GEF Solar Chill

Training Module 2

INSTALLATION

TOPICS FOR INSTALLATION MODULE

1. Checks prior to installation
2. Safety
3. Tools and equipment
4. Site preparation
5. Refrigerator installation
6. PV installation

CHECKS PRIOR TO INSTALLATION

- Relevant skills with locally-sourced manpower
- All equipment, materials and tools needed for installation must be available prior to any work
- Relevant training if needed prior installation
- Well designed installation coordination helps with a successful installation of the units

Skills and experience are mediated during this training

CHECKS PRIOR TO INSTALLATION

- Site Pre-Assessment
  - Facility profile
  - Local conditions
  - Building and refrigerator placement
  - Solar PV site assessment (roof, ground, pole,…)

CHECKS PRIOR TO INSTALLATION

Local conditions

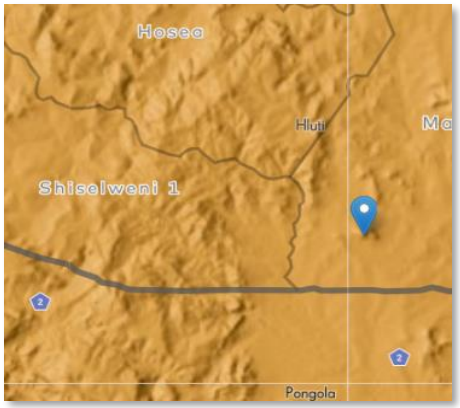
- Environment
  - Climate and terrain

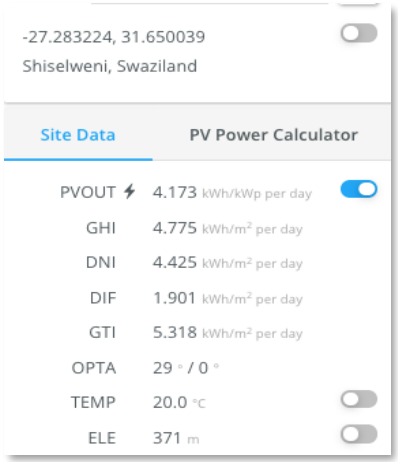
- Risks
  - Drought, Earthquake, Flood, Forest Fire, Landslide, Windstorm, Wildlife & Livestock
  - Theft, Vandalism, Security

CHECKS PRIOR TO INSTALLATION

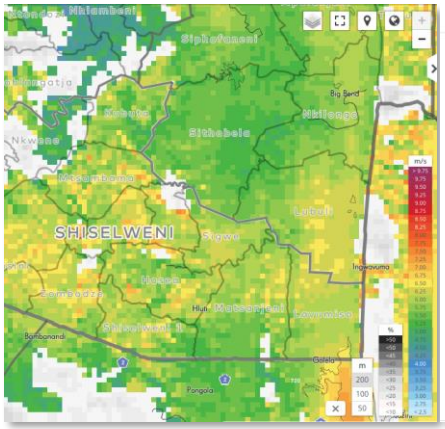
Climate and Terrain

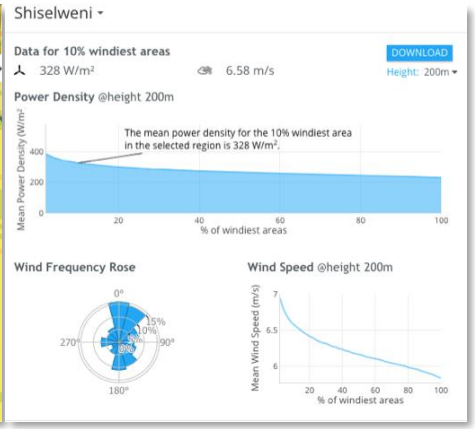
- Solar irradiation
  - Optimal angle for PV array
  - http://globalsolaratlas.info





- Wind conditions
  - Check array wind loading
  - https://globalwindatlas.info/





SAFETY FIRST

- Know where the first aid kit is
- Work safely
- Do not take risks
- Solar Chill appliances use R600a flammable refrigerant

Graphics: FGL/IM-PAHO And Solar Electric Light Fund

SAFETY FIRST! FOR HEALTH STAFF, PATIENTS & YOU

- Before starting know local risks
  - Keep staff, patients away from work area
  - Keep work area clean and free of hazards like packaging, falling objects, open excavations, tools out of place
  - Identify structural hazards and mitigate

