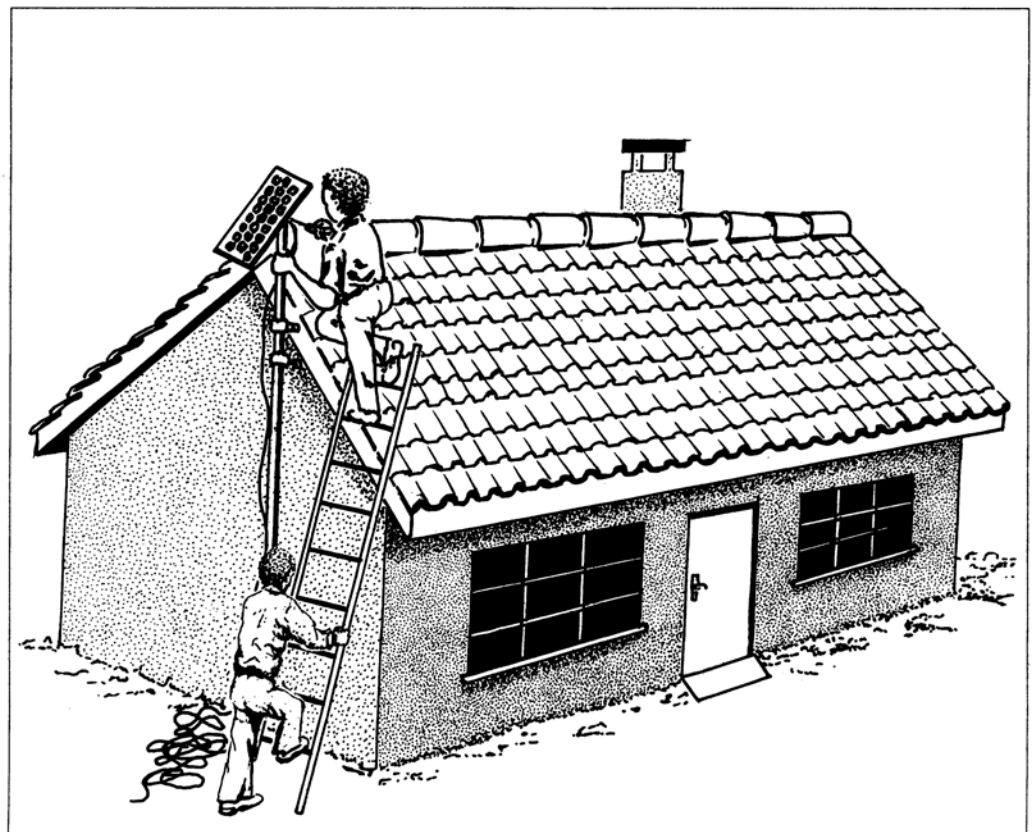


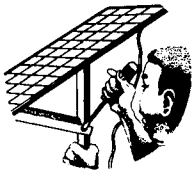
Chapter 11

Installing a System

This chapter describes the actual process of installing a solar electric system. It guides the reader through the following tasks:

- *Preparation of tools and materials necessary to complete an installation;*
- *Positioning, mounting and wiring solar cell modules;*
- *Positioning and wiring the control and batteries;*
- *Laying the cables;*
- *Making and inspecting the final connections before commissioning the system; and*
- *Training the system managers.*





Installing a System

Warning:
Installation should be performed by qualified personnel only.

Warning:
Do not connect cables to the modules, controller or batteries until the final connection sequence.

Foreword to Installation

Once a system has been planned and the necessary equipment obtained, installation can begin. In all cases, a qualified electrician should supervise work to ensure that the system is installed according to the local electric safety codes, and so that no person is injured or equipment damaged during installation.

The installation methods presented in this text are based on techniques used by several companies in rural East Africa. The effectiveness of these methods is demonstrated by the fact that thousands of small systems have been installed using these techniques since 1984. The methods are, in general, similar to wiring practice already familiar to East African electricians although they are adapted to low voltage dc principles.

Recommended Installation Procedure

1. Check to make sure that all equipment is on site.
2. Lay cables to loads. Attach lamps and sockets.
3. Locate site for solar modules, lay cables and install array.
4. Locate site for battery, lay cables and install.
5. Locate site for controller, lay cables and install.
6. Complete the final connection sequence and commission system.

Installation Tips

- Before beginning an installation, make sure that all equipment is at hand. This includes tools, materials, necessary spares and information resources. Solar electric installations are often conducted in remote areas where equipment and spares are not available. Installations have been delayed (at great cost to the electric agent) because there

were not enough connector strips carried to site, or because a certain special screw was missing!

- Follow the recommended sequence of installation. Do not connect appliances, lamps, batteries or solar cell modules to the control until the last step. Follow the final connection sequence carefully (see pages 89 - 90).
- Complete the installation with help from an electrician.
- Always try to use proper tools for each task (see next section).
- Maintain high work standards. Work standards refer to the way the wires are laid, the consistency of switch placement, the method with which fixtures are attached to walls and the general neatness of the work. High standards will make the system look more attractive and last longer, and will add to the system safety.

Tools and Materials

It may be difficult to obtain tools, extra parts and equipment on site. For this reason, make check lists of all the materials and tools needed during installation before departing for the installation site. This list should be carefully cross-checked during trip preparations. Use the information gathered during the planning stages (i.e. the map of the site, the worksheets and the circuit diagram, see Chapter 9) together with Tables 11.1 & 12.1 to make the check lists.

