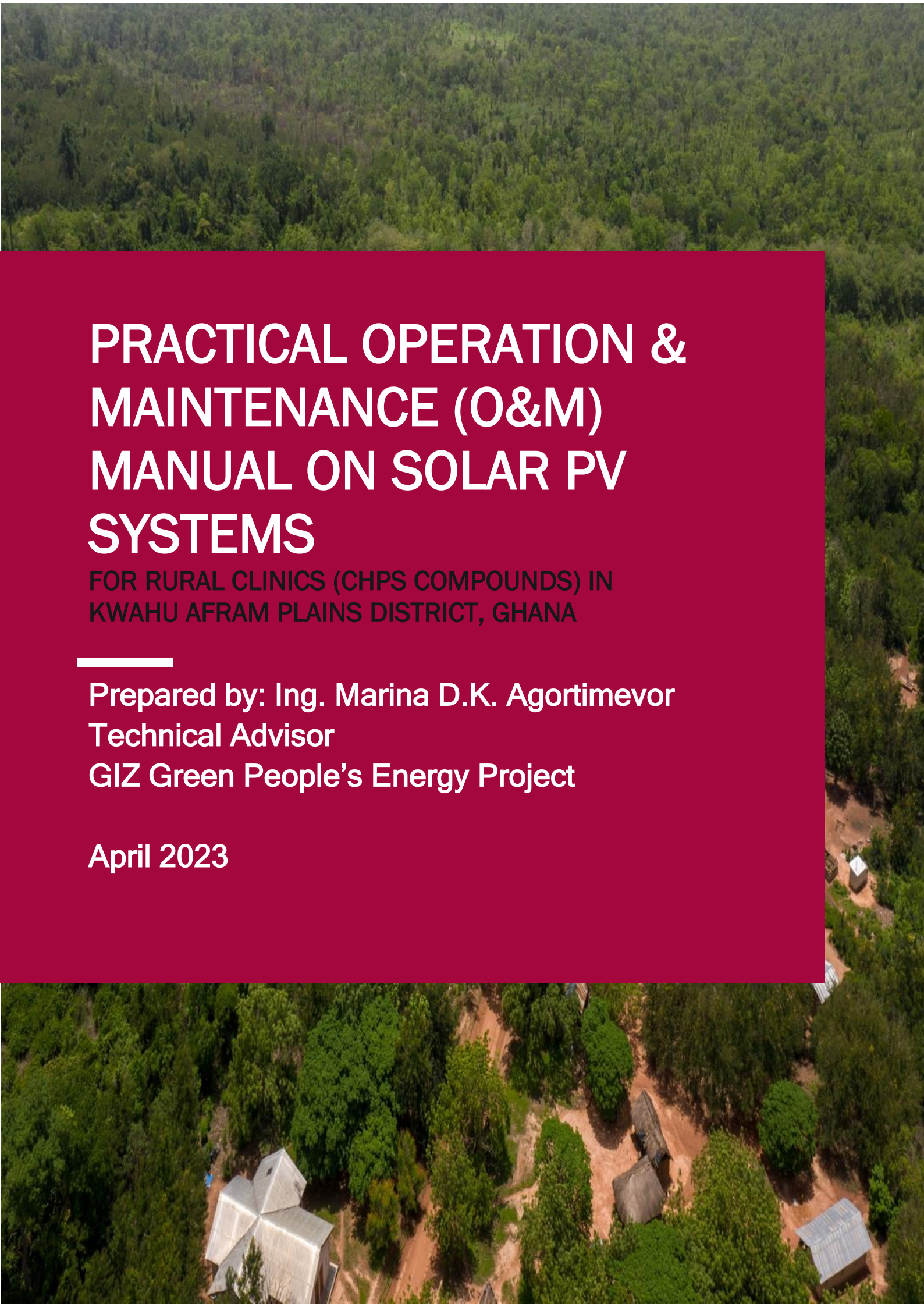

PRACTICAL OPERATION & MAINTENANCE (O&M) MANUAL ON SOLAR PV SYSTEMS

FOR RURAL CLINICS (CHPS COMPOUNDS) IN KWAHU AFRAM PLAINS DISTRICT, GHANA

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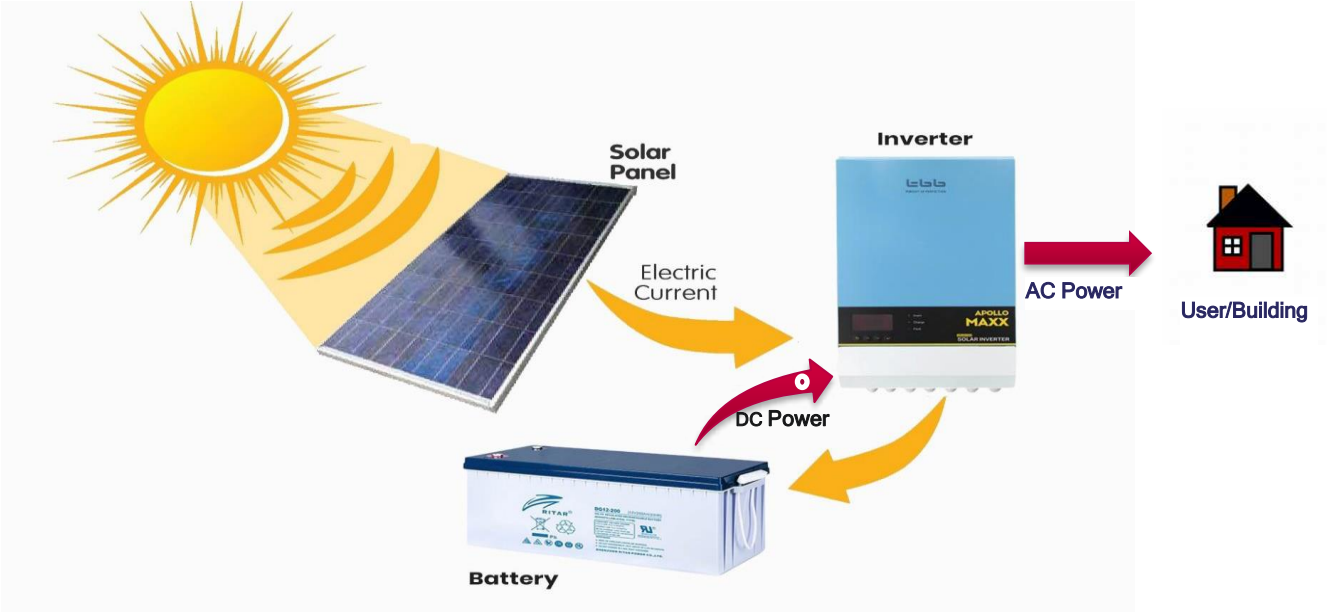
Introduction

Solar Photovoltaic (PV) Systems

A solar photovoltaic (PV) system is composed of **one or more solar panels combined with an inverter and other electrical and mechanical hardware that use energy from the Sun to generate electricity**. PV systems can vary greatly in size from small rooftop or portable systems to massive utility-scale generation plants

A typical photovoltaic system consists of some or all of the following components:

- Solar Panel - Converts sunlight to electricity/DC power
- Inverter - Converts DC power from the solar panel and battery to AC power.
- Battery(s) - Stores excess electricity generated by solar panel



Description Of Installed System at CHPS Compounds

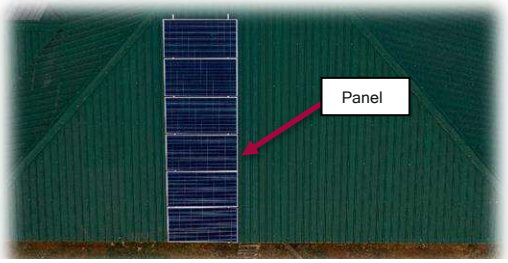
A 2KWP STANDALONE PV SYTEM

The system is a standalone system which is a system independent of the electricity grid, with the excess energy produced being stored in batteries to be used and managed by an inverter. The size of the PV system installed is 2000Wp.