- Wear protective gear as needed
  - Hard hat
  - Eye protection
  - Shoes

Photo: American Optometric Association

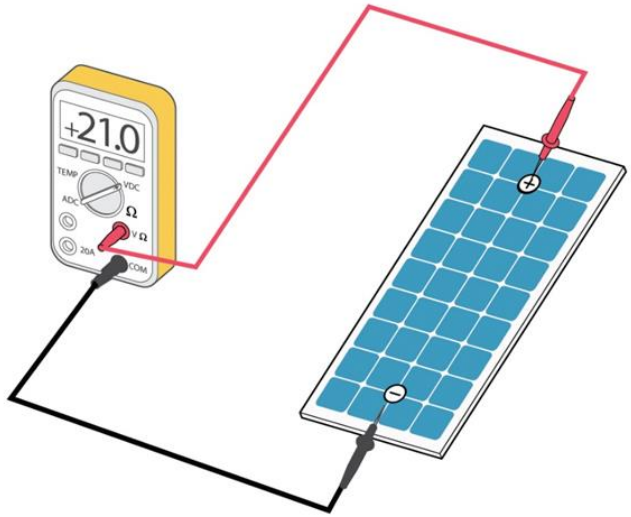
SAFETY FIRST! SAFELY WORK AT HEIGHTS

- Take extra precautions when working at heights
- Always check roof structure
- Rope in on steep slopes
- Scaffold for pole work
- Prevent falling objects

Photo: FGL/IM-PAHO and Solar Electric Light Fund (SELF)

SAFELY WORK WITH DC ELECTRICITY

- DC arcing can burn you and damage connectors, cable and switch contacts
- Solar modules generate DC electricity
- Typical solar array = 300 to 400 Watts
- Voltage ranges from 0 to 45 (Voc)
- Amperage depends on solar intensity
- Amps range from 0 to 20 amps (Isc)
- Do not bypass fuse



Measuring open cercuit voltage or polarity (correct polarity +21 Vdc)

Photo: FGL/IM-PAHO and Solar Electric Light Fund (SELF)

SAFELY WORK WITH HEAVY WEIGHTS

- Solar direct drive fridges can weigh over 100 kg
- Steel poles can weight over 100 kg
- WHO PQS recommends maximum carrying load of 25 kg per person

SAFELY WORK WITH LARGE SOLAR MODULES

- Large solar modules can catch wind and become difficult to manage
- A 300-Watt module may weight more than 25 kg
- Safest to handle by two persons
- WHO PQS recommends maximum carrying load of 25 kg per person

Photo: Alex Adams Photography

TOOLS FOR INSTALLATION

12/24VDC Power Pack

Field technician Cold Chain Toolkit

TOOLS FOR INSTALLATION

- Very good list from PAHO guide

Site survey and assessment tool list

Tools to bring to site assessment

- ❑ First-aid kit
- ❑ Overnight kit
- ❑ Water / water purification filter or tablets
- ❑ Food
- ❑ Sunscreen / hat
- ❑ Notebook, pencils, pens
- ❑ Knife
- ❑ Camera (fully charged)
- ❑ Cell phone (fully charged)
- ❑ GPS (fully charged)
- ❑ Tool belt (hammer, screwdrivers, adjustable wrench, pliers, 30m & 8m tape measures)
- ❑ Multimeter
- ❑ Thermometer
- ❑ Shading analysis tool (e.g. solar pathfinder kit, dome, tripod, extra sunpath diagrams, wax pen)
- ❑ Compass
- ❑ Inclinometer
- ❑ Ladder, safety ropes
- ❑ Shovel
- ❑ Rag

SITE PREPARATION

- Dry and well-ventilated place (good air circulation especially around the compressor)
- No install the unit near heat sources or in direct sunlight
- Door big enough to pass the fridge
- Place must protect the unit against rain and dust
- Room volume:
  - Check the amount of refrigerant (refrigerant mass) used in the appliance indicated on the name plate
  - Minimum volume of room in m^3 = Refrigerant mass ÷ 8

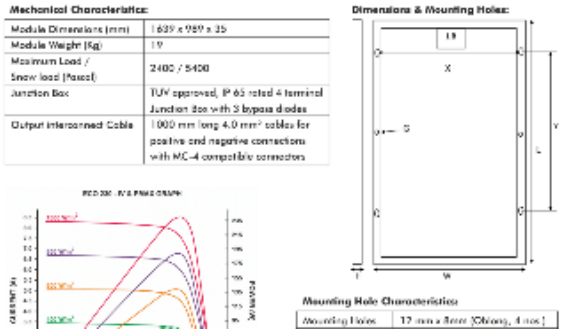
SITE PREPARATION: CAUTION

Any change of component placement (e.g. location of fridge or array) can impact the success of the installation.

The SDD kit has a fixed cable length and specific mount structure. Before accepting any change assure the installation can be completed without compromising the solar radiation on the array or requiring added cable or requiring a change of mount structure.