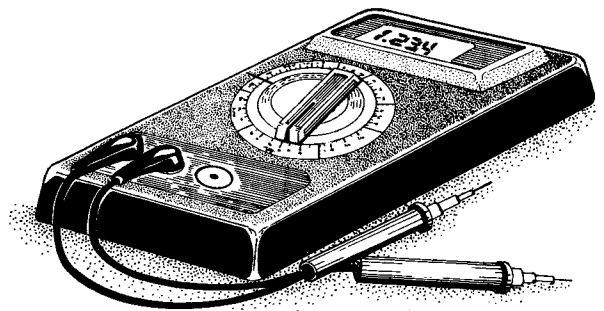


Figure 11.1
Digital volt meters are extremely useful when installing and repairing solar electric systems



Installing a System

Table 11.1: Recommended Tools for a Solar Electric Installation

Tool	Purpose of Tool
Crimp tool	Attaching ring and spade terminals to wires
12V dc Soldering iron	Connecting wires to terminals, fixing electrical parts
Voltmeter	Testing connections, measuring voltage
Screw drivers (star & flat-bladed)	Tightening screws and terminals
Hydrometer	Measuring battery state of charge
12V drill & drill bits	Drilling holes for various purposes
Tape measure	Measuring distances and marking wire clip placement
Pencil & paper	Taking notes on measurements
Hack saw	Cutting metal frames
Utility knife	Various cutting jobs
Wire cutter & stripper	Preparing cables
Torch	Laying wires in dark places (ceiling)
Pliers	Holding bolts and nuts during tightening
Adjustable spanner	Tightening battery terminals
Hammer	Various construction tasks
Shovel	Digging trenches
Level	Checking grade of mount, laid wire and foundations
File	Smoothing rough surfaces after cutting
Extension cord	Running power from batteries to tools
Inclinometer & compass	Fixing the angle of solar modules
Product literature for system components	Source of reference information

Unless you have a portable generator, there won't be 240 volt power for tools. Thus, all power tools must be rated at 12 volts dc to be powered by the batteries or solar modules. Upon arrival at site, the batteries should be filled (see page 88) and connected to the modules for charging so that there is power for tools and lights during the installation work.

The installation, maintenance, and troubleshooting work described in Chapters 11 and 12 requires that installers use a voltmeter, preferably a digital voltmeter (DVM). Voltmeters are useful when checking for broken wires (continuity), polarity, and when measuring voltage of modules and batteries. Many digital voltmeters also allow measurement of current. Make sure you are familiar with the use of the

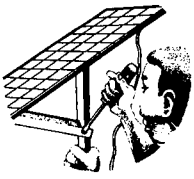
voltmeter, as a mistake could damage the meter or cause injury (consult the manual if necessary).

Safety

Solar electric systems have a good record for safety. Nevertheless, installers should be aware that the equipment they are working with has potential to cause serious injury if safety standards are not observed. In the remote areas where many systems are installed, there are few doctors or hospitals, so it is especially important to use care to avoid accidents.

In general, to avoid shock risks when working with electricity you should:

- always remove rings and jewelry;



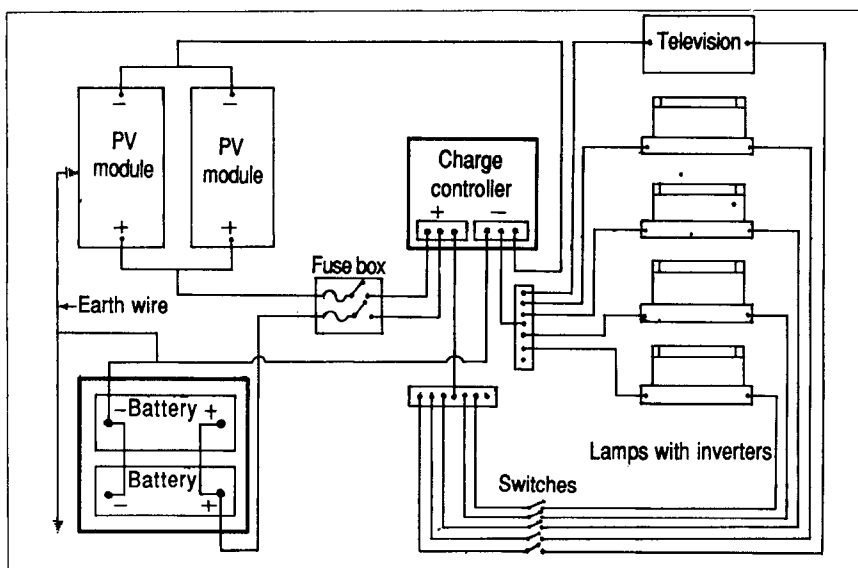
Installing a System

- use insulated tools;
- keep loose cables and metal tools away from the control, batteries and arrays so that they do not accidentally come into contact with live terminals or leads;
- always be aware of possible shocks from modules and batteries, and take steps to avoid them.

Batteries need to be handled with special care.

- Battery acid is extremely corrosive. It can destroy clothes, burn skin or cause blindness if it comes in contact with the eyes. Wear protective clothing and glasses, and use a funnel to avoid splashing when filling cells. *Always* keep fresh water available to rinse spilled acid off clothes, hands and eyes. Baking powder (*chapa mandasi*) neutralizes acid spilled on clothes and on the floor.
- Batteries are heavy. Carry them upright, from the bottom, or by the handles provided. *Never* lift batteries by the terminals.
- Make sure that batteries are located in a ventilated space. Do not smoke near batteries.
- Beware of electrical current in a battery. If the terminals of the battery are accidentally shorted, someone could get a bad shock.

Figure 11.2
Circuit diagrams are used by electricians to plan wire layout. This circuit diagram is for the system described on page 67.



Modules are expensive and potentially breakable, so:

- Transport with care. Beware of the back side of the module which is especially fragile.
- Beware of shocks when wiring and installing modules. One 40 Wp cannot easily cause a lethal shock. However, several modules in series or parallel are more dangerous. Disconnect or cover the array with a blanket when wiring to avoid shocks.

