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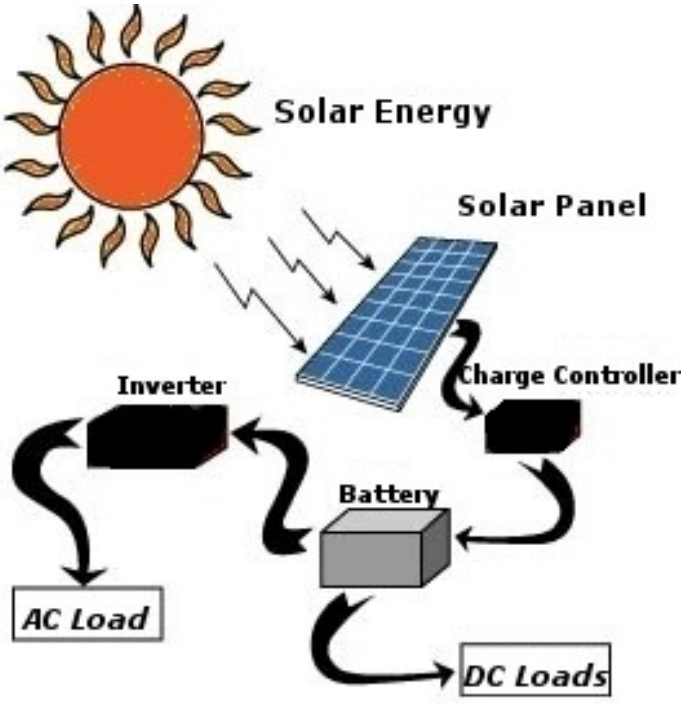
Introduction

The Improving Health Facility Infrastructure (IHFI) project, funded by USAID, works to improve the access to and reliability of energy while reducing costs in health facilities in countries around the world. In Guyana, IHFI has focused, in part, on solar PV electrification of rural health centers and clinics.

In this context the IHFI Guyana energy team conducted sites assessments of several hinterland health centers/outposts to design and implement energy solutions to improve delivery of health services.

This manual outlines certain preventive maintenance elements of small stand-alone solar PV systems. It explains routine maintenance tasks involved in the care of batteries, solar panels, wiring and loads for stand-alone PV systems. The picture below shows the components of a typical stand- alone system.



Maintenance

Proper maintenance ensures that solar system life is preserved for as long as possible and the original conditions of the system are sustained, while compensating for normal wear and tear. Solar systems require little maintenance as compared to other electric systems such as diesel generators; however, they are not maintenance free. This document provides instructions on performing preventative maintenance on major components of a solar PV system:

1. Battery
2. Solar Panels
3. Charge Controller
4. Inverter
5. Wiring and connections

Battery Maintenance

A battery is a device which is used to store electrical charge. The pictures below show two common types of batteries used in solar installations.

Sealed Gel Battery

Deep Cycle Flooded -Lead Acid Battery

Batteries should be regularly and carefully maintained to extend their useful life. These activities include:

1. Inspecting and cleaning regularly
2. Checking the electrolyte level (not required for Gel Batteries)
3. Keeping in a high state of charge

1. Battery Inspection and Cleaning

A visual inspection should be done to assess the general condition of the system's batteries. Check for any electrolyte leak, cracks in the batteries, or corrosion at the terminals or connectors.

Effects of poor maintenance techniques are shown in the pictures below.

Batteries should be clean, dry and free of electrolyte and corrosion residue. Corrosion at battery terminals is seen as a white coating around the battery terminals. Cleaning should be done once monthly.

Precautions

To minimize hazards, the following precautions should be taken prior to carrying out battery maintenance.

- Safety goggles must be worn when performing battery maintenance
- Protective gloves and chemical-resistant rubber gloves must be worn to prevent contact with battery acid.
- If there is acid spillage, neutralize the acid with a water and bi-carbonate soda solution. Metal files should not be used to remove corrosion.
- Use tools with insulated handles to carry out any maintenance.

Do not smoke or light fire near batteries. Batteries produce hydrogen gas which is highly flammable.

Before maintenance is carried out, each component of the system should be isolated. This would involve switching off circuit breakers to and from the battery bank and the solar panels. Battery cleaning procedures are as follows:

1. Switch off/disconnect all loads on the system. Turn off or disconnect the solar charge. Then turn off the circuit breaker to and from the battery bank.

