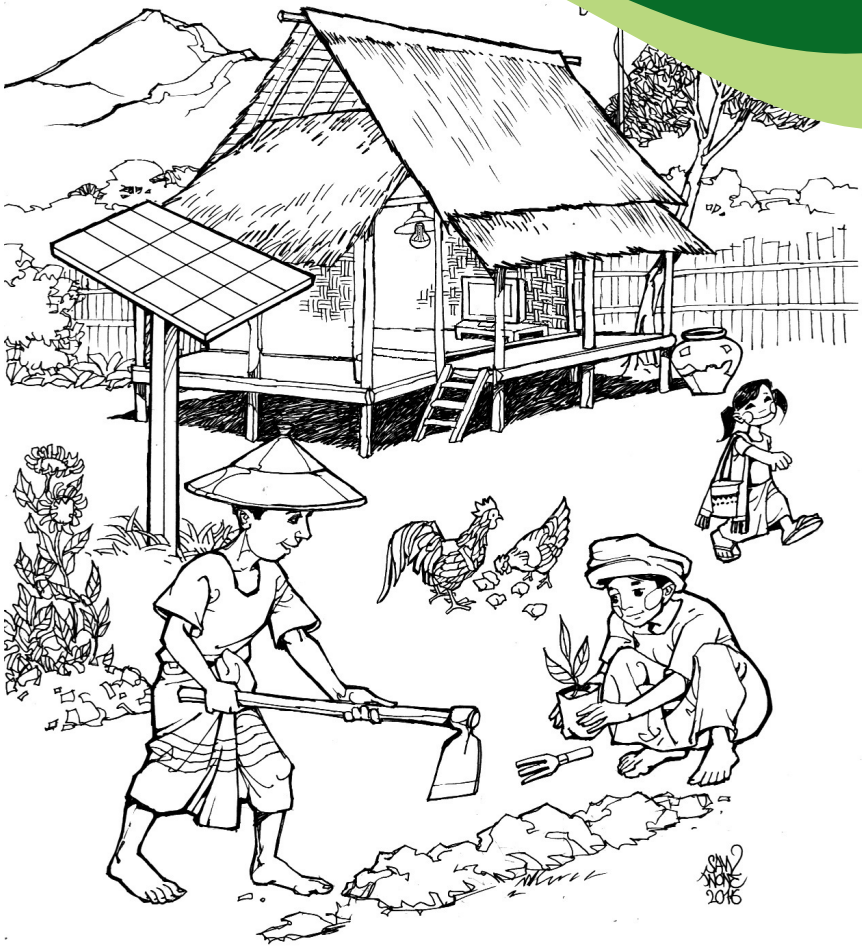
Solar Home System

User Guide Myanmar



Solar Home System
User Guide: Myanmar

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Chris Greacen

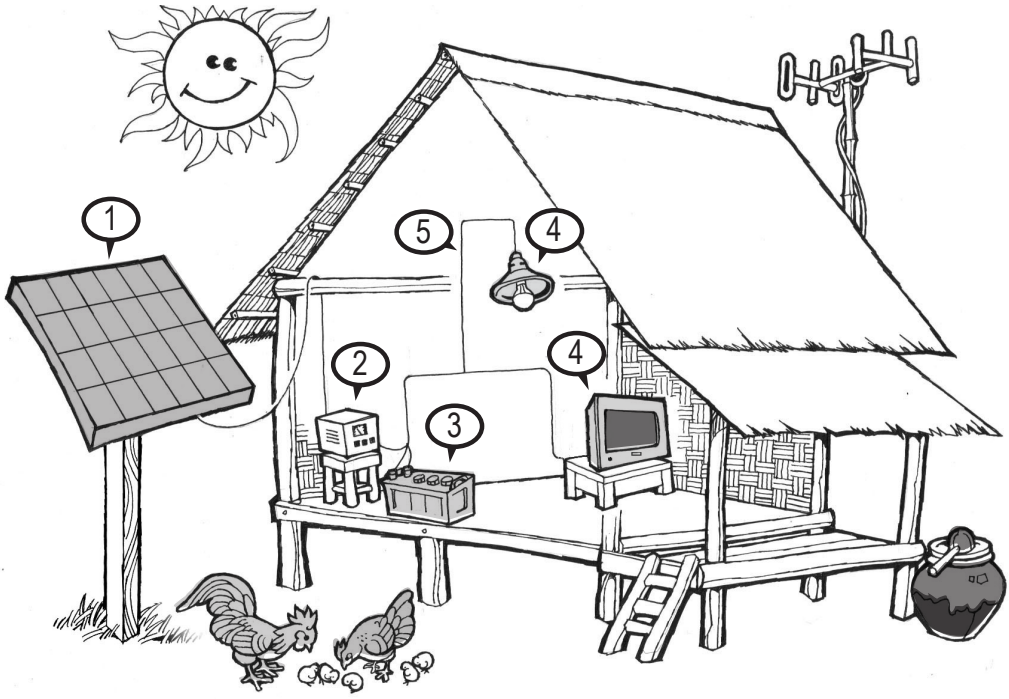
About this initiative:
This booklet explains the workings of a Solar Home System and clarifies bestpractices for operation and maintenance.

CONTENTS

COMPONENTS OF A SOLAR HOME SYSTEM (SHS)

A SHS gives enough electricity to power small appliances such as lights, radios or TVs. It converts energy from the sun into electricity.

A correctly installed and managed SHS can last for several years.



A SHS has five main components:

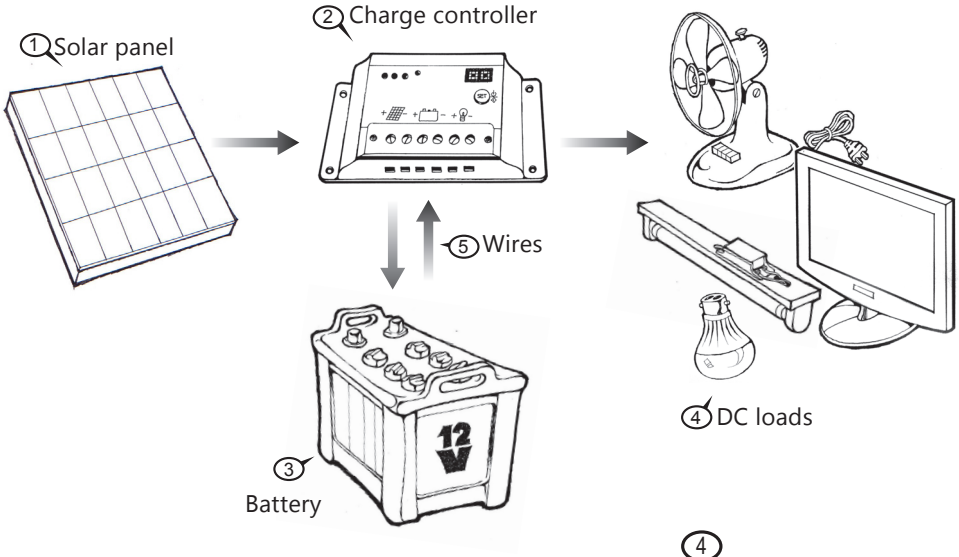
1. Solar panel
2. Charge controller
3. Battery
4. Loads
5. Wires

The role of the inverter is discussed separatly in the manual.

ROLE OF EACH COMPONENT

① The **solar panel** receives the sun's light energy and converts it into electricity.

② The **charge controller** protects the battery from being damaged.



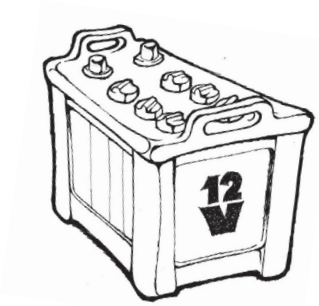
③ The **battery** stores the electricity produced by the solar panel and delivers it to the load when needed.

④ **Loads** are the appliances powered by electricity.

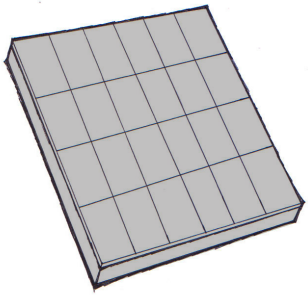
⑤ **Wires** transport the electricity and connect the system components together.