Ladders/Roof Mounting. A high percentage of the injuries from solar electric installations are caused by falls from the roof. When on the roof:

- Use stable ladders, and position them correctly. Have somebody hold the bottom part of the ladder.
- Use ladders or planks while walking on the roof to prevent the tin (*mabati*) from ripping.

First Aid kits should be on the site during any installation.

- Keep the kit well-stocked and ready.
- Make sure someone knows how to use it.

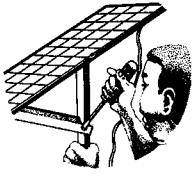
Wiring the Load

Wiring of the house or building is usually the first task during a solar electric installation. This is especially useful if the installers need a place to work, because the installed lamps and tools can be temporarily connected to the battery in one room, providing a convenient place to organise and conduct assembly work even after sunset.

Wiring Guide-lines

During wiring of the load (and the other system components, as well) the following guide-lines should be followed:

1. *Use a circuit diagram.* Keep a copy of the diagram near the control box. The more complex a system is, the more useful a circuit diagram will be for electricians who want to repair the system in the future. If, for example, a



Installing a System

A labelled cable can be easily identified if it gets disconnected.

school lighting system is to be expanded later, a circuit diagram will enable electricians to quickly understand how the system is wired.

2. *Follow established cabling colour codes.* Electrical cable is insulated with colour-coded covering which specifies its function. Systems that do not use proper wire colouring are both illegal and dangerous. The established East African wire colouring codes are given in Appendix 4.
3. *Label cables.* Pieces of labelled electrical tape fixed onto cable from connector strips, batteries and/or charge controllers enables quick identification of the cable without the need to waste time following it. For example, a positive cable from a control panel to the array should be labelled 'ARRAY +'. With a label, the wire will still be identified even if it accidentally gets disconnected.
4. *Always double check polarity when wiring.* It is easy to fix the wrong cable to the wrong terminal. If this is done with a load wire, then an expensive fluorescent lamp or appliance could get ruined by reversed polarity. Modules will be damaged by reversed polarity.
5. *Earth module frames and loads.* It is always good practice to earth systems for safety and for protection from lightning (see page 52). The larger the system and array, the more important earthing is.

Low Voltage Wiring Practice

Because of the voltage drop that occurs in the case of poor connections, all connections should be as tight and secure as possible. Always use stranded wire in low voltage applications.

When preparing cables:

- Cut the exact amount of insulation required from the end of the wire;
- Avoid cutting the small strands in the wire;
- Twist the wire strands before inserting them into connector strips.

When laying cables:

- Use correctly-sized connector strips for joining cables.
- Never allow 'twist' connections between cables as they are likely to come apart or cause a voltage drop.
- When tightening screws in connector strips and terminals, turn the screw until it is tight enough for a secure connection, but not so tight that it cuts the wire.
- Locate all connections so that they are accessible.

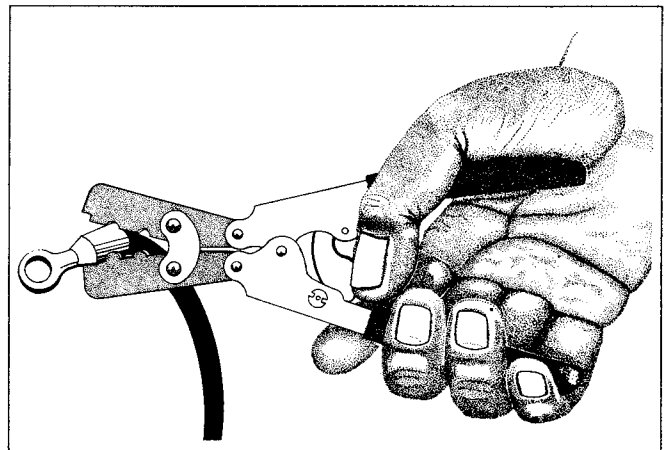
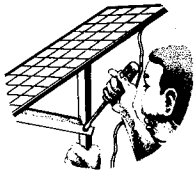


Figure 11.3

Crimping tools are special types of pliers used for making electrical connections. They securely attach 'ring' and 'spade'-type connectors to the end of wiring cable, by pinching (i.e. crimping) the metal connector collar tightly around the end of the wire. Ring or spade-type connectors attach more securely to terminals than bare wire.

- Use a crimping tool if one is available. Crimping tools and connectors make secure electrical contacts and enable work to be done quickly (See Figure 11.3).
- Clip cables neatly to the wall, spacing



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Solar cell modules should be mounted in a place where they can receive a maximum of solar radiation, but where they will not be shadowed, overheated, or covered with dust.

the clips at regular intervals, or run cables in conduit that is properly fixed to the wall;

- Make sure all wire runs are clipped so they run exactly horizontal or vertical (use a levelling tool);
- Place light switches and power sockets in wall-mounted pattress boxes.
- When positioning switches and sockets, consider needs of users.
- Use standard OFF and ON positions throughout the installation (OFF is up in East Africa).
- When laying conduit outdoors, make sure it is supported every three metres, and within six cm of the electrical box.
- Make sure controller and junction boxes are sealed, as spiders and wasps like to use such boxes as homes.

Mounting Solar Modules

Before installation begins, the mounting location and the method of mounting should be chosen. Solar cell modules should be mounted in a place where they can receive a maximum of solar radiation, but where they will not be shadowed, overheated, or covered with dust. They should be located as close as possible to the batteries and control, and in a place that is safe from vandalism and theft.

Handling Solar Cell Modules

Solar cell modules, like any other pieces of glass, can be broken. However, the glass used to make modules is a very strong type designed to withstand the impact of falling hailstones. Modules can be broken by thrown rocks, and they may break if they are dropped. Once broken, it is likely that a new module will have to be bought, as modules are almost impossible to repair.