REFRIGERATOR INSTALLATION

- First - Read All Instructions Before Starting
  - Fridge Manufacturer Instructions: Refrigerator Manuals & Solar Manual/Instructions
  - Component Instructions: Solar Module Mfc (if found) & Support Structure (if found)
  - Project Requirements: Acceptance forms, other



REFRIGERATOR INSTALLATION

- Good air circulation, especially around the compressor
- Keep the ventilation openings of the compressor cover always free from any obstructions
- Make sure that a minimum distance is provided between the unit and any wall or other device located next to it
- Do not locate the unit below a ceiling fan or right next to air-conditioning equipment
- The device must be standing horizontally
  - Use a water level to check and to correct if necessary

PV: PRE-DETERMINED MOUNTING

- SDD Kit includes one type of mount structure
- The Kit has a standardized adjustable tilt roof/ground mount
- The mount can accommodate most sites
- Pole mount is the exception

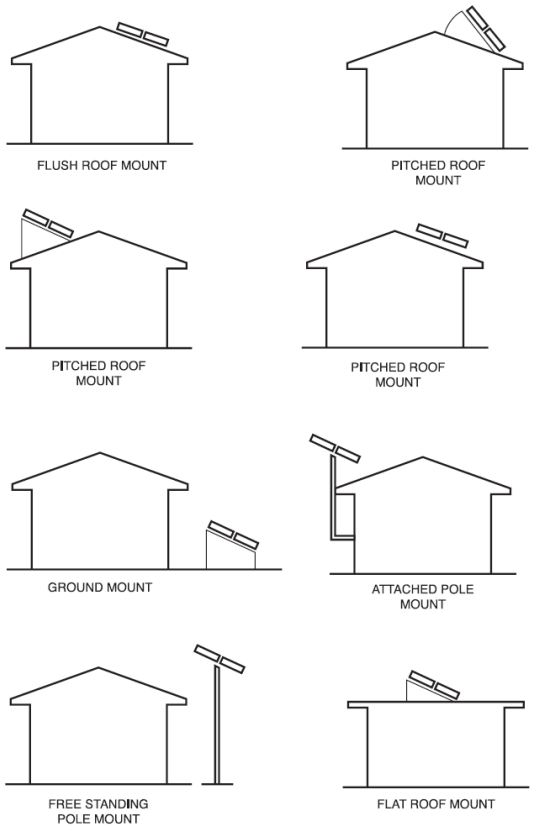
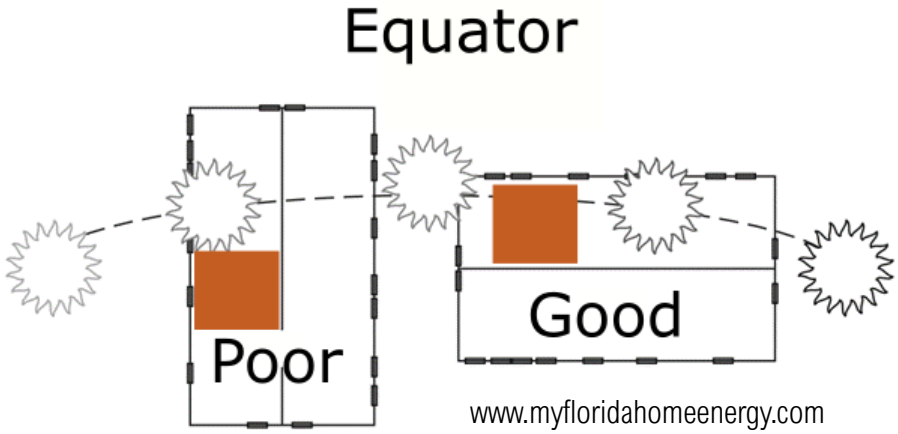


Photo: FGL/IM-PAHO and Solar Electric Light Fund (SELF)

PV: SOLAR IRRADIATION

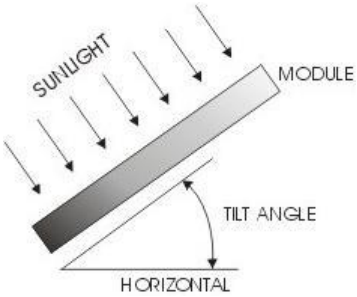
- Optimal tilt angle for PV*
  Kenya: minimum 10°
  eSwatini: 25 – 30°

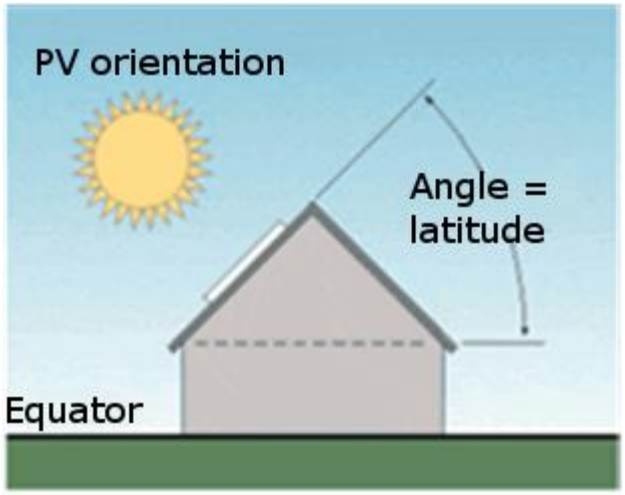
- The solar panels must face towards the equator



www.myfloridahomeenergy.com

* Kenya is near the equator and eSwatini is around 27° south





www.reuk.co.uk / www.mothermana.com

PV: POLE MOUNT

- Pole mounts can add complexity, cost and extra installation time

- Consider pole mount when
  - Roof is unstable, repair costly
  - Roof has too much shade
  - Roof orientation/tilt is poor
  - Cable is too short
  - Theft is a concern