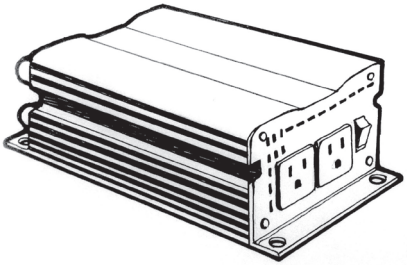
ELECTRICAL UNITS

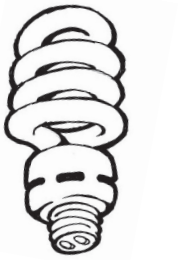
What is electricity?
Electricity is the constrained movement of very small electrons particles. Copper or Aluminum are usually used to conduct electricity. Electricity is a form of energy.



Battery


Solar panel


Inverter


Light

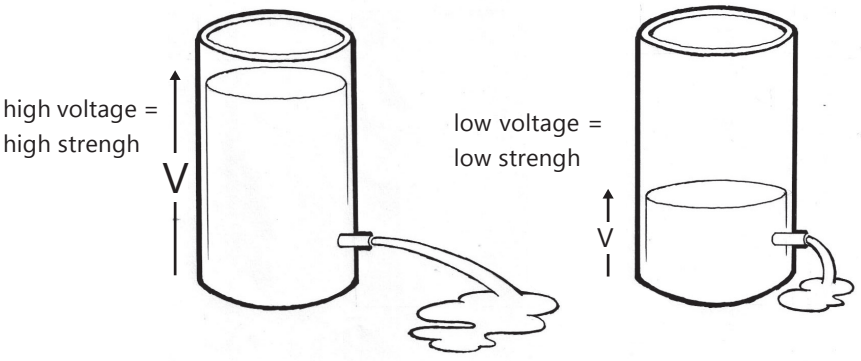
Basic electrical measurements descriptions:

Variable	Unit	Symbol
Voltage	Volt	V
Current	Ampere	A
Resistance	Ohn	Ω
Energy	Watt hour	Wh
Power	Watt	W

Voltage:

Force that "pushes" the electrical particles through the wires. It is the strength of electricity.

Voltage can be compared with the water pressure in a water tank.



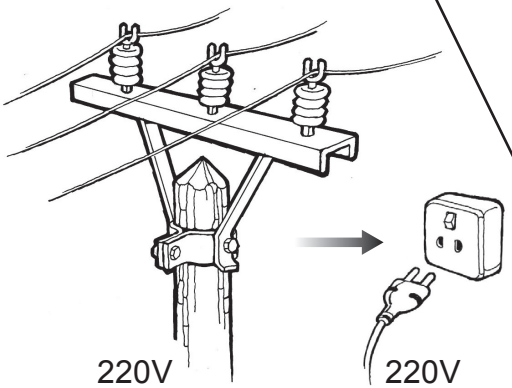
A SHS can operates at 6 or 12 V.

The solar panel is designed to charge a battery and electrical appliances (light, fan, TV, etc.) are designed to work at the same voltage.

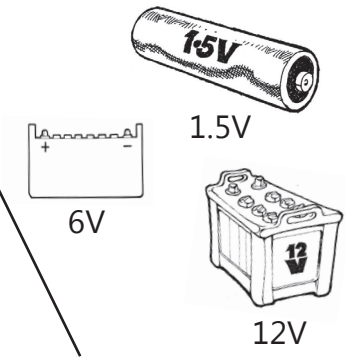
The voltage of electricity delivered by diesel generators or grid electricity is generally 220V.

Examples:

(i) Gouvernment grid



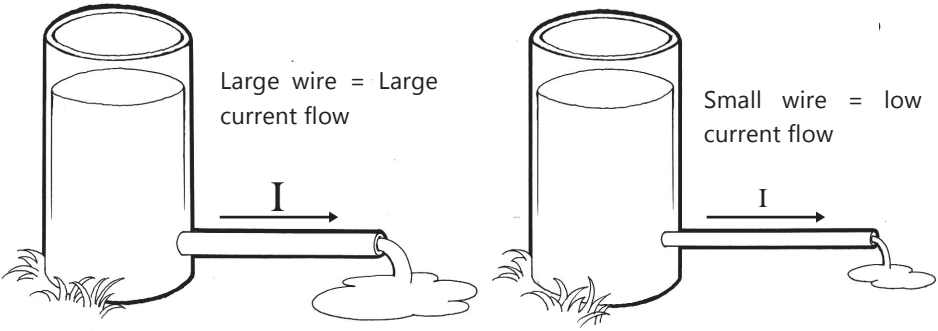
(ii) Batteries and dry cells



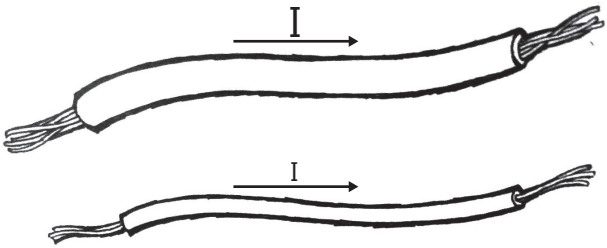
Current:

Quantity of electrical particles that moves through the wire per amount of time. It is the flow of electricity.

Current can be compared to the water flow in a pipe.



Thick wires can transport a large amount of current while thin wires can only transport a small amount of current.



The size of the wire depends on the amount of current that needs to be carried.

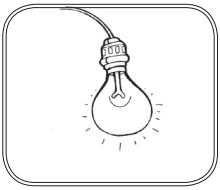
A SHS has larger wires because of its high current.

Resistance:

Opposition to the flow of electricity. The resistance of wires should be limited to a minimum.

■ The resistance depends on the size of the wire

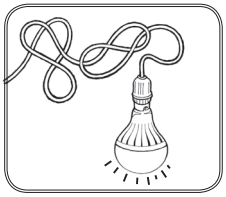
Thin wire has a higher resistance



Thick wire has a smaller resistance

■ The resistance depends also on the length of the wire

Short wire has a smaller resistance



Long wire has a higher resistance

Size and length of wires need to be chosen carefully to limit resistance.

ELECTRICAL UNITS

Energy:

Energy is what makes things work or move.

Power:

Power is the rate at which energy is consumed or produced. Power can be produced by the sun, wind, rivers, biomass, etc.

Chemical power

Biomass power

Hydro power

Human mechanical power

Solar power

Relation between Power and Energy:

Power × **Time** = **Energy Consumption is 20Wh**

10W

2 hours

In a SHS, energy from the sun is converted into electricity. The amount of energy converted defines the amount of energy you can use.

ALTERNATING AND DIRECT CURRENTS

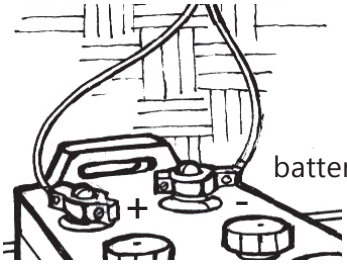
The flow of electricity can move in two ways → Direct current (DC)

→ Alternating current (AC)

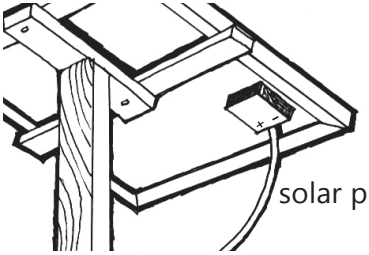
Electrical appliances are either DC or AC.

Direct Current or DC:

Electricity flows constantly in the same direction. A DC system has a plus (+) and minus (-) signs. It is what defines the direction of the flow of electricity.



battery



solar panel

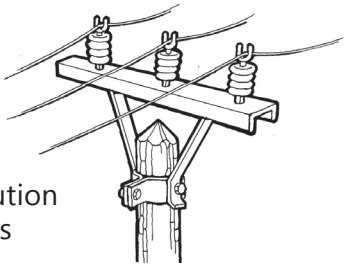
(+) red color (-) black color

Electricity produced by a solar panel and stored in a battery is DC electricity.

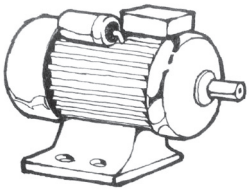
Alternating Current or AC:

The flow of electricity changes regularly in a short period of time.