Care must be taken when transporting modules. The back side of modules especially should be protected

during travel or work. Hard, sharp objects (such as screw drivers) which strike the back of the module can break a cell from behind. Even if only one cell is broken, the module will be ruined. Modules should never be twisted, as this could break the cells inside.

If holes must be drilled in the frame for mounting purposes, take care not to punch through the frame into a cell. Use a piece of wood behind the frame to prevent such an accident. Better still, use the holes that were drilled in the frame at the factory.

Choosing The Mounting Site

The most important consideration in the search for a mounting place for the module is that it gets as much sunlight as possible. When choosing the place to fix the module (or array), the following points should be taken into consideration.

Modules should be located:

- off the ground, if possible, so that they are out of the dust and out of the way of humans and animals. Do not locate modules near chimneys or kitchens lest they be covered with soot and smoke.
- in a place where they will not be covered by shadows. Check the position of the sun during different times of the day (and during different seasons) to determine whether shadows from trees or other objects will fall on the intended module location. Even if one cell is shaded, the output of a module will fall considerably.



Figure 11.4
Module site. Do not place module where it might be shaded by trees or obstructions.



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Between the module and the battery or control, use a cable with a great enough diameter to ensure that the voltage drop is less than 5%.

- in a place where they will not get too hot. If fixed on a tin roof, modules should be at least 10 centimetres off the tin roof top. If possible, the module should be located where it will be cooled by the wind.
- in a secure place. Do not place modules where they might be stolen. Do not locate them where they might be vandalized or hit by stones.
- in a place that is as near as possible to the batteries and control. If the modules are located too far from the control and batteries, there will be a voltage drop and power loss. Use a wire with a thickness great enough to ensure that the voltage drop is less than 5% between the modules and battery (see Chapter 8).

Method of Mounting

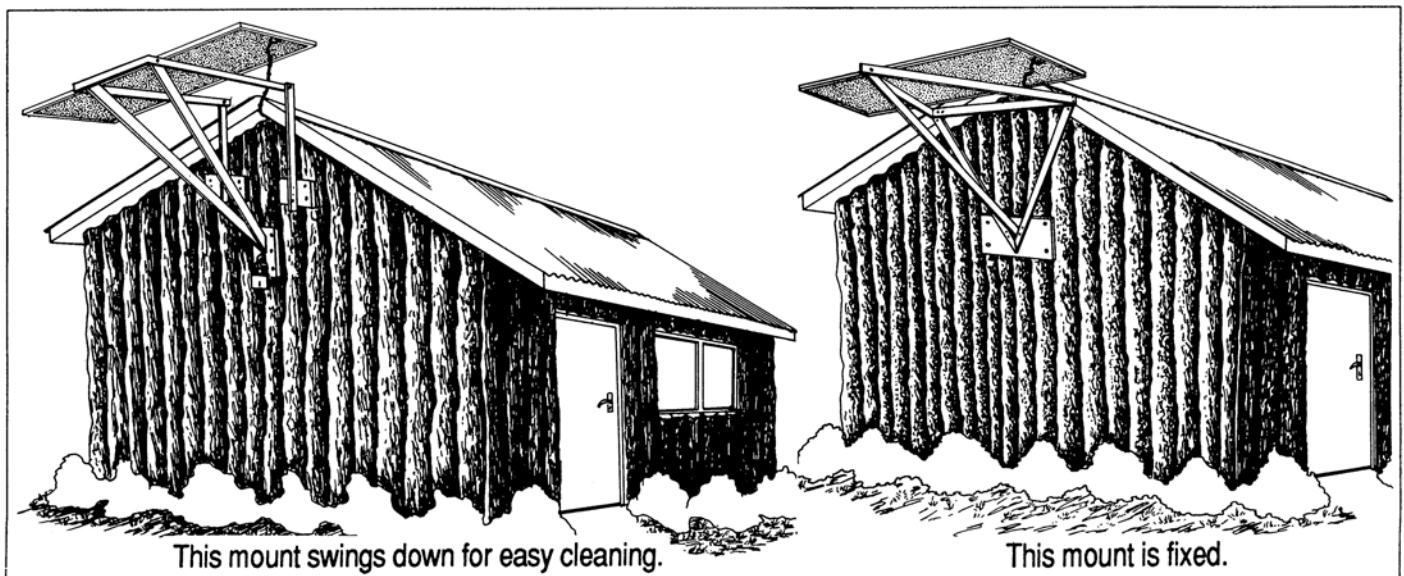
Once the site has been chosen, it is necessary to decide whether the array will be mounted in a *fixed* or *tracking* position. Solar electric suppliers supply mounts (or plans for mounts), and will be able to help decide which mount is the best for a given installation.

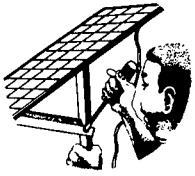
Tracking equipment, however, adds extra cost and complications to the system, and increases system management work. In East Africa, a cheap, easily-operated tracker that increases module output by 25% has been developed (see page 15).

If the module is to be mounted in a *fixed position*, then the decision should be made as to whether it will be mounted on the roof, on a pole or on the ground. Fixed mounts must be rigid, flat and well-ventilated. They must also be strong enough to withstand the strongest expected winds in the location without bending or breaking.

- Roof top mounts use racks or brackets to fix the array to the roof structure. Their advantage is that they are safe and secure, although it may be difficult to clean modules mounted high on the roof. Brackets may be constructed so that they pivot downward for easy cleaning (see Figure 11.5), or so that their angle can be adjusted seasonally.
- Pole mounts are popular with systems that have up to four modules. They keep the modules well off the ground in secure highly visible places. Pole mounts are more expensive than roof top mounts, as they require metal pipes (6 cm steel poles) and, sometimes, a foundation. Note that small pole mounts are easily converted into trackers for one module systems.
- Ground mounts are used for arrays of four or more modules (i.e. for water pumps, refrigeration or large home systems with no other suitable place to locate the modules). They secure modules to racks fixed in concrete found-

Figure 11.5
Two fixed roof top
mount designs





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Check with solar dealers to find what tilt and direction fixed modules are commonly mounted at in your area.

dations and may be fenced off to protect the array from animals and curious people. Under normal circumstances, a one or two module system would not be ground mounted.