Photo: Tamarac Solar Side of Pole Mount

PV: POLE MOUNT (cont´d)

- Plan for additional site requirements including
  - added time
  - added materials (heavy metal pole, concrete, conduit)
  - added tools and equipment (excavation, concrete, scaffold)
  - added protection (from vehicles, animals)
  - maintenance requirements (access, tools, supplies, user training)
  - added labor

Photo: Shawn McCarney Photography

PV: CONSIDER MAINTENANCE

- Important that health worker can access the array for routine cleaning
- Make safe access
- Train users to operate and maintain
- Kit may not have maintenance tools/supplies
- SC Project to obtain and provide all necessary items not found in the kits
- Photo - Note pole mount with overhead conduit for solar array cable to building

Photo: Solar Electric Light Fund

FLAT CONCRETE ROOF MOUNT

- Note the craftsman assuring the modules align
- Do not allow structure to bend solar modules or open circuit failure can occur
- Kit mount structures allow for tilt angle adjustment
- Kit may not have the correct foundation fasteners for all sites
- These must be theft deterrent

Photo: Solar Electric Light Fund (SELF)

PV: SLOPED ROOF MOUNT (WITH TILT ANGLE ADJUSTMENT)

- Kit mount structure allows tilt angle adjustment
- Photo shows multiple solar arrays for multiple SDD's at a District vaccine depot
- Some kits may not have the correct roof structure fasteners for all sites
- These must be theft deterrent fasteners

Photo: Solar Electric Light Fund (SELF)

PV: SLOPED ROOF MOUNT (AT SAME TILT, ORIENTATION AS ROOF)

- Kit mount structure allows for flush mount
- Photo shows 4 module array mounted at same tilt as roof with 10cm airspace for ventilation
- Some kits may not have the correct roof structure fasteners for all sites
- These must be theft deterrent fasteners

Photo: Solar Electric Light Fund (SELF)

PV: DO NOT POSITION SOLAR ARRAY LIKE THIS

- This array was found facing west when the orientation was specified as equator facing (e.g. face south if you are in the Northern hemisphere)
- Use the compass and follow manufacturers directions (some areas may require adjustment due to magnetic declination)
- Strike a line (pencil or chalk) for the north/south orientation
- Next strike a perpendicular line east to west to position the front edge of the array
- Install in alignment with marks

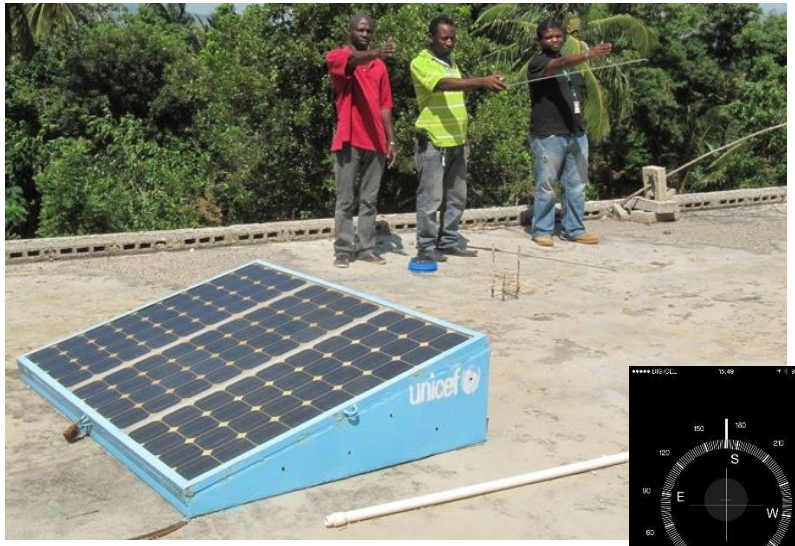


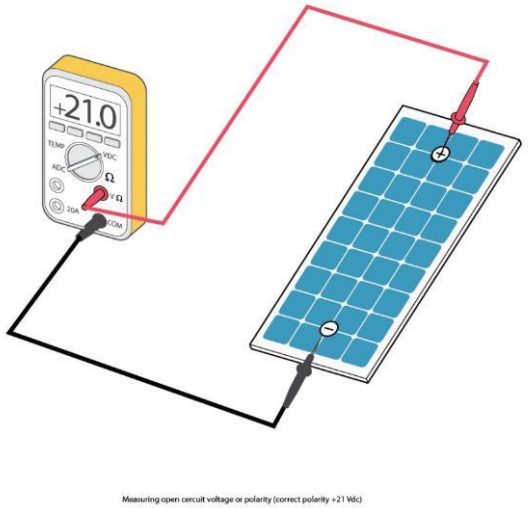
Photo: Solar Electric Light Fund (SELF)