It is usally produced or consumed by rotative systems such as an alternator or a motor.



distribution lines



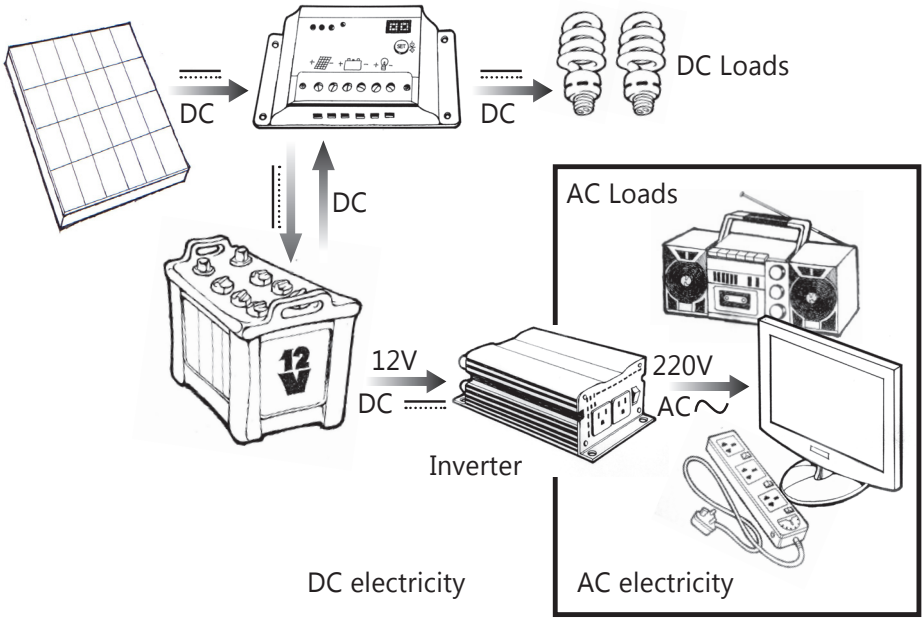
motor

WHAT TO USE IN A SHS: AC OR DC?

AC appliances are easier to find because electric lines and diesel generators deliver AC electricity.

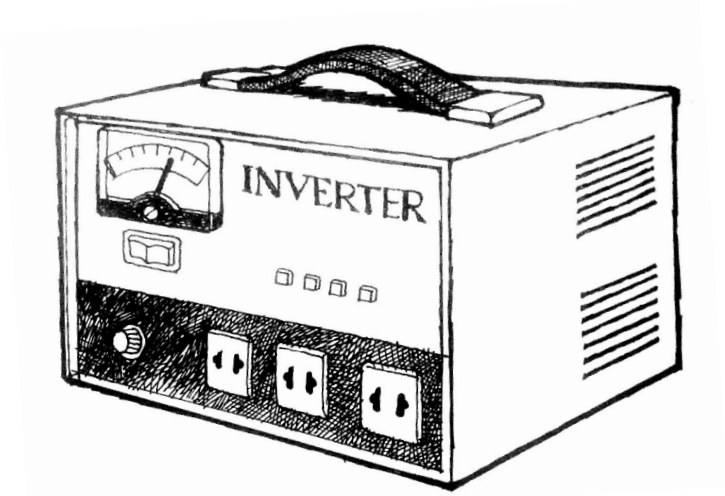
However, DC appliances are more easily adapted to a SHS and are becoming more and more available.

In a SHS with AC appliances, an inverter can convert DC electricity to AC electricity.



However, it is best to have DC appliances to avoid using an inverter. Read more about problems with inverters on the next page.

WHY NOT USE AN INVERTER?



It consumes energy to work (10 to 15% at full load and more if less appliances are working).
DC appliances consume less energy than AC appliances.

It adds cost to the system. Because of the self energy consumption of an inverter, the battery and solar panels need to be bigger.

It is a sensitive element that can fail (due to water vapor or insects, misuse, etc.).

It introduces high voltage in a SHS that can be dangerous. for the user.

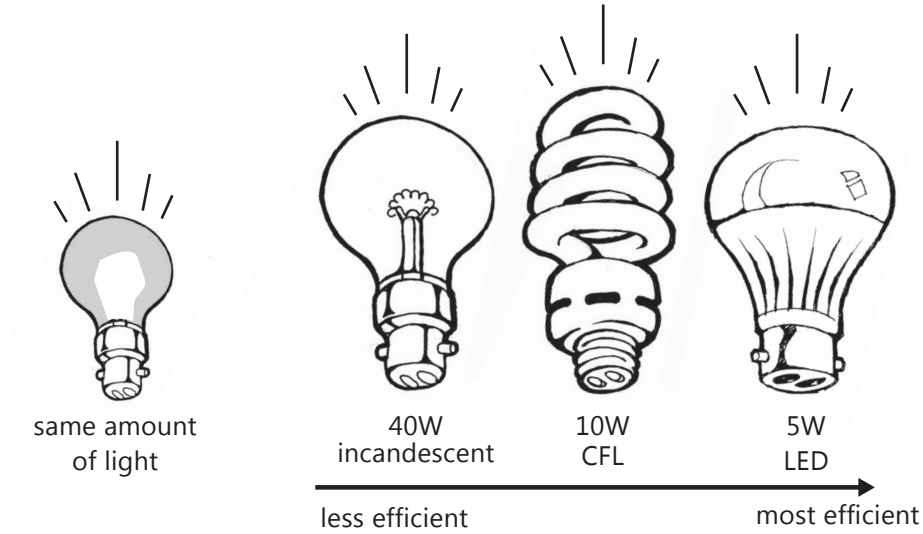
Inverters do not produce electrical energy but consume it from a battery.

In brief, an inverter should be used only if the appliances you want to use are not available in DC.

HOW TO CHOOSE APPLIANCES

Some electrical appliances are specially made for SHSs. They consume a small amount of energy but work very well.

Let us compare lights that produce the same amount of light but have different energy consumption.

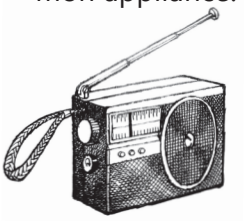


The incandescent lamp will consume a high amount of energy for the same service than other lamps. It is an inefficient appliance that should not be used.

Choosing highly efficient appliances is very important to make the most of the energy available. It is also less expensive in the long term.

POWER RATINGS OF ELECTRICAL APPLIANCES

The following list gives an idea of the energy consumption of common appliance.

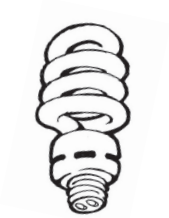


Radio 6W

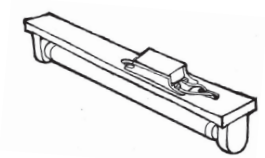
LCD TV 15W

Phone charger 5W

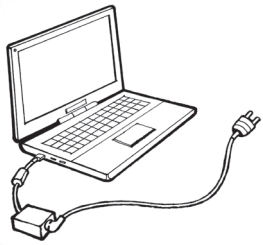
LED 3-10W



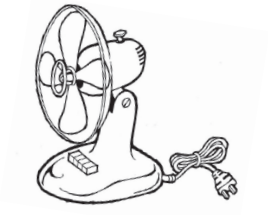
CFL 10-20W



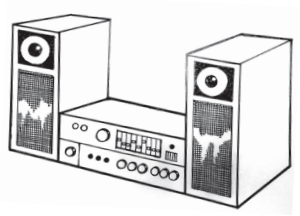
Fluorescent tube 20-40W



Laptop 20-50W



Electric Fan 10-200W



Hi-Fi System 10-300W

Toaster 1000 W

Incandescent Light 20-100W

Iron 1500W

Rice Cooker 1000W

Boiler 1000W

Some electrical appliances are not appropriate for a SHS.

PRODUCTION OF ENERGY

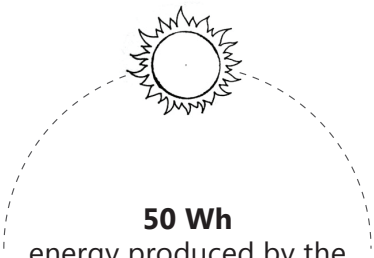
How much electrical energy can be produced in a SHS?

The production of energy depends on different factors (location, efficiency and size of components, etc.).

A SHS can deliver 50 Wh to 350 Wh of electrical energy every day.