Fixed mounts must be aligned so that rain-water runs off the modules (i.e. they must have at least a 5° tilt), and so that the modules face the direction where they are likely to get the best sun. In Kenya, modules are usually mount with a tilt of 10° to the north. This is because the cloudiest season in Kenya is between April and July when the sun is in the northern hemisphere, and the tilt enables the system to make best use of the sun when it does appear in the cloudy season. Check with local solar dealers to find what tilt and direction fixed modules are commonly mounted at in your area.

Construction of Mounts

Once the type of module mount design has been chosen and the required materials obtained, the mount can be assembled. Most solar electricians are familiar with mounting methods, and can help in the assembly and installation process.

When constructing all types of mounts (both fixed and tracking) corrosion-resistant, weather-proof parts should be used. Stainless steel and anodized aluminium angle irons are commonly used to make mounts in East Africa. If the steel used to make the frame is not weather-proof, then it should be coated with a layer of red oxide paint to prevent corrosion. Wood can also be used to build mounts inexpensively, but wooden mounts do not last as long as metal ones. Note that bolts, nuts and washers should also be weather-proof and corrosion-resistant.

When mounting modules on the roof, use ladders and walk boards to protect roofs from the weight of installers. Minimize the number of people on roof. Bolt the mount securely to roof timbers, or to the "facia board" at the peak of the roof (see Figure 11.5). Avoid tears in tin which cause rain leakage.

When installing an array with several modules, attach the modules to the frame

on the ground, and then attach the frame to the fixtures on the roof or pole.

Wiring the Modules

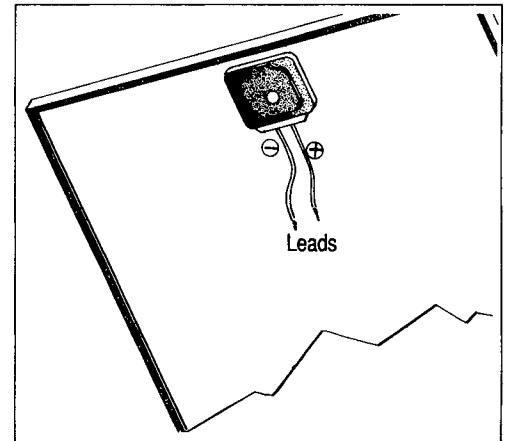


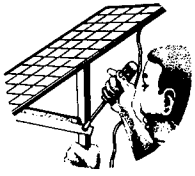
Figure 11.6
Backside of module showing leads from junction box.

Unless the batteries are being charged to power equipment during installation, *do not* attach the module leads to the battery or control until the *final connection sequence*. The following practices are advisable during wiring:

- Use properly sized cable.
- Earth the entire array (as described in Chapter 8) by connecting the frame and negative terminal of each module to an earthing cable.
- Wire the junction boxes carefully. Use a soldering iron or crimp tool to make sure that the connections are good. Make sure that the junction boxes are well-sealed to prevent possible corrosion.

If there is *more than one module* in the array, then the modules must be wired in a configuration that matches the system voltage. Two questions should be answered before attempting to wire modules together:

- How many modules should be wired in series?
- How many modules should be wired in parallel?



Installing a System

(The principles of series and parallel circuits are discussed in Appendix 2)

Most small systems in East Africa have a voltage of 12 volts. Likewise, most modules commercially available in East Africa produce current that approximately matches the charging characteristics of 12 volt batteries. Such modules are always wired in parallel in 12 volt systems. Figure 11.7(a) shows two 10 Wp amorphous modules wired in parallel to charge a 12 volt battery.

If the system voltage is 24 volts, then two standard modules must be wired *in series* to charge two 12 volt batteries *in series*. Figure 11.7(b) shows 2 modules in series charging two batteries wired in series.

Always consult a qualified electrician to make sure that the series and parallel wiring of modules and batteries has been properly done.

The battery should be located in a cool, vented room where there is little traffic.

Battery and Controller Installation

After installing the module, the battery and controller should be installed in the most appropriate room or building.

Choosing the Battery Location

The battery should be located in a cool, vented room where there is little traffic. The following recommendations should be followed when locating and installing the battery:

- *Nearness to array.* The battery should

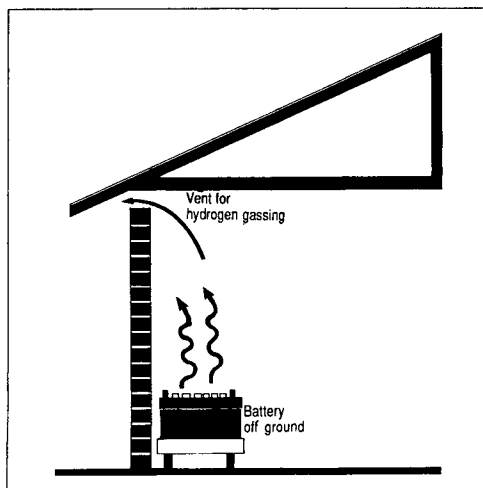


Figure 11.8
The battery should be located in a place that is well-ventilated.