The PV module used is a polycrystalline cell type specifically Ameri AS- 6P 340W. The inverter used is a TBB Apollo Maxx which is a multi-functional inverter, combing functions of inverter, solar charger and battery charger to offer uninterruptible power support in a portable size. The battery used is a Ritar DG 12V200Ah battery. 12 batteries are installed.

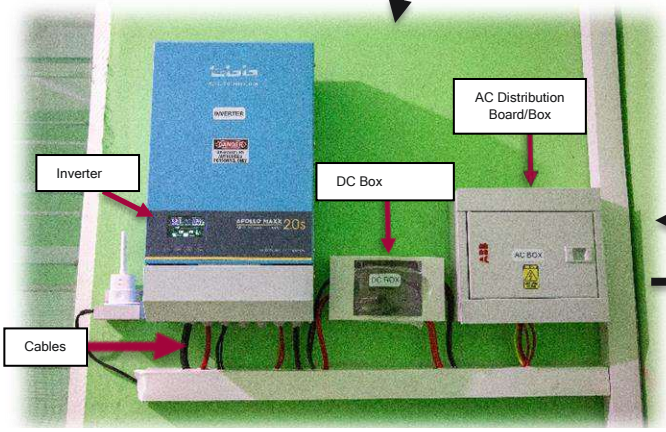
An AC distribution board (ACDB) (also known as panel board, breaker panel, or electric panel) is present. The primary function of the ACDB is to serve as a control point to regulate all AC power to connected loads. It houses miniature circuit breakers to disconnect incoming and outgoing AC connections.

The images below show one of the installed systems at a CHPS compound and its components:



Solar Panels Installed on Roof of CHPS

AC power generated from solar powering LED bulb at CHPS



Inverter, DC box, AC Box, Cables & Accessories

Batteries connected to Inverter & Accessories

Operations

Start Up Procedure

WARNING: You must follow the shutdown procedure in the order of the steps stated. Failure to follow the sequence can result in arcing and damage to the system. A fire is possible. Also, make sure all loads are off before you begin.

Note: *Next to the inverter is a start-up procedure label similar to this.*

Figure 1

Figure 2

STEP 1: *Turn **ON** the circuit breaker in the "DC/ ENERGY BOX" tagged "BATTERY", See **figure 1**. The box sits in between the battery and the inverter for protection and isolation functions*

STEP 2: *If the inverter does not start automatically, locate the **ON/OFF button** underneath the inverter (see **figure 2**) and press and hold for 2 seconds to put it into standby mode. The power LED will light up and the LCD will enter into the self-diagnostic mode.*

STEP 3: *Switch ON the solar panels by turning **ON** the circuit breaker in the "DC/ ENERGY BOX" tagged "SOLAR PANEL", **See figure 1**. Wait until the inverter recognises the PV panels. A PV panel symbol will appear on the information screen of the inverter; See **figure 3 below***

STEP 4: *Wait on standby mode for 30 seconds, then press the **ON/OFF** button (see **figure 2**) again for 1 second to turn on the inverter into the inverting mode. Then observe the LCD and inverter LED to make sure the inverter is running normally.*

STEP 5: *Within the "AC/ENERGY BOX", switch ON the breaker tagged "LOAD" or "MAIN", (see **figures 4 & 5**) to connect the output energy to the Distribution Box*

Figure 3

Figure 4

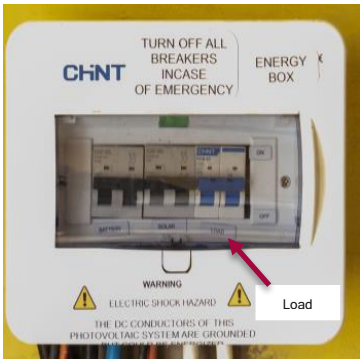
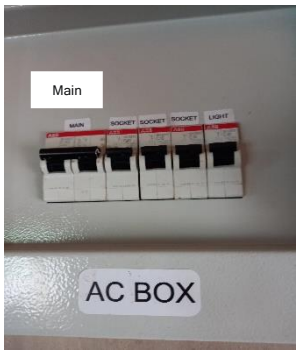


Figure 5



Shut Down Procedure

WARNING: You must follow the shutdown procedure in the order of the steps stated. Failure to follow the sequence can result in arcing and damage to the system.