Example 1

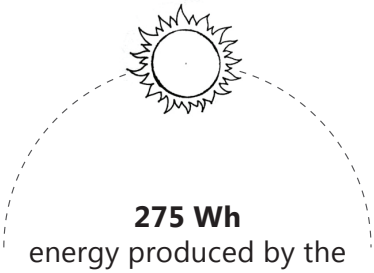
- Sunny area in dry zone
-  20 Wp solar panel
-  35 Ah battery
-  5A charge controller
- 70% system efficiency
- 30% is lost in the system due to resistance and quality of components



50 Wh
energy produced by the SHS in one sunny day.

Example 2

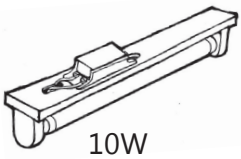
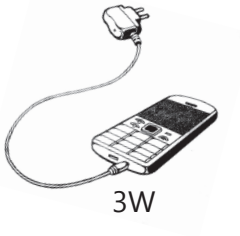
- Sunny area in dry zone
-  120 Wp solar panel
-  200 Ah battery
-  10A charge controller
- 70% overall efficiency
- 30% is lost in the system due to resistance and quality of components



275 Wh
energy produced by the SHS in one sunny day.

CONSUMPTION OF ENERGY

The dimension of components of the SHS (solar panel, battery, charge controller, etc.) are determined by the energy consumption needed by the household.

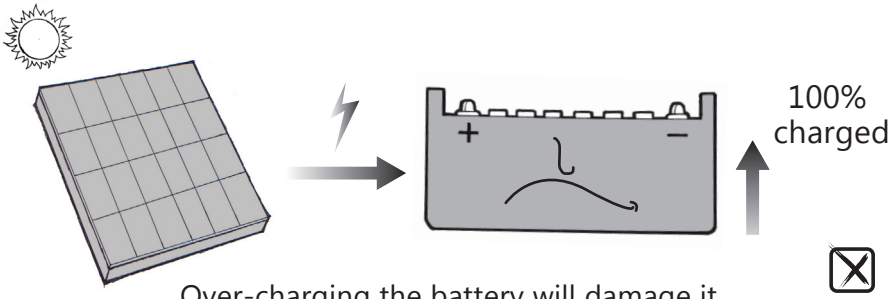
Load		Hours of utilization/day		Daily energy consumption
 3W 3W 3W	X	 5h	=	45 Wh
 10W	X	 4h	=	40 Wh
 3W	X	 3h	=	9 Wh
		Total	=	94 Wh

Once you have defined your energy consumption, ask your local retailer to provide the correct choice of components for a proper system.

BATTERY CHARACTERISTICS

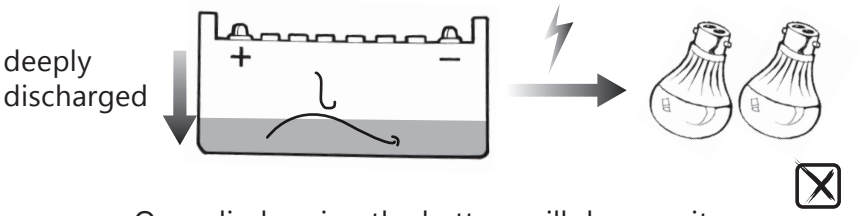
The battery is the most sensitive element in a SHS. A battery can be damaged in two ways:

■ **The battery is fully charged but continues getting electricity from the solar panel:**



Over-charging the battery will damage it.

■ **The battery is running low and loads keep drawing electricity from it:**



Over-discharging the battery will damage it.

Lead-acid batteries usually used in a SHS should not be discharged more than 50%. Under this level, their lifespan will be reduced.

Car batteries are not made for deep discharge and their lifespan will be reduced if the depth of discharge goes under 20%.

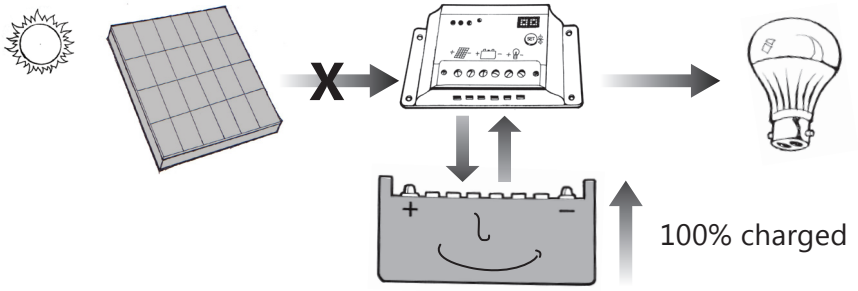
ROLE OF THE CHARGE CONTROLLER

The role of the charge controller is to protect the battery against over-charging and over-discharging.

The charge controller can measure how much a battery is charged.

Over-charge protection:

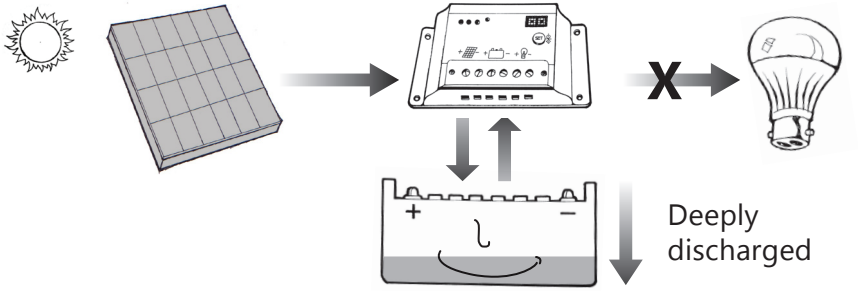
When the charge controller detects that the battery is fully charged, it disconnects the solar panel from the battery.



The charge controller reconnects the solar panel to the batterry when it needs to be recharged again.

Over-discharge protection:

When the charge controller detects that the battery is deeply discharged, the charge controller disconnects the loads from the battery.

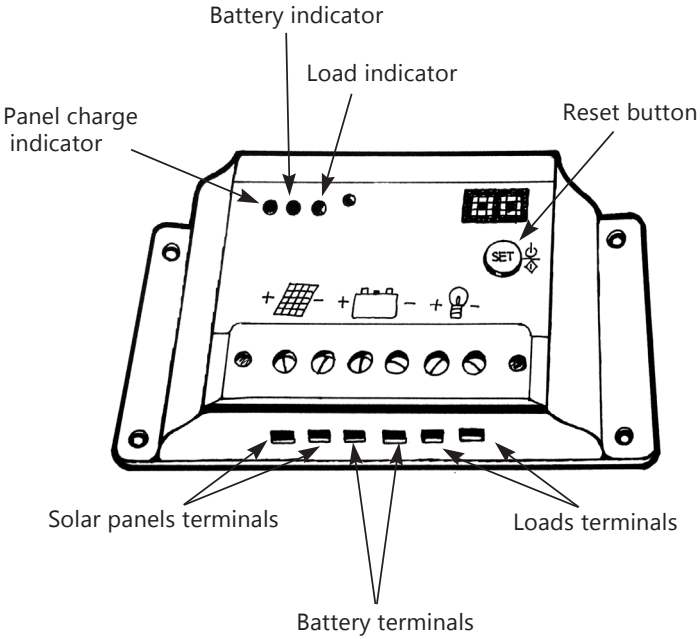


The charge controller reconnects the loads to the battery when it has been recharged by the solar panel.

ROLE OF THE CHARGE CONTROLLER

The charge controller is the device that connects DC loads, the solar panel and the battery.

It also provides information to monitor the system. Understanding what the indicator lights mean will help you detect and resolve problems.