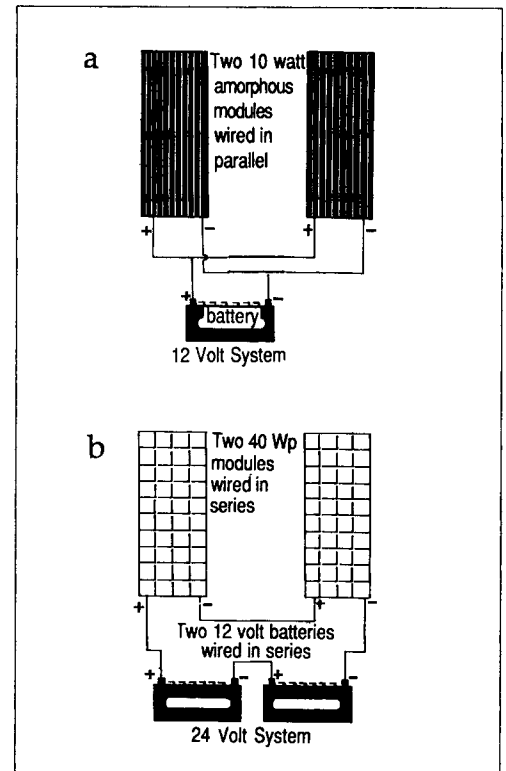
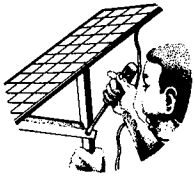


Figure 11.7 Modules charging batteries in parallel and series.

be located as close as possible to the array to reduce voltage drop. Check that the size of the cable is large enough to carry the charge current from the module without more than 5% voltage drop.

- *Ventilation.* The battery room *must* have some sort of opening for air to enter and leave. Batteries emit explosive gases when charging and this must be allowed to escape. Place a "NOSMOKING" sign in the room where the batteries are located.
- *Temperature.* The battery should be located in a place where the temperature does not get too high. If the battery temperature gets above 40°C, the battery's lifetime and performance will be reduced. *Never* place the battery where it will be exposed to the sun.
- *Battery boxes.* Batteries should not be kept on the floor, as this will increase their self-discharge rates. Batteries should be kept in a vented wooden box to reduce self-discharge, to prevent children and animals from injur-



Installing a System

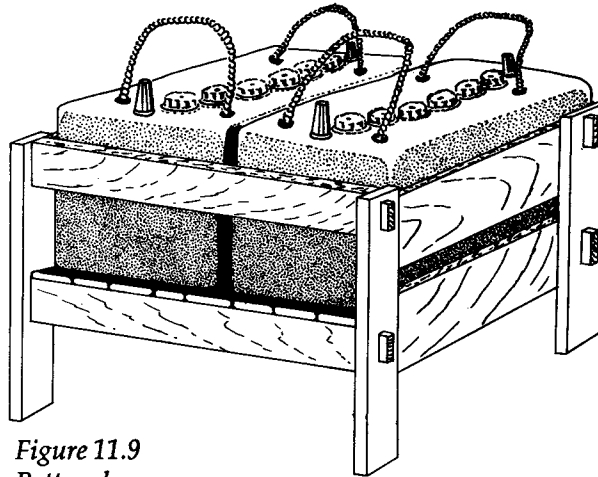


Figure 11.9
Battery box

Do not put the battery in a closet and forget it! Batteries must be maintained.

ing themselves accidentally and to prevent objects from falling on them, (see Figure 11.9). If it is not possible to construct a box, keep the batteries off the ground on a plastic or wooden tray (but not metallic).

- *Security and safety.* The battery should be located where it is secure and not likely to be stolen. Ideally, it should be in a closet or room where children and animals cannot tamper with it. However, the place should be accessible for easy state of charge measurement and cleaning. In an institution, the room where the battery is kept should be locked.

Transporting and Filling the Battery

Locally-made lead acid batteries are usually supplied *dry* for solar electric applications. This means that when they are sold, sulphuric acid electrolyte has not yet been added to the cells. The acid is supplied in plastic jerry cans (i.e. *mutungis*) which can be safely sealed for transport to remote areas. Because batteries are likely to tip and spill during transport on the rough roads, it is recommended that they always be transported dry, and acid carried separately in sealed jerry cans.

After arrival at the site, acid should be carefully poured into the batteries until they are almost full, either by using a plastic tube, or by using a funnel. Wait ten minutes for the acid to settle and then top them up. Afterwards, wipe the top of the batteries, and rinse the funnel, plastic tubes, clothes and hands that have come into contact with acid.

- Keep plenty of water around when filling the battery so that any spills can be quickly rinsed. Be aware that sulphuric acid is dangerous, and take care when pouring it.
- Wear old clothes and goggles when filling batteries. Fill them outside if possible.

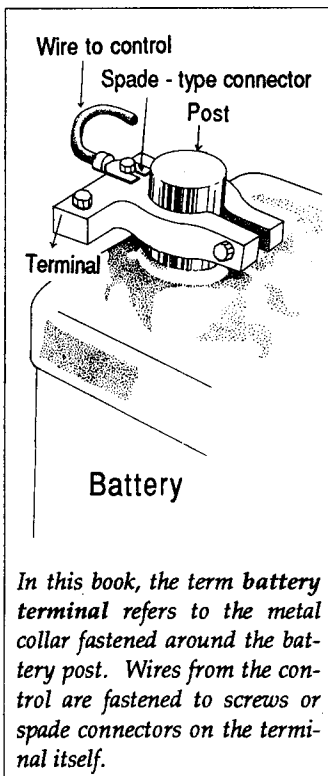
Once the batteries have been filled, they are charged and can produce a very high current. Keep tools and cables clear of the terminals and posts, as accidental short circuits are both expensive and dangerous.

Battery Wiring

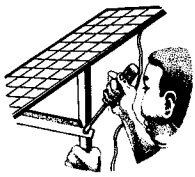
As stated previously, the cable run from the modules to the control and batteries should be as short as possible. If the modules are on the roof, run the cable through the roof space down an *inside* wall. If the modules are on a separate pole or ground mount, protect the underground cable run with conduit, and mark the place where the cable is.