PV: USE COMPASS AND ANGLE FINDER TO ORIENT SOLAR ARRAY TO MANUFACTURER'S SPECIFICATION

Photos on next 3 slides: FGL/IM-PAHO and Solar Electric Light Fund

PV: TEST MODULES BEFORE ASSEMBLING

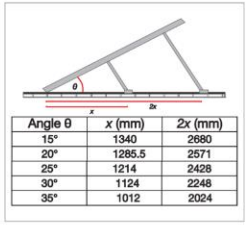
- Solar modules are very reliable and seldom arrive failed
- It is advisable to test each solar module for open circuit voltage
- Optionally test for short circuit current
- Proceed only with modules that perform as expected



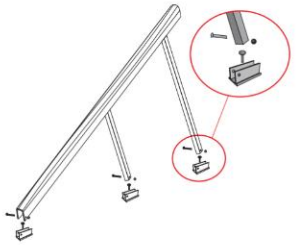
Graphic: FGL/IM-PAHO and Solar Electric Light Fund (SELF)

PV: ASSEMBLE STRUCTURE

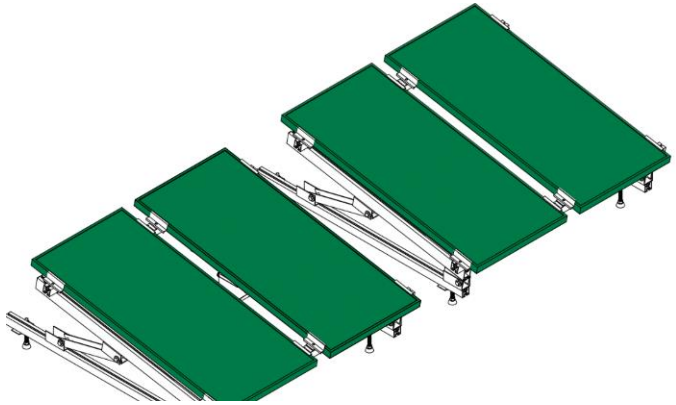
- Kit includes a specific mount structure
- Carefully follow Kit instructions
- Each manufacturer has a different design
- Assemble and add solar modules



Angle θ	x (mm)	2x (mm)
15°	1340	2680
20°	1285.5	2571
25°	1214	2428
30°	1124	2248
35°	1012	2024



1. • Attach feet to the surface so that they are correctly spaced for the required angle.



PV: DO NOT MAKE UNAUTHORIZED MODIFICATIONS

- This steel box was built to deter theft…and it worked
- But the steel box has far too little ventilation and the solar array temperatures were abnormally hot
- One module needed to be replaced (on left)
- The two modules on the right show heat damage in the EVA backing.
- Read the solar module manufacturers instruction and allow adequate ventilation.
- If no array ventilation instructions provided then build the array with a 10 cm clearance from module baking to roof or foundation
- Notice that the 2 year structure is rusting as PQS materials (corrosion resistant) were not used for the structure

Photo: Solar Electric Light Fund (SELF)

PV: FASTENING THE ARRAY

- Important connection
- For orientation
- For wind resistance
- To prevent theft all added fasteners must be theft deterrent to assure array security
- Kit may not have the correct fasteners for all sites

PV: THEFT DETERRENT FASTENING

- To prevent theft
- Cannot be installed or removed without unique tool(s)
- Standard expansion anchors with theft deterring nuts
- Aluminum module rail is connected to mounting foot with bolt with unique head and theft deterring nuts

Photo: FGL/IM-PAHO and SELF

PV: THEFT DETERRENT FASTENING

- To prevent theft
- Cannot be installed or removed without unique tool(s)
- Hangar bolt screws into wood frame under metal roof
- Aluminum module rail is connected to mounting foot with bolt with unique head and theft deterring nuts
- In some cases added stainless steel armor has protected aluminum from the hack say of a thief

Photo: Solar Electric Light Fund

PV: FASTENING THE ARRAY

- Through bolt is preferred over screws when possible
- Carriage bolt with theft deterrent nut shown
- Alternately, use threaded rod with theft deterrent nut on both ends

- Photo: FGL/IM-PAHO and Solar Electric Light Fund (SELF)

PV: FASTENING ARRAY (CORRUGATED ROOF COVERING CONTINUED)

- Corrugated roofing requires fastener to connect with firm substructure
  - Through bolts
  - Threaded rod (back support may be needed)
  - Lag screws (wood structures only)
  - J hook (metal structures typically)
- Do not screw into corrugated roofing without firm connection to substructure (e.g. rafters)
- Purlins may not be adequate structural support

Photo: FGL/IM-PAHO and Solar Electric Light Fund (SELF)

PV: FASTENING ARRAY (CORRUGATED ROOF COVERING CONTINUED)

- Corrugated roofing "peaks" are better penetration points to avoid leakage
- Horizontal supports rest on peaks or attach to raised mounting feet as shown in image
- Rear legs adjust tilt angle and often require cutting on site to provide tilt angle on tilted roofing
- Use sealant on all penetrations