Note: Next to the inverter is a shutdown procedure label similar to this.
After the inverter is powered OFF, there is still residual power and heat in the chassis, which may lead to electric shock or burning. Therefore, after the inverter is powered off, wait for 5 minutes if you will be opening the chassis of the inverter.

See shutdown procedure below:

STEP 1: *When the inverter is in the inverting mode or charging mode, press the* ***ON/OFF*** *button (see* ***figure 2*** *above) for 2 seconds to turn off the inverter into the standby mode*

↓

STEP 2: *Within the "AC/ENERGY BOX", switch* ***OFF*** *the breaker tagged "LOAD" or "MAIN", (see* ***figures 4 & 5****) to disconnect the output energy to the Distribution Box. The breaker sits between the battery and the inverter for protection and isolation functions*

↓

STEP 3: *Switch OFF the solar panels by turning* ***OFF*** *the circuit breaker in the "DC/ ENERGY BOX" tagged "SOLAR PANEL",* ***See figure 1****. The PV panel symbol will disappear on the information screen of the inverter.*

↓

STEP 4: *Wait in the standby mode for 30 seconds, and then press the ON/OFF button again for 1 second to turn on the inverter into the inverting mode and observe the LCD and inverter LED to make sure the inverter is running normally.*

↓

STEP 5: *When the inverter is in the standby mode, press the ON/OFF button for 5 seconds to turn off the inverter into the complete off mode*

↓

STEP 6: *Turn OFF the circuit breaker "BATTERY" between the battery and the inverter*

Emergency Shut Down Procedure

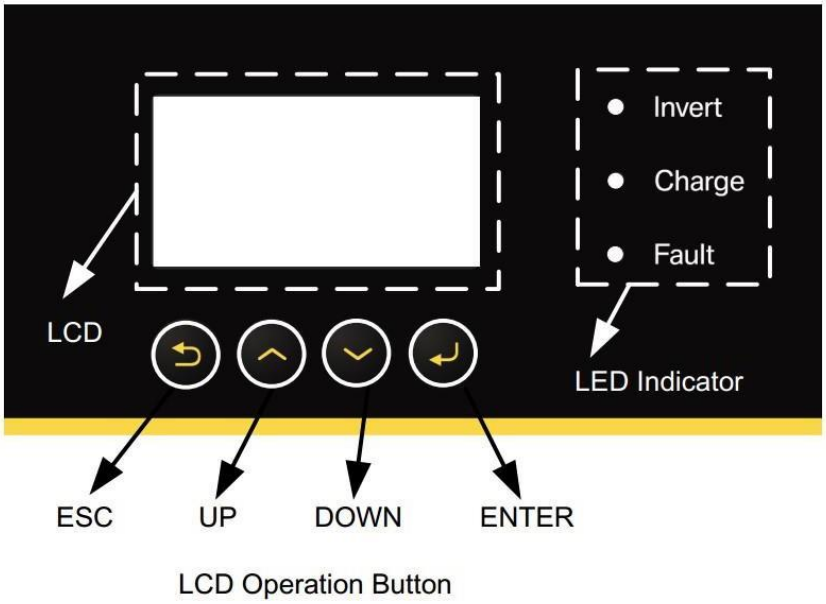
In the case of an emergency like fire, smoke etc, immediately turn off all breakers in this order:

Main/Load Breaker → Battery Breaker → Solar Panel Breaker

Then follow up with the rest of the shut down procedure stated above.