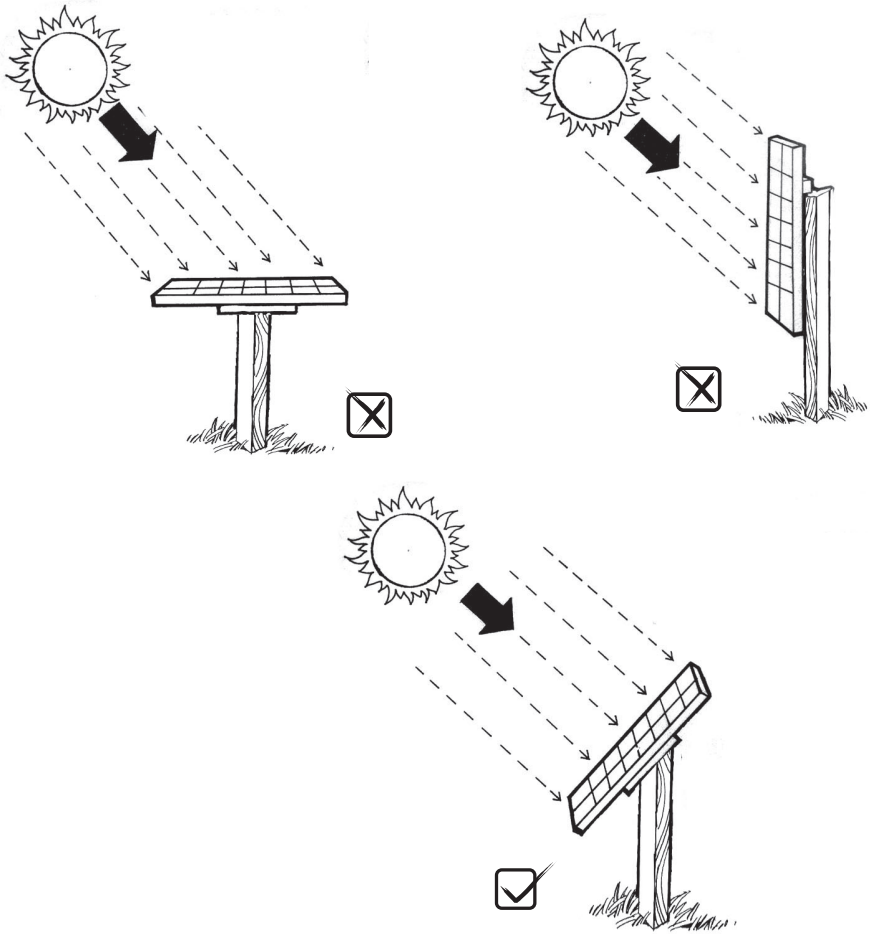
Example of a solar charge controller

The indicators lights on a charge controller depends on its model. One key information the user can monitor on a charge controller is the state of charge of the battery.

In general, green lights indicates that the system is fonctionning normally while red lights indicates that the system has a problem. Please refer to the charge controller manual to know the meaning of the indicator lights.

SOLAR PANEL ORIENTATION

A solar panel receives more energy when it is oriented toward the sun. When it receives more energy, it produces more electricity.



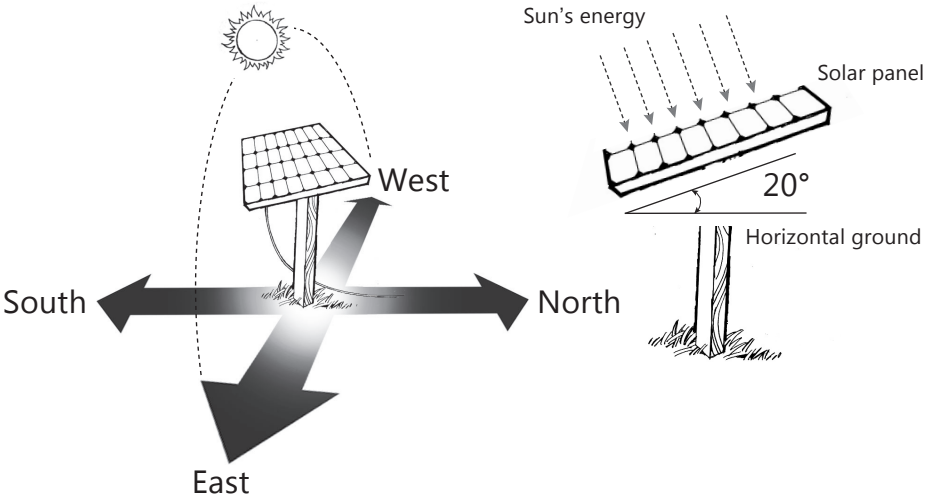
The position of the solar panel is generally fixed in a SHS. As the position of the sun in the sky changes throughout the year, it can be difficult to choose the best position for the solar panel.

Read more about this on the next page.

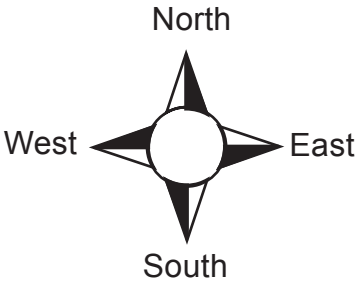
SOLAR PANEL ORIENTATION

How to orient your solar panel in Myanmar:

The solar panel should be oriented **toward the south with a tilt angle of 20 degree.**



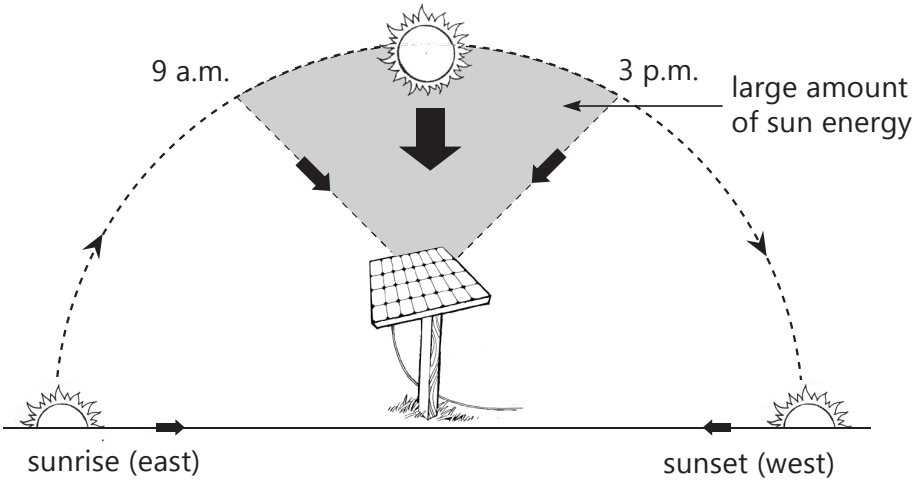
The sun rises in the east and sets in the west. If you look at the sun pathway during the day, you are facing the south direction.



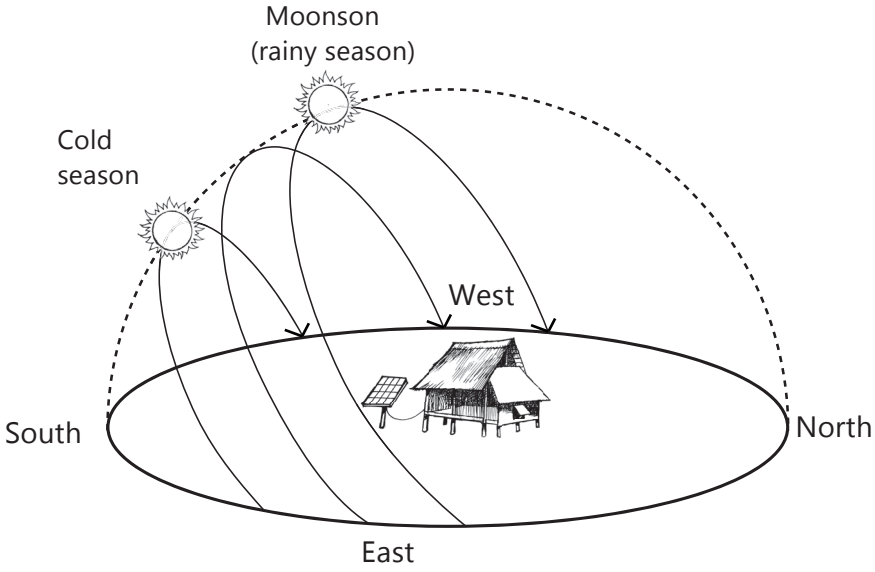
SOLAR PANEL ORIENTATION

The energy of the sun is strongest between 9 a.m. and 3 p.m. with a peak at noon.

It is necessary to orient the solar panel correctly to capture this energy.



The sun's path through the year in Myanmar:

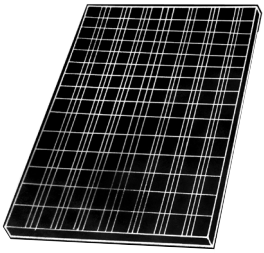


SOLAR PANELS

A solar panel is rated in Watt Peak (Wp).

Example:

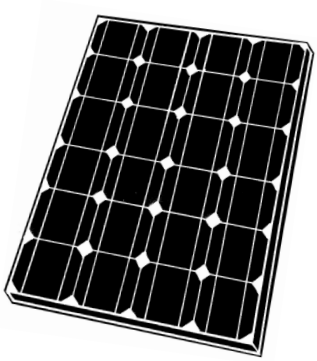
80 Wp solar photovoltaic panel



Watt peak correponds to the power that a solar panel can produce under ideal conditions. The actual power output under normal conditions will be less.