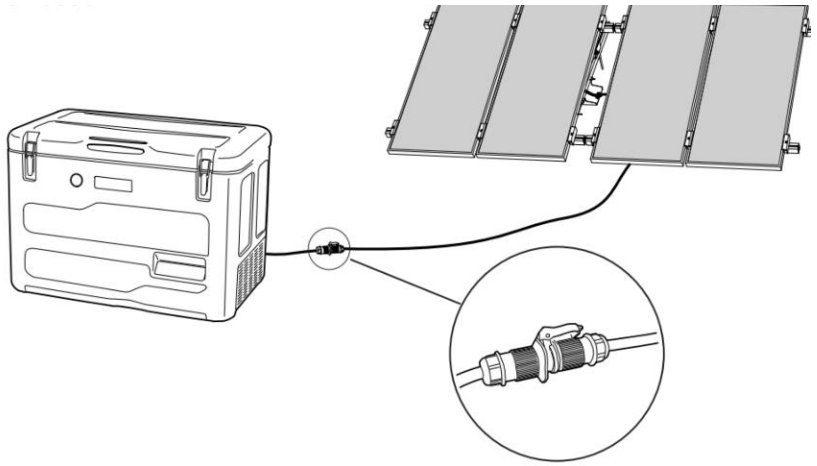
PV: FASTENING ARRAY (CORRUGATED ROOF COVERING CONTINUED)

- Through bolt from previous slide through metal roof covering, sheathing into added back support
- Back support fastened to adjacent roof structure in 2 places

- Photo: FGL/IM-PAHO and Solar Electric Light Fund (SELF)

PV: CONNECT THE SOLAR ARRAY TO FRIDGE

- Solar array cable connects the fridge to the array
- Cable is rated for sunlight exposure
- “Plug and play” connectors are outdoor rated (IP 65 or more)
- Do not position cable or connectors where they will lay in water



PV: CABLE ENTRY (THROUGH THE WALL)

- Do not enter cable through open windows or through window materials
- Metal can cut cable
- There is no strain relief
- This installation would fail acceptance

Photo: Solar Electric Light Fund (SELF)

PV: CABLE ENTRY (SLOPED ROOF)

- Do not enter cable through the roof like seen here
- Metal can cut into cable
- Roof can leak
- This installation would fail acceptance

PV: CABLE MANAGEMENT

- Most kits will supply some type of cable fastener
- Photo shows a stainless-steel cable clip to guide and fasten solar array cable to backside of solar module
- Avoid reliance on nylon wire ties as even UV resistant ties will not last the life of the solar module

Photo: FGL/IM-PAHO and Solar Electric Light Fund (SELF)

PV: CABLE MANAGEMENT (NOTE: MOST ITEMS SHOWN NOT IN THE SDD KIT)

- The cables enter the building through a concrete wall
- Steel conduit protects the cable to the junction box
- Conduit supported each meter with stand off conduit clamp
- Strain relief fitting hold cable securely, 1 per meter minimum

Photo: Solar Electric Light Fund

- Wall mounted cable clips route cables to refrigerators
- Penetration is sealed with concrete (provided by installer)

PV: CABLE MANAGEMENT (BAD WAY)

- Do not leave cables loose and unfastened
- Photo shows loose cables, sharp bend stress points, and a trip/fall hazard
- All cables need to be secured
- Avoid sharp metal corners
- Avoid cable against unprotected metal edges

Photo: Solar Electric Light Fund (SELF)

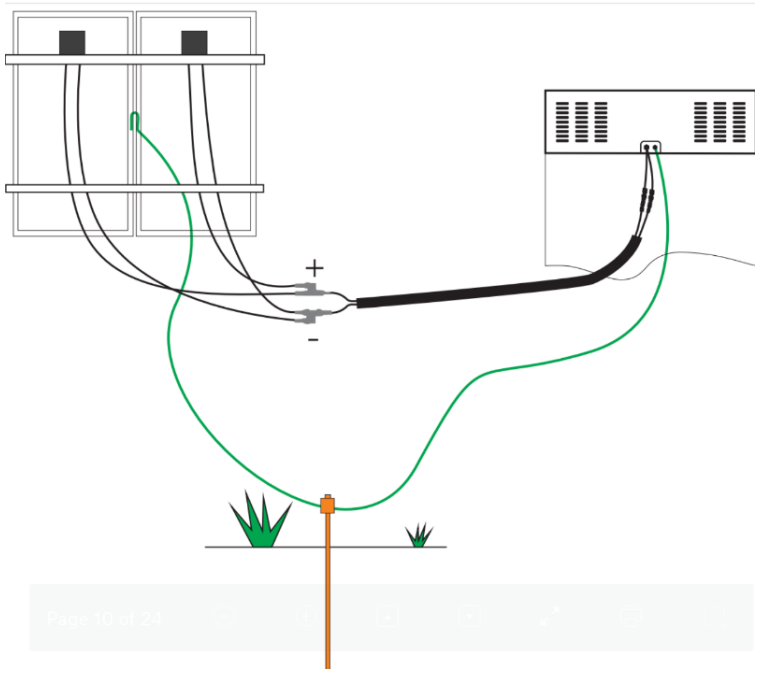
PV: CONDUIT MANAGEMENT

- Do not leave conduit loose and unfastened
- Photo shows metal conduit suitable for areas where people, animals may come in contact with it
- It is fastened securely with concrete screws