2. Ensure that the caps on the batteries are sealed tight to keep any dirt from entering the battery. Wipe the top and outside of the battery with a (damp) cloth. If corrosion is present at the terminals, mix baking soda with fresh water and apply the solution to the affected area. Stubborn areas should be scrubbed with a metal brush. After cleaning, rinse the terminals with water. If available, apply petroleum jelly or grease to the connected terminal to prevent future corrosion.

3. Maintenance of gel cell and AGM batteries relates only to the battery terminals and connections. The terminals and posts should be wiped until they are shiny, and if corroded, clean them properly with Bi-carbonate soda and water. If available, apply petroleum jelly or grease to the connected terminals.

2. Checking the Electrolyte level

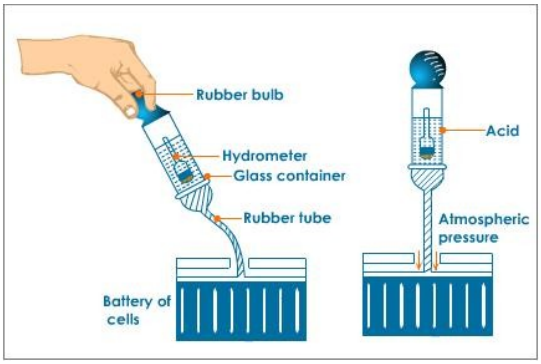
Battery maintenance involves checking the cell electrolyte level for correct acid volume once a month. The cells should be watered back to the original acid level which is ¼ - ½" below the bottom of the vent well (the tube inside the battery cell with slots on each side).

Use only distilled water to top up the batteries.

Testing for the specific gravity of electrolyte in the battery is an accurate way to measure and compare the state of charge of each individual cell.

The process of checking the electrolyte specific gravity for a "Deep Cycle Flooded" Lead Acid battery is given below:

1. First, remove the caps from each cell one at a time. Carefully insert the hydrometer into the cell.
2. Draw liquid into the hydrometer and avoid bumping the hydrometer. The float should not be flooded or sticking to the sides of the glass tube.
3. Obtain a reading by looking at the float which corresponds to a level on the tube. The acid level in the batteries should be within two centimeters of the top of the battery. A visual inspection could also be made to check the condition of the plates. Record the cell number and the results.
4. Do not replace liquid from one cell to another.



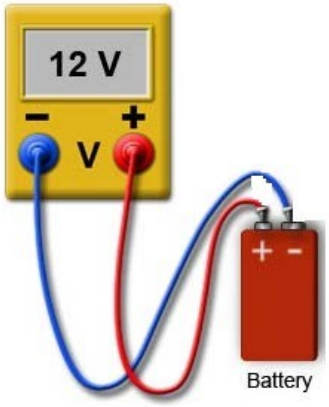
The table below shows typical battery state-of-charge at various levels of specific gravity. The voltages mentioned below are for 12V and 6V batteries.

State of Charge	Specific Gravity	Voltage - 12V	Voltage - 6V
100%	1.265	12.7	6.3
75%	1.225	12.4	6.2
50%	1.190	12.2	6.1
25%	1.155	12.0	6.0
Discharged	1.120	11.90	6.0

Note that the table above gives only indicative values; specific gravity will vary somewhat depending on the battery type and brand, and on the battery's temperature.

The specific gravity readings of each cell should be recorded and maintained in a log sheet.