A solar panel is made of individal cells connected together. Each cell converts energy received from the sun light into a small amount of electricity.

solar cell



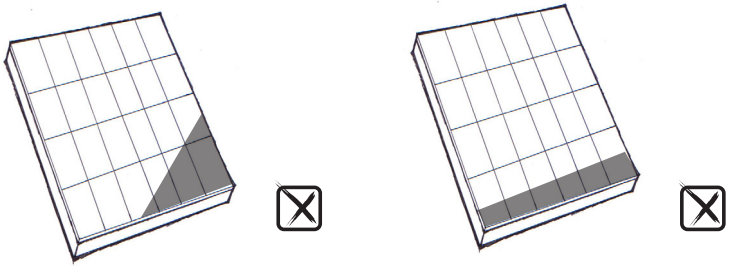
Photovoltaic module

At the back of the solar panel, a label from the manufacturer should indicate its electrical characteristics. It is a sign of quality.

THE PROBLEM OF SHADING

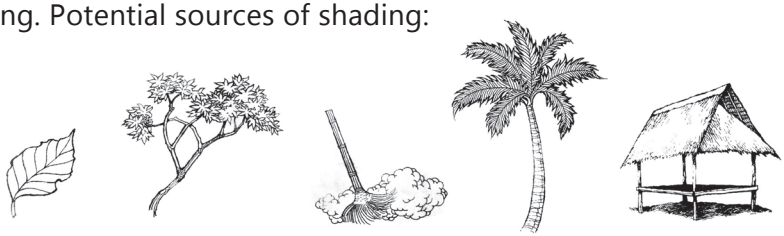
Shading should be avoided on solar panels.

The power output is significantly reduced when there is shade on the solar panel, even if it's only one cell.



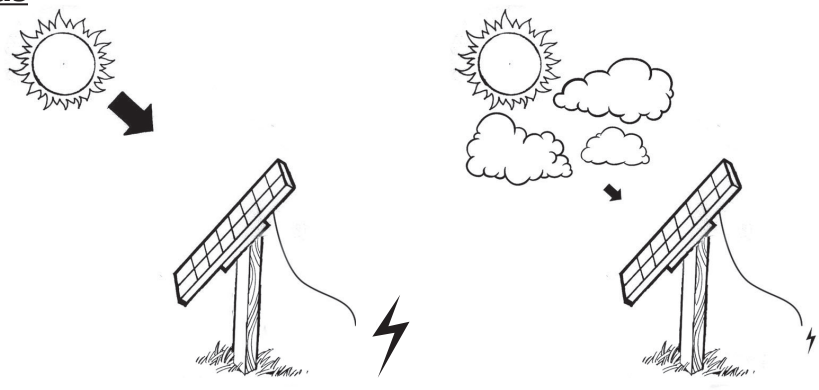
Solar panels can also be damaged if they are partially shaded for a long time.

The position of the solar panel should be carefully selected to avoid shading. Potential sources of shading:



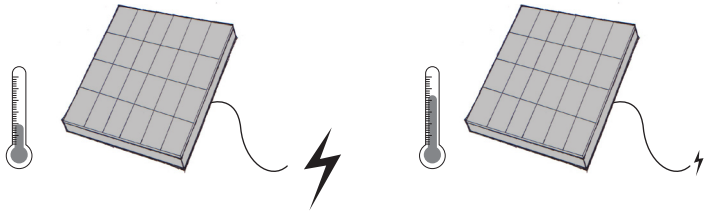
leaves branch dust tree other house

Clouds

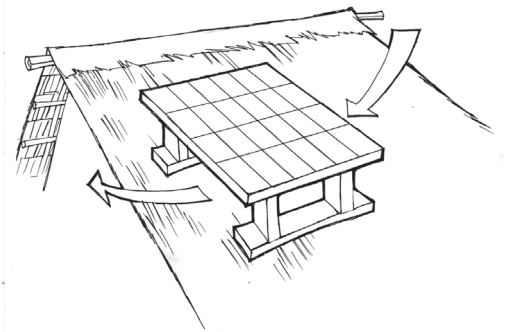


A SHS will receive less of the sun's energy on cloudy days. The solar panels will still be working but the electricity produced will be less.

Temperature



A solar panel will produce less electricity if it has a high temperature.

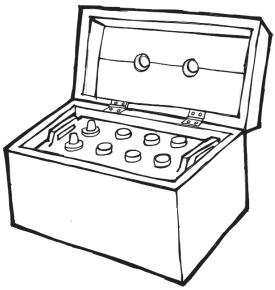


A good practice is to have space between the roof and the solar panel to let the air cool the panel down. It will reduce the temperature of the solar panel

BATTERY SAFETY

Batteries have significant potential hazards and need to be managed carefully.

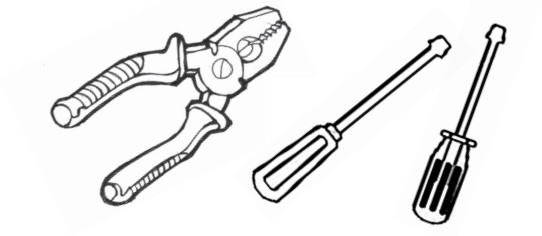
Risk 1:
A Battery stores a lot of energy. If an object that conducts electricity connects the (+) and (-) terminals, it can get red hot and cause burns. It can also cause an explosion or fire.

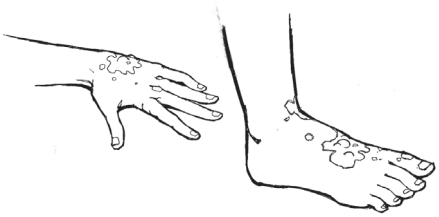


➥ Enclosing the battery will reduce the likelihood of an accident. The box needs to have holes to allow hydrogen gas to escape.

➥ The battery's location should be protected from children and animals.

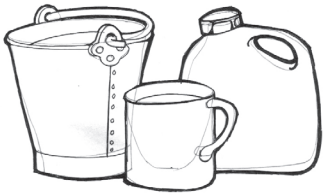
➥ Use insulated tools (they don't conduct electricity).





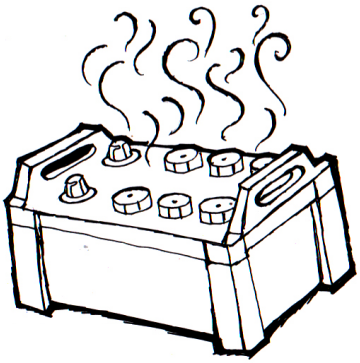
Risk 2:
Battery contains sulphuric acid. It burns skin and clothes.

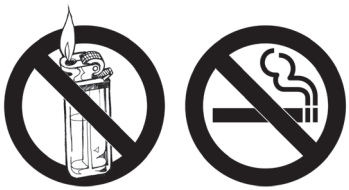
➥ Wear non absorbent gloves and safety glasses when dealing with batteries.



➥ Always have water nearby and wash yourself with plenty of water in case of contact. Baking soda (sodium bicarbonate) is useful to have to neutralize spills.

Risk 3:
When operating, the battery can release hydrogen. It is a flammable gas and can lead to explosion if accumulated.

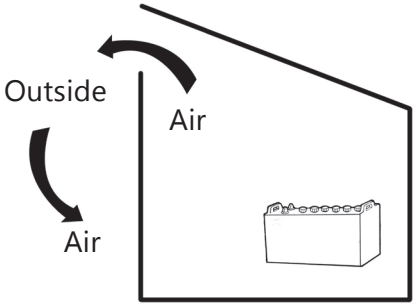




➥ Do not smoke or put open flames near a battery.

BATTERY SAFETY

- Install the battery in a ventilated area.



Risk 4:
A battery contains environmentally un-friendly materials so proper battery recycling or disposal are very important.

- Do not throw the battery in nature.

- Return dead and defective batteries where you bought it. Dead batteries can also often be sold to a battery recycler who will use the materials to make new batteries.

WIRES AND CONNECTORS

What type and size of wire should be used?

Insulated copper wire should be used.

Wires from PV module to charge controller: 2,5 mm^2
Battery to charge controller: 2,5 mm^2
Charge controller to big loads: 2,5 mm^2
Charge controller to small loads: 0,5 mm^2

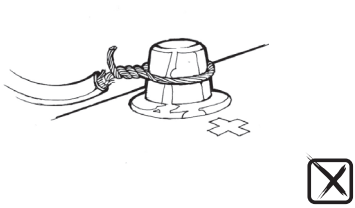
These sizes will limit the amount of resistance.