If there is only one 12 volt battery, attach the cables to the battery terminals (when the terminals are *not* attached to the battery), tighten the screws and secure them. It is always better to use ring or spade-type connections on terminals than to simply wind the wire around the terminal screws. Unless the battery is being used to power tools and lights, leave one terminal disconnected from the battery until the final connection sequence. Coat the outside of the terminals with a thin layer of petroleum jelly. Check the electrolyte level in each cell. Check the state of charge of each cell to make sure that no cell is bad.

If there is more than one 12 volt battery, *make sure* that they are arranged properly in series or parallel. Twelve volt batteries in 12 volt systems are arranged in *parallel*. If there are two 12 volt batteries in a 24 volt system, they should be arranged in series. If there are four 12 volt batteries in a 24 volt system, two should be in series and two should be in parallel.



When wiring, have an electrician check series and parallel connections.



Installing a System

Final Connections

For final connections in small systems, the guide-lines below represent a method of safely commissioning the system. These guide-lines are designed for systems that use charge controllers, but the order can be adapted for systems that do not use controllers.

- AN ELECTRICAL TECHNICIAN PROPERLY TRAINED AND EXPERIENCED WITH SOLAR ELECTRIC SYSTEMS SHOULD MAKE THE FINAL CONNECTIONS. This supervisor should conduct commissioning tests of the array, the junction boxes, the support structure, the solar modules, the control unit and the battery.
- Follow the manufacturer's instructions for controls and inverters.
- If the installation is for an institution, there should be an official handover to the operator/client with some type of receipt/record of transaction to mark the occasion.

Caution:

Solar electric equipment is expensive. Damage to the equipment can be prevented by following the four steps slowly and carefully.

Before commencing with the final connection sequence, the wires should have been installed without being connected to the control terminals. Before beginning this process, disconnect fluorescent tube lamps to allow a polarity check to be made.

1 Connect the Wires from the Battery to the Charge Controller

Make sure that the wires are securely connected to the battery terminals, and that the inside surface of both terminals is clean and shiny. Make sure the battery posts are clean. After checking to make sure that the wires are *not* touching the control terminals, place both terminals on the battery posts without tightening the clamping bolts (this will enable them to be removed quickly if there is a problem). The black wire should be connected to the negative (-) and red wire should be connected to positive (+).

Connect the black negative wire to the indicated negative terminal on the controller (i.e. BATTERY -), and tighten. Touch the red power wire to the positive BATTERY terminal on the control very briefly. If there is a spark, the controller may be defective, or there may be some other mistake; so re-check the connections. If there is no spark, connect the positive red battery cable to the terminal and tighten.

2 Connect and Check the Load

Since the battery is connected, power is now available to check the wiring of lamps and sockets in the load. Before beginning, all dc globe lamps should be removed from their lamp holders and no fluores-

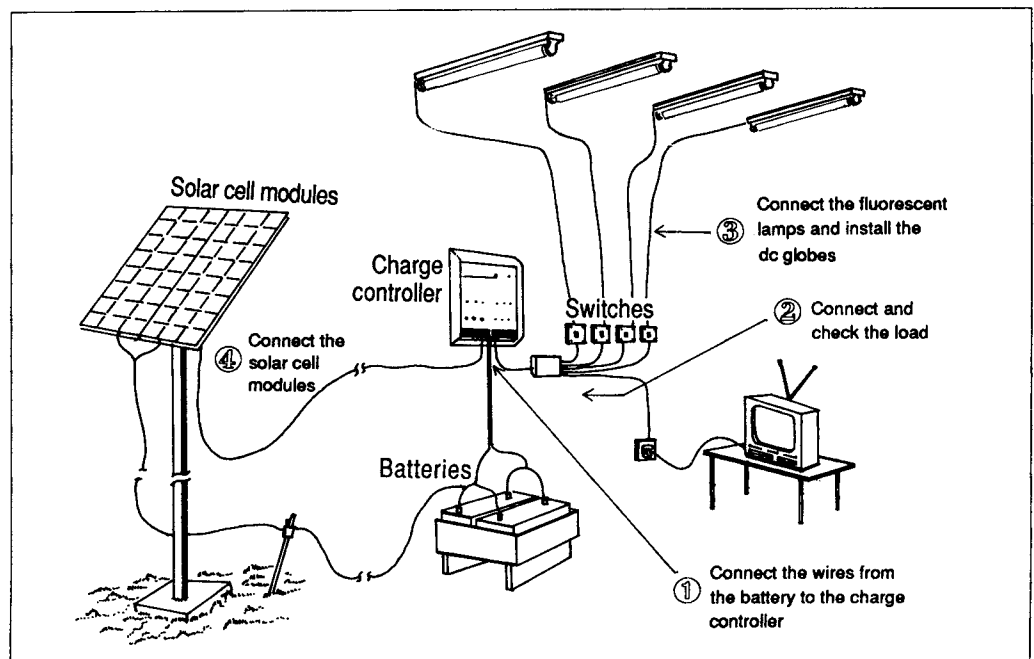
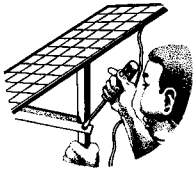
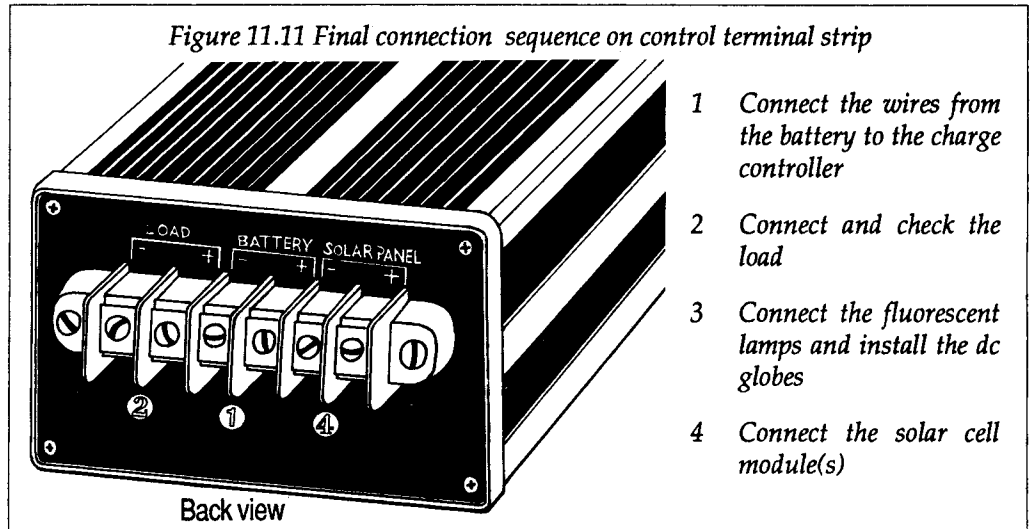