3. Checking Battery Voltage

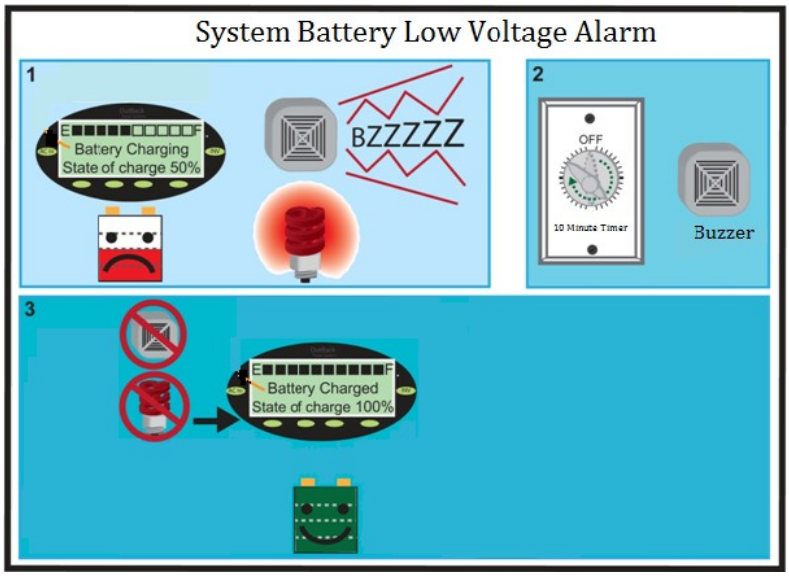


Another important measure in determining the battery state of charge is the battery voltage. A volt meter is used to measure this quantity. The positive lead of the volt meter should be connected to the battery's positive terminal and the negative lead of the volt meter should be connected to the negative terminal of the battery. The table above shows the corresponding battery voltages and the corresponding state of charge of the battery. After measuring each battery's voltage, it should be recorded and maintained in a log sheet.

Battery Alerts

The solar system has an alarm to produce a visual and audible indication to alert a low battery state of charge. When the battery state of charge falls to 50% the alarm will trigger and buzzer will sound for 10 minutes. The buzzer will be automatically turned off, but will start again every 10 minutes.

Turn off lights connected to the solar system to avoid deterioration of the battery.



Solar Panel Maintenance

The solar array (a number of solar panels connected together) is often thought to be maintenance free. However, occasional maintenance and inspection of the solar array must be performed to ensure the optimal use of the solar panels. This can be done by keeping the surface (glass) area of the module clean from any excess dirt.

1. To remove a layer of dust and dirt from the modules, simply wash the panel with water. If the module has thick dirt or grime and bird droppings, which are harder to remove, wash with cold water and rub the panel surface with a sponge.

Do not use a metal brush to clean solar panel surface. Detergents should not be used.

2. A visual inspection of the modules can then be done to check for defects in the modules such as cracks, chips, de-lamination, fogged glazing, water leaks and discoloration. If any obvious defects are found, note their location in the system logbook, so they can be monitored in the future in case further deterioration affects the modules' output.

3. The condition of the array mounting frame should also be noted. Items to observe should include the array mounting bolts (e.g. bolt rusting) and checks to ensure that the frame and modules are firmly secured. The junction boxes should also be checked to ensure that the wires are not chewed by rodents or insects.

Take adequate precautions while doing maintenance of the solar panels since these are located on rooftops and there is the risk of falling off.

Inverter/Battery Charger and Charge controller

This component can be maintained by minimizing dust accumulation. A dry cloth should be used to wipe away any accumulated dirt/dust. A visual inspection should be done to ensure that all the indicators such as LED lights are working and that the wires leading to and from this device are not loose. Note that the charge controller should indicate that the system is charging when the sun is up. If not, contact the installer immediately.

Wiring and Connections

Wiring installations should be checked for any cracks, breaks or deterioration in the insulation/conduits. Inspect panel boxes to ensure that they have not become a home for rodents and insects. Also inspect connections for any corrosion and/or burning. Switches should not spark when turned on or off. The following sections of conduit and wiring should be checked for any signs of damage:

- Solar panels to the charge controller
- Charge controller to the battery bank
- Inverter/charger to the battery bank
- Generator to Inverter/charger
- Inverter/charger and Generator to the AC outlets
- Battery bank to the DC outlets/load.

If damage is found, consult with the installer as soon as possible. All ground wires should be checked to ensure they are not broken.

Solar System Maintenance Schedule

Maintenance Task	Daily	Weekly	Monthly	3 Months
Visual Inspection of system wiring, Lights and vaccine freezer		√		
Solar Panel Maintenance				√
Battery Inspection		√		
Battery Cleaning			√	
Wiring Inspection		√		
Inverter/Battery Charger		√		
Charge Controller		√		
Battery "top-up"			√	

Panel Maintenance Log Sheet (every 3 months)

Date	Name of Maintenance Technician	PV Module Clean		Array Frame			Array Cabling	Array Output voltage
		Yes	No	Good	Fair	Bad		

Weekly Battery Inspection Log Sheet for "Deep Cycle Flooded" Lead acid Battery

Date	Battery Number	Specific Gravity	Terminals/Connection Tight		Voltage	Water Level			Action Taken
			Yes	No		Good	Fair	Low	

Weekly Battery Inspection Log Sheet for AGM and GEL Batteries

Date	**Battery Number**	**Terminals/Connection Tight**		**Voltage**	**Action Taken**
		Yes	No		