Inverter Operation & Display Panel

The operation and display panel includes four buttons and an LCD display, indicating the operating status and input/output power information. See images below:



LCD Operation Button

Button	Function
ESC	To exit the setting mode or confirm the fault code
UP	To go to the previous selection.
DOWN	To go to the next selection.
ENTER	To enter the setting mode or confirm the selection

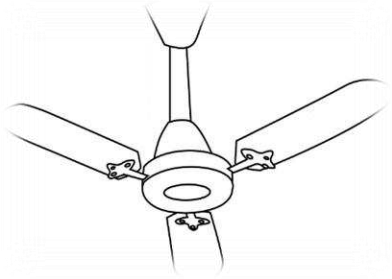
LED Indicator			Function
Invert	Green	Solid on	Inverter mode
		Flashing	Power Assist mode
Charge	Green	Solid on	The battery is charging
		Flashing	The battery is fully charged
Fault	Red	Solid on	Fault occurs
		Flashing	Warning occurs

Energy Efficiency & Loads to Use

ALLOWED AC LOADS

LED Light Bulbs

Charging of Mobile Phones & Lamps

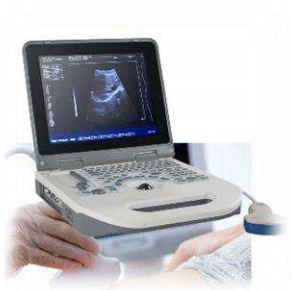


Ceiling Fan/Standing Fan

Television

Vaccine Refrigerator

Laptop



Portable Ultrasound Machine

Note:

1. Use more of the loads during sun hours(8am-5pm) to reduce discharge of the batteries at night. Eg. Charging of phones, lamps etc should be done in the daytime.
2. Check power rating of electrical appliances before you connect to the solar system. Total power rating of electrical loads of the facility should not exceed 1900W to prevent system shutdown.

DISALLOWED AC LOADS

Electric Kettle

Pressing Iron

Electric Immersion Boiler

Hair Dryer

Maintenance

Common Tools Used

Multi Meter

Screw Drivers

Spanners

Hammers

Pliers

Maintenance Warnings

WARNING: Do not attempt to clean or come in contact with the surface of a solar module with broken glass. This could result in a dangerous electric shock.

WARNING: Solar modules remain live during daylight hours, even when the DC isolator is off. Therefore, wiring etc. will still be energised even when the DC isolators are off. Hazardous voltages are present whenever solar panels are exposed to light.

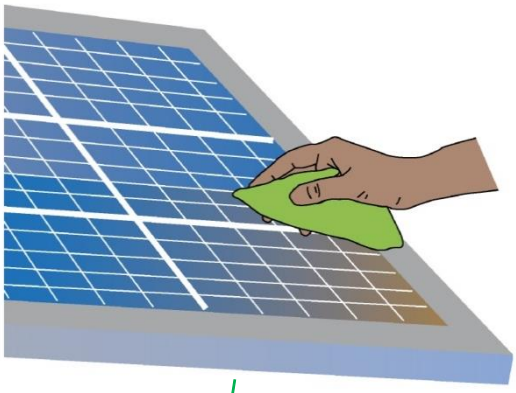
WARNING: The system should be shut down following the shutdown procedure before performing any maintenance.

WARNING: Read and obey all warning signs before performing any maintenance

CAUTION: Appropriate precautions must be taken when working at heights. Do not attempt to access the roof unless the precautions to prevent falling from heights are in place. GIZ recommends that only GHS focal persons/certified electrician who have been trained to work at heights conduct all solar system maintenance at height.

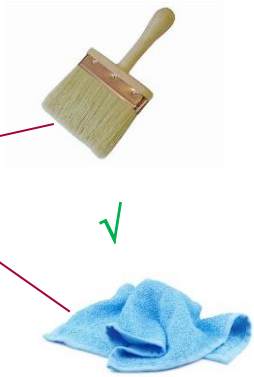
Maintenance Tips

1. Clean solar panel with soft cloth or soft mop and water anytime it is dirty. Do this when panels are cool and do not use soap/detergent for cleaning. Also do not step on the solar panel nor use pressure washers for cleaning.



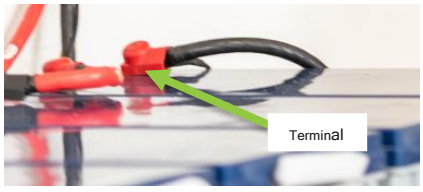
2. Trim trees that may create shade over the panels.