Photo: FGL/IM-PAHO and Solar Electric Light Fund (SELF)

PV: SOLAR ARRAY CABLE CONNECTION

- All kits have a solar array cable that connects to the solar array module(s) directly to the fridge
- Follow manufacturer instructions
- Cables are prepared with “plug and play” quick connectors
- It is advisable to still check polarity
- Note: it may be easier to connect cables at the same time you assemble the mount structure



PV: PARALLEL SOLAR MODULES

- Most kits have two or more solar modules
- Follow manufacturer instructions
- Parallel branch “plug and play” quick connectors or junction boxes are used to combine all modules into a single output to the solar array cable
- Use specified branch connectors for parallel connections

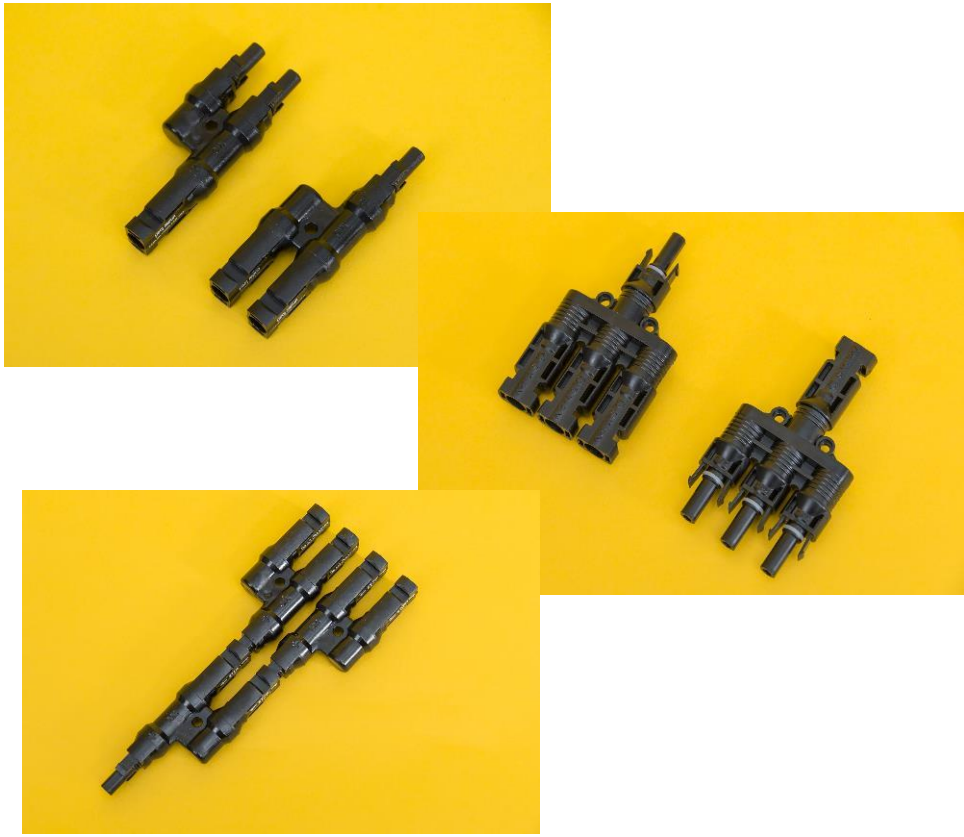
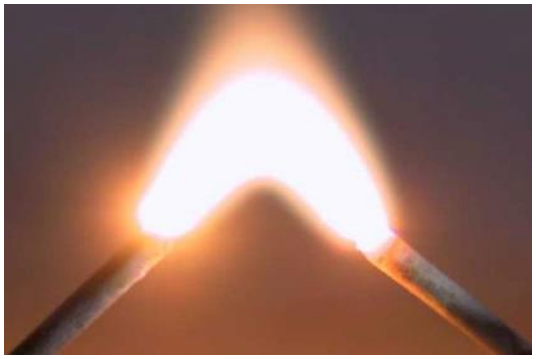


Photo: FGL/IM-PAHO and Solar Electric Light Fund (SELF)

PV: CONNECTING THE CABLES

Photos on next 2 slides: FGL/IM-PAHO and Solar Electric Light Fund

PV: DISCONNECTING THE CABLES (NEVER UNDER LOAD)



Do not disconnect live cables or arcing occurs

Photos: FGL/IM-PAHO and SELF, Arc photo: Wikipedia - Achim Grochowski, Achgro-Own Work

PV: TESTING THE ARRAY (EXAMPLE: OPEN CIRCUIT VOLTAGE)

- Assume solar array is rated at 22 volts (Voc)
- At mid-morning 20.9 Vdc is typical as an array warms and this causes some voltage loss
- Note: cloud cover does not impact voltage greatly
- A reading of 20+ volts indicates that the array is performing as expected

Photo: FGL/IM-PAHO and Solar Electric Light Fund (SELF)

PV: TESTING THE ARRAY (EXAMPLE: SHORT CIRCUIT CURRENT)

- Do not measure current without covering the array when connecting and disconnecting the meter
- Assume this solar array is rated at 15 amps (Isc) Rating found on module specification sheet x qty of modules in parallel
- If clear skies at mid-day then the spec sheet rating should be measured (+/15% to 20%) but if there are some clouds that will reduce solar radiation and Isc will be reduced proportionally.