Figure 11.10
Installation sequence in a
solar electric home system



Installing a System

Figure 11.11 Final connection sequence on control terminal strip



cent tube lamp should be connected (if sockets are on the same load circuit as the lamps, disconnect the positive wire from each socket). First, connect the negative wire from the lamps circuit (or *load circuit* if there is not a separate lamps and socket circuit in the system) to the negative load terminal on the controller, and turn the main switch ON. Touch the positive wire to the positive load terminal and check for sparks. There should be no spark since all of the lamps (and sockets) have been disconnected. If there is a large spark and/or a fuse has been blown, then there must be a short circuit somewhere. Find it and fix before proceeding. If there is no spark, then the wires can be fixed to the control terminals.

Polarity of the fluorescent tube lamp wires should now be checked using a voltmeter. If the polarity is wrong, fluorescent tube fixtures will be damaged. Set the voltmeter at the DC VOLTS scale, and connect the red voltmeter wire to the red fixture wire (from the battery) and the black voltmeter wire to the black fixture wire. Have someone switch the lamp ON and read the voltage on the voltmeter. If the voltmeter displays the system voltage, then the polarity is proper. Repeat this test for each fluorescent lamp (polarity does not matter with globe lamps).

Now check the socket circuits (if there is a separate outlet circuit on the control and load). Connect the black wire from the

sockets to the proper terminal on the control, and touch the red wire briefly to the positive terminal with the "sockets" main switch turned ON. If there is no spark, secure the wires to the terminals.

Polarity of each socket should be checked with a voltmeter. Reversed polarity in sockets will damage some dc appliances such as televisions. An easy way to check outlets is to use a three pin plug with the cover removed. Insert the plug into the socket, and check the polarity by touching the red meter wire to the 'L' (+) terminal and the black meter wire to the 'N' (-) terminal.

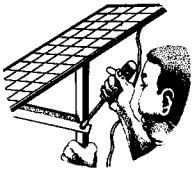
3 Connect the Fluorescent Lamps and Install the dc Globes

Now that the polarity has been checked, the tube lights can be connected and put into service. After connecting each lamp, turn it ON to see if it lights properly, and to check if the switch is properly installed (OFF is up). When connecting the fluorescent lamp leads, note that in some wire coding systems, white lamp leads are *negative* and black lamp leads are *positive* (read the label for details). At this point, the dc globe lamps can also be inserted into lamp holders, and checked for proper operation and switch placement.

4 Connect the Solar Cell Module(s)

First, turn all the lamps and sockets OFF using the main switches in the control (if there is none, turn them OFF at the room

Polarity of the fluorescent tube lamp wires should be checked using a voltmeter.



Installing a System

switches). If there the array is above 60 Wp, cover it with a blanket before wiring. Connect the cable leading from the control to the module leads (or terminals), observing proper polarity. Some types of modules have terminal boxes, while others have long cables (leads) attached to the back of the module. A junction box should be used to make the connection with the wire to the control. Use connector strips inside the box; seal and fix it to the mount when finished. Once the connections are complete, you can remove the blanket from the array if necessary.

Now, connect the black charge wire leading to the module to the negative SOLAR terminal of the controller. Meanwhile, attach the voltmeter to the battery terminals. Write down the battery voltage. Touch the red charge wire to the control terminal briefly. If there is a charge indicator light it should come ON, and the battery voltage should jump between 0.3 and 0.4 volts (depending on the time of day).

If no problems have been encountered, secure these wires. The system wiring is complete, and it can now be safely commissioned and used.

User-Training

As explained in the next chapter, not much is required in the management of a solar electric system, but it *does need to be managed*. The person who installs a system is usually not the person who operates and maintains it. It is crucial to the success of the system that the users learn how to manage

and maintain the system. This means that during the installation process, someone must teach the person responsible for managing the system what he or she needs to do.

The system manager needs to learn the following:

- *Maintenance routine.* What tasks need to be completed and how often (i.e. on a daily, weekly or seasonal basis)? Which tools are required and how are they used?
- *Expected service operations and schedule.* Which parts wear out and how are they replaced? Where are they available? The system manager should be given a schedule of the service contract (if there is any).
- *What records need to be kept?* In some systems, particularly institutions, records should be kept regarding the age and condition of the batteries (they will have to be replaced), the place of purchase of system components, and the electrical details of the system (i.e. circuit diagrams). The manager needs to be shown how to keep these records.
- *What to do in case of breakdown.* The manager should know who to contact in the case of a problem that cannot be solved on the site. There should be some kind of regular contact (at least annually) between the operator and the sales agent or installer.

It is crucial to the success of the system that the users learn how to manage and maintain it.