3. Clean inverter, DC and AC (Energy) box, and batteries when dusty with a dry soft cloth or soft hand dusting brush.

4. Do not put anything on top of the batteries, keep it free and dry from any liquid especially water.

5. Battery terminals must be covered



6. Do not touch the battery terminals with metal objects; otherwise, you can get an electric shock.

7. Check connections for loose contact/connections and tighten them.

System Failure

If the system appears to be not functioning, i.e. blank LCD and no LED lights:

1. Please verify that all breakers are in the “on” position.
2. If the screen remains blank, switch all breakers off by the shut-down procedure stated earlier. Leave inverter in the “off” position for 10 minutes then re-energise by the start-up procedure.
3. If the inverter is still not functioning, please put the Leave inverter in the “off” position and contact the technical focal person at GHS or the supplier company DENG Ltd..

Periodic Maintenance Schedule

SUB-SYSTEM OR COMPONENT	MAINTENANCE ACTION	FREQUENCY	REMARKS	RESPONSIBLE
SITE	Verify: 1. General Cleanliness (accumulation of debris around and/or under array/ batteries and environment). Follow tips above. 2. Check impact of bats on the roof and PV system 3. Check shading of solar panels from surrounding trees. In case of shading, cut parts of tree that are causing shadow.	Weekly	Clean if necessary	In - Charges/volunteers
PV MODULES	1. Verify Cleanliness (accumulation of dust or fungus on array) 2. Cleaning: Simply wash with water to remove layers of dust and dirt. Follow tips above.	monthly	Clean if necessary	In- Charges/volunteers
	1. Visual check of connectors and cables 2. Check roof for cracks and holes and repair where necessary 3. Clearing of obstructions of sunlight/shading to the panels (trees etc.)	Quarterly	Repair/ tighten if necessary Trim trees if required.	In- Charges/volunteers

	Check for visual defects including: 1. Fractures 2. Cracks and Chips 3. Browning 4. Moisture Penetration 5. Frame Corrosion	Biannually	Modules with visualdefects should be further inspected for performance and safety to determine the need for replacement.	Technical focal persons
	Verify Bypass Diodes	Annually	Any defective seals, clamps and bypass diodes are to be replaced	Technical focal persons
	Verify Mechanical Integrity ofConduits	Quarterly	Any damaged conduit is to be replaced	Technical focal persons
	Verify Insulation Integrity of Cablesinstalled without conduit	Quarterly	Any damaged cableis to be replaced	Technical focal persons
WIRING INSTALLATION	Check Junction & Distribution Boxes for: 1. Tightness of Connections 2. Water accumulation/build up 3. Integrity of Lid Seals	Annually	Any defective seals,clamps, blocking diodes and surge arresters are to be replaced.	Technical focal persons
	4. Integrity of Cable Entrance and/or Conduit sealing 5. Integrity of Clamping devises			
ELECTRICAL CHARACTERISTIC	Measure Open Circuit Voltages	Annually		Technical focal persons
	Measure Short Circuit Currents	Annually		

PROTECTIVE DEVICES	Verify: 1. Integrity of Fuses 2. Operation of Circuit breakers and RCD's (perform short circuit tests) 3. Operation of Solar Array Isolation Devices 4. Operation of earth fault protection system **Earthing** Check for: 1. Tightness of Connections 2. Corrosion 3. Solar Panels earthing condition 4. Inverter earthing condition 5. Solar farm earthing condition Conducting an earth resistance test and confirming that value is within accepted limits.	Annually	Correct and improve earthing if necessary	Technical focal persons
BATTERIES	Check: 1. For carbons on the battery terminals. If found, grease the terminals 2. Voltages of the various batteries for their threshold Ensure long term record keeping of battery state of charge (soc)	Quarterly		Technical focal persons
INVERTER	1. Visual inspection, external cleaning and blowing of dust from vents and fan areas Use dry cloth to wipe away dust 2. Verify that LEDs are working properly and wiring is intact.	Quarterly		Technical focal persons
MOUNTING STRUCTURES	Visual check of stability, rigidity, fixing and tightening of the mounting rails, bolts and clamps on panels as well as other fastening devices to verify their integrity.	Quarterly		Technical focal persons
	Inspection for Corrosion	Biannually		