Photo: FGL/IM-PAHO and Solar Electric Light Fund (SELF)

- Note: example meter is capable of reading 20 amps DC and is set correctly
- A reading of 9+ amps indicates that the 15 amp array is performing as expected with medium cloud cover

PV: GROUNDING

- All solar modules require a ground connection
- Follow manufacturer instructions
- Use specified ground hole on module. Do not drill new ground holes (this could void warranty)
- The photo shows one method of grounding using a bolt on lug
- The copper ground wire will attach to a copper plated steel ground rod driven into the earth

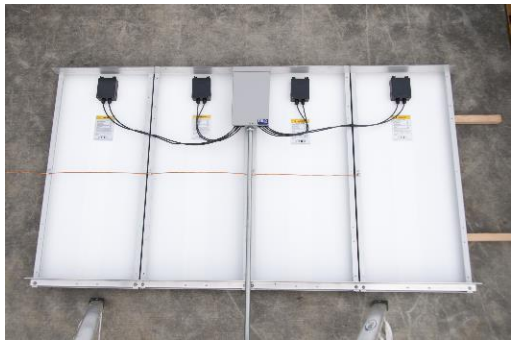
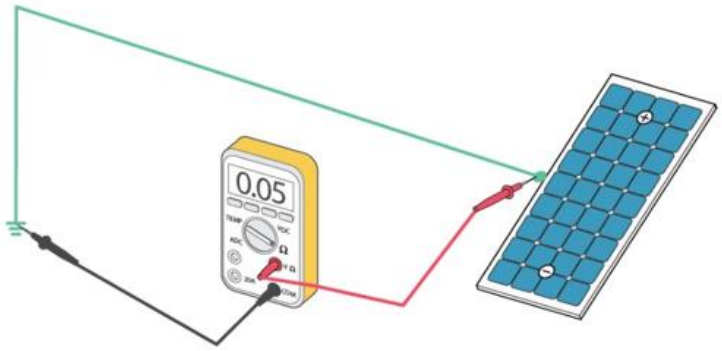


Photo: FGL/IM-PAHO and Solar Electric Light Fund (SELF)

PV: TESTING THE ARRAY (GROUND CONTINUITY)

- There must be continuity between the solar array structure and modules to earth
- As a rule, the resistance should measure 0.05 Ohms or less



Graphic: FGL/IM-PAHO and Solar Electric Light Fund

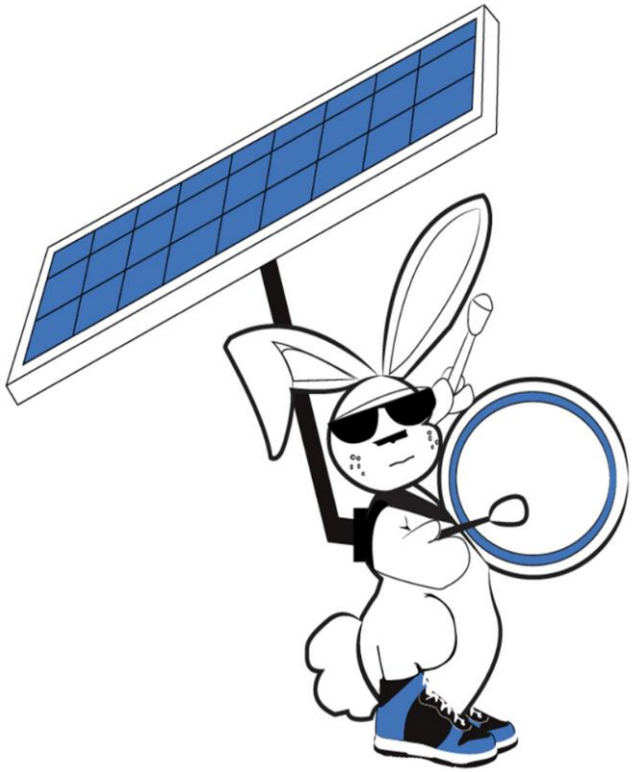
PV: SEAL ALL PENETRATIONS

- Use concrete for concrete penetrations
- Use high quality sealant (often supplied with the SDD kit)

Photo: US Government, Public Domain

CLEAN UP

- When you have done everything else well, the final step of the installation is to clean up all unused construction materials, packaging and retrieve tools.



Graphic: Mike McCarney/ Akomplice

Thank you for your attention!