Connectors are very important because electricity has to flow through them. Bad connections correspond to a loss of energy.

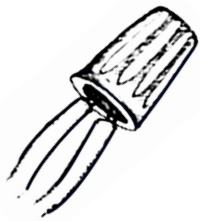
Bad practices:

Crocodile cable

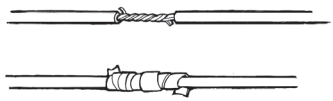
Wire rolled around the battery terminal



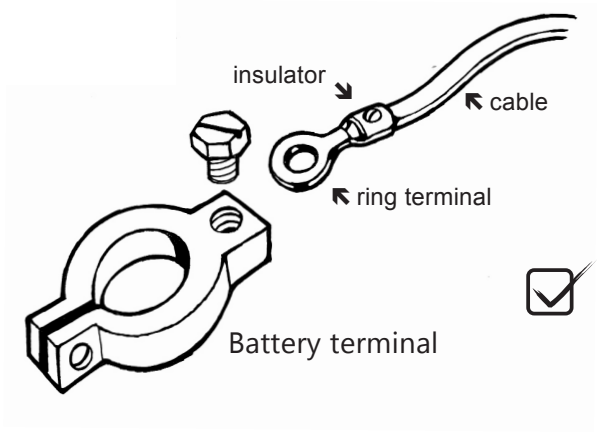
Wire nuts



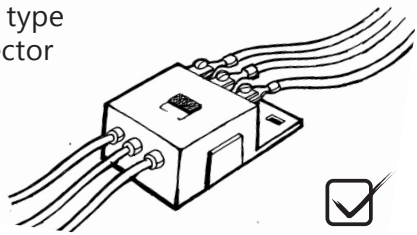
Cable strippped and taped



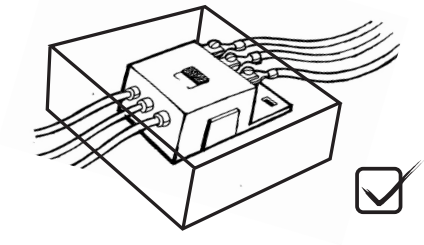
Good practices:



Screw type connector



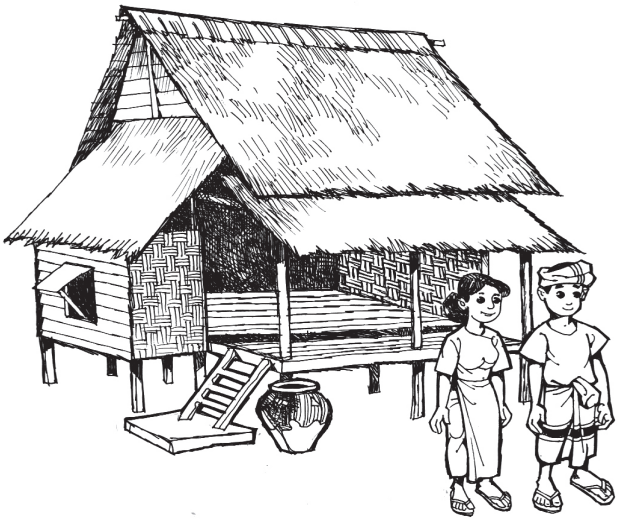
Screw type connector and weather proof junction box for outside connections



OPERATING THE SHS

To operate your SHS correctly, you need to balance the energy production and energy consumption.

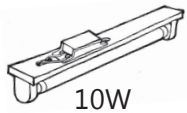
Example: Ei Phyu Khine and Kyaw Kyaw



Ei Phyu Khine and Kyaw Kyaw want to buy a solar home system to have lighting for a few hours during the early morning and evening. They also want to charge their mobile phone that they recently bought.

What will be their daily energy consumption ?

3W 3W during  5h = 30 Wh/day



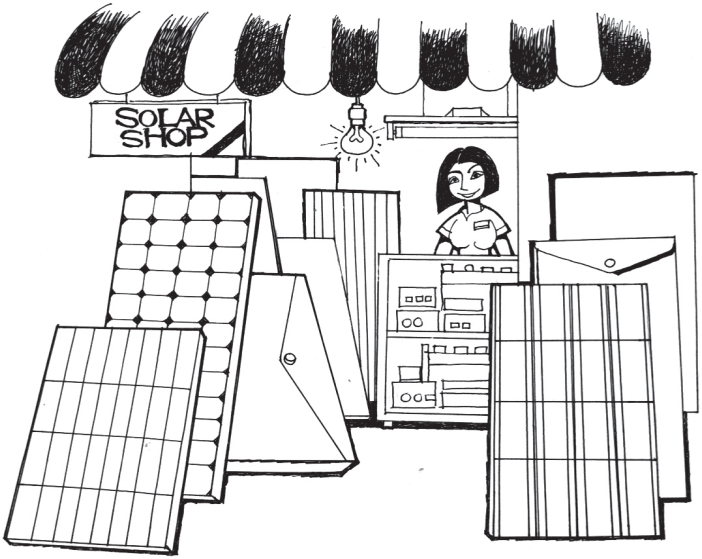
10W during  4h = 40 Wh/day

3W during  3h = 9 Wh/day

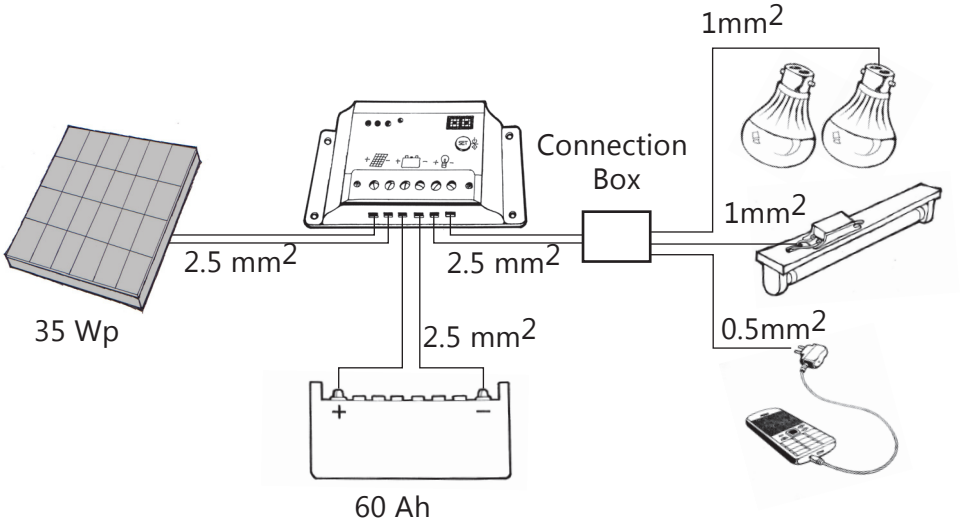
Total = 79 Wh/day

Each day, they will consume 79Wh of energy

Example (continued)



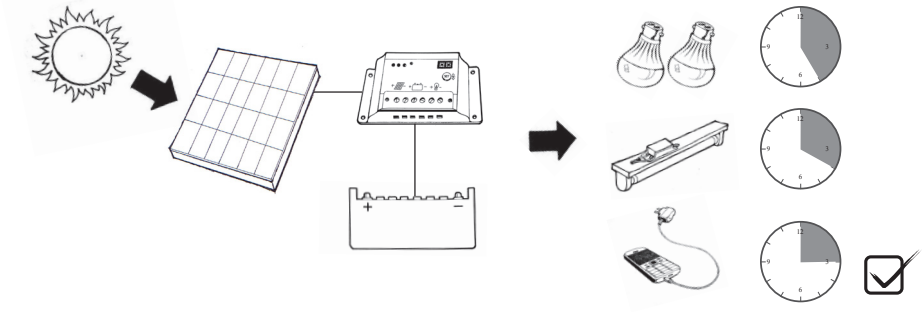
The electronic shop seller advises them to buy products with labels that show signs of quality. She helps them determine the size of the panel, the battery, the charge controller and the wires. She also gives advice on electrical connectors.



Scheme of the 12V DC configuration

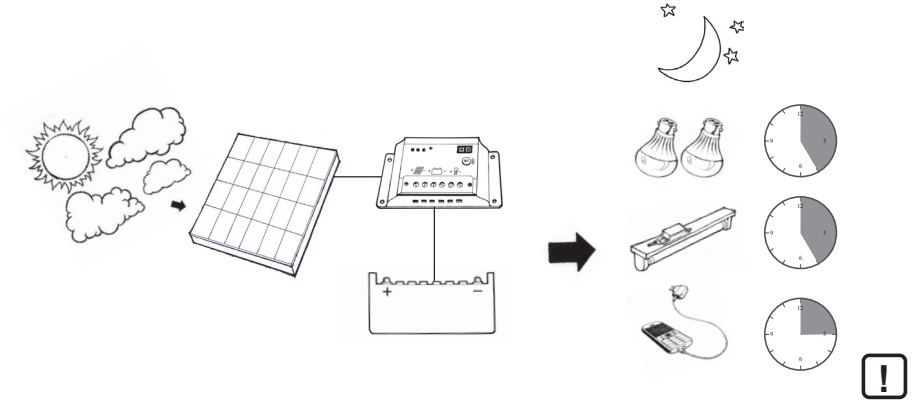
Example (continued)

- Case 1: Production = Consumption



In this case, the SHS is working properly. It produces the electricity needed to power the appliances. The battery is completely charged at the end of the day. Ei Phyu Khine and Kyaw Kyaw are careful not to let their charge controller show "low voltage" light by making sure they do not use too much electricity.

- Case 2: Production < Consumption (cloudy weather)

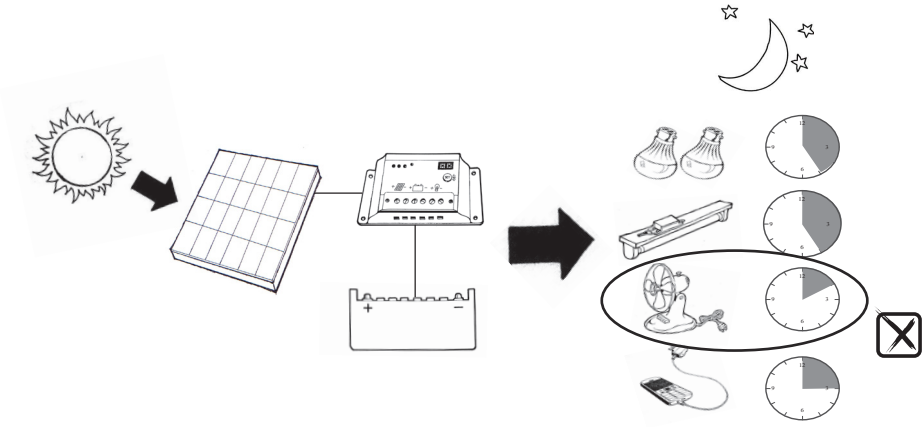


Because of the cloudy weather, not enough electricity is produced to completely charge the battery. If no action is taken, the battery is going to be deeply discharged and the appliances will stop working.

To prevent this Ei Phyu Khine and Kyaw Kyaw should check the indicators on the charge controller regularly and reduce their electricity consumption if needed.

Example (continued)

- Case 3: Production < Consumption (over-consumption)



Ei Phyu Khine and Kyaw Kyaw recently bought a fan and connected it to the SHS. Every day, they are consuming more than 79Wh which means than the battery will be deeply discharged and eventually damaged.

Because the dimension of the components are not adapted anymore, the system will regularly fail.

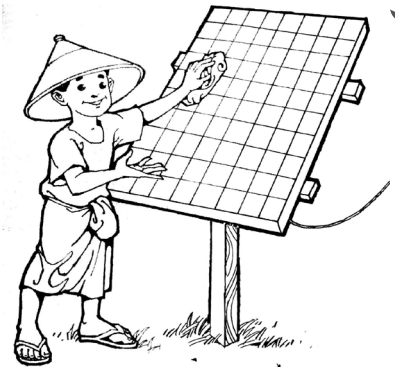
Summary of good practices to operate a SHS:

- ❖ Make sure that the battery is fully charged at least once a week.
- ❖ Verify the charge controller to know the charge of the battery.
- ❖ Reduce consumption during cloudy weather.
- ❖ Do not connect additional appliances at all.
- ❖ Save energy and switch off appliances when they are not being used.

MAINTAINING THE SYSTEM

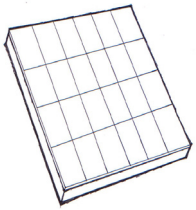
Maintaining the system will make it generate more electricity and last longer.

Solar Panel



- Clean the panel with clean water and a soft cloth. Do it preferably in the morning or during the evening.

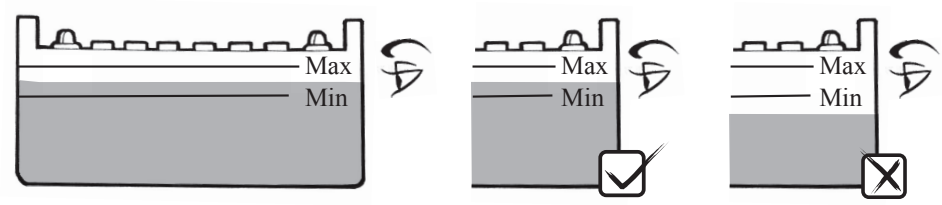
- Regularly check that there are no objects or shading on the solar panel, that the cells are not damaged and that the panel is tightly fixed.



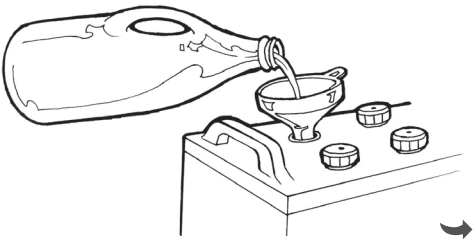
Appliances

- Clean the lights and appliances regularly.

Battery



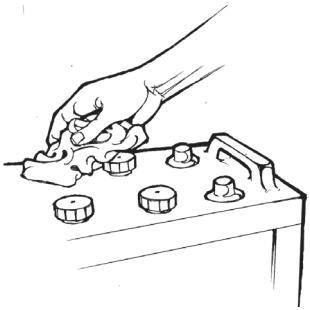
➥ Regularly check the level of liquid in the battery.



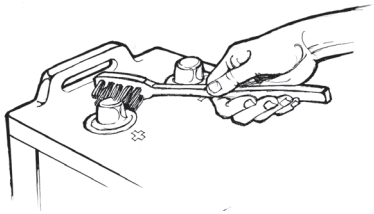
➥ Use only distilled water to fill up the battery when the level is under the “Min”.

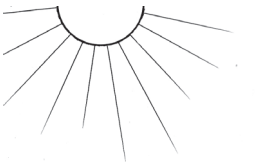
Do not use normal water (bottle water, tap water, etc.). It will damage the battery.

➥ Regularly clean the battery with a damp cloth.

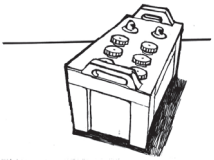


- If there is corrosion (white color around terminal), clean it with a metal brush and charge the battery completely.

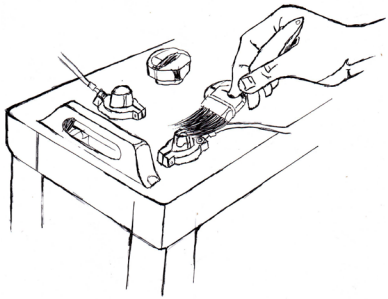




- Do not let the battery sit under the sun.

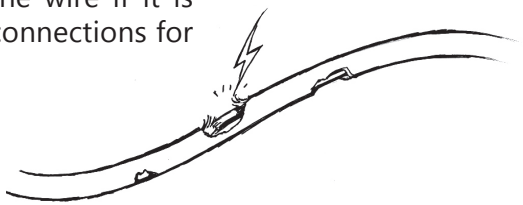


- Apply petroleum jelly to the terminals to protect them from corrosion.



Wires and connectors

- Regularly check the wire and look for cracks. Replace the wire if it is damaged. Check all connections for tightness.



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Solar Home Systems (SHSs) offer a practical and sustainable solution to the lack of electricity across Myanmar.

This Manual covers the basics of how SHS works and how to operate one properly. It includes :

- **an overview of each SHS component**
- **best practices for operating and maintaining a system**
- **common mistakes made by users**
- **tips to make the SHS last as long as possible.**