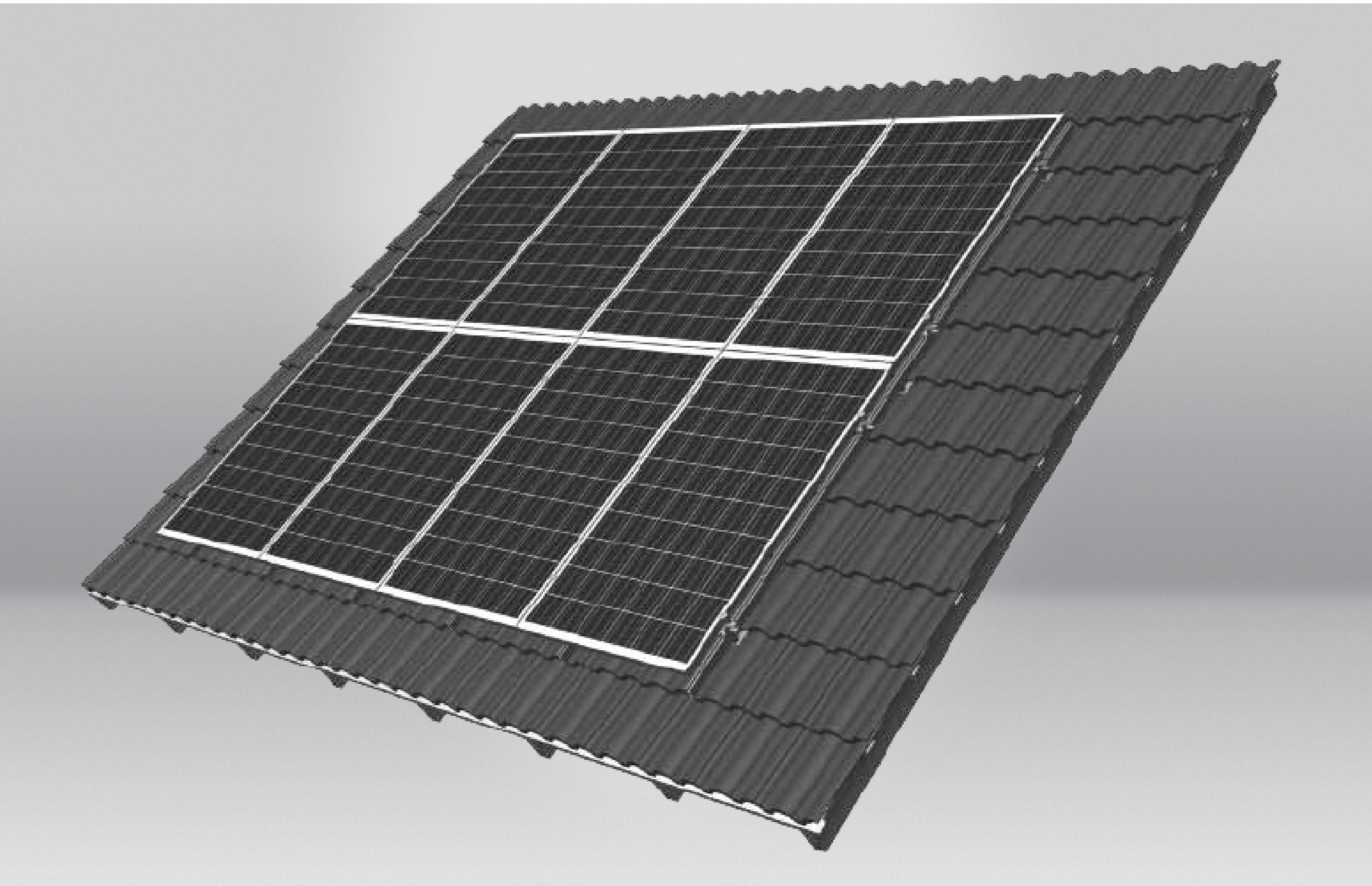
February 2012

Installation Best Practices



America's largest solar manufacturer since 1975

Table of Contents

Table of Contents (cont'd)

Purpose

Define the rules, guidelines, best practices and instructions for successful evaluation, design, installation and maintenance of a SolarWorld Sunkit.

Scope

SolarWorld is committed to providing high quality products and the best solutions for system owners – including modules, projects and Sunkits® systems. These solutions begin with accurate and detailed site assessment and evaluation. A quality system design must incorporate safety first and foremost, followed by a balance of financial return, system efficiency, and aesthetics. As with any building component, it must be understood that there is as much art as there is engineering in the design of a quality solar electric system. Sunkits is a SolarWorld brand solution and while there may be many opinions on best practices for solar installations, systems that are approved or certified with a SolarWorld Sunkits brand should adhere to SolarWorld standards of system design and installation practices to ensure quality for current and future system owners. A Sunkits, and any PV system, is intended to last a minimum of 25 years. In reality, SolarWorld anticipates the solar array may produce valuable energy for twice as long. Such a term of operation must be understood during system design and installation process.

Disclaimer of Liability
Since the use of this guide and the conditions or methods of installation, operation, use and maintenance of the module are beyond SolarWorld control, SolarWorld does not assume responsibility and expressly disclaims liability for loss, damage, or expense arising out of or in any way connected with such installation, operation, use or maintenance. The information in this guide is based on SolarWorld's knowledge and experience and is believed to be reliable; but such information including product specifications (without limitations) and suggestions do not constitute a warranty, expressed or implied. SolarWorld reserves the right to make changes to the product, specifications, or guide without prior notice.

Distribution list

Sunkits sales, customer service, marketing, engineering teams, and contractors.

Terms

Solar Module/Solar Panel – These are interchangeable terms as they have come to mean the same thing. Historically groups of smaller solar modules were pre assembled on rails or into a larger panel assembly. (a solar panel referred to panelized modules)

kWh per kw – kiloWatt hours produced per kilowatt of solar. This is a benchmark that indicates how much power a system produces for a given unit of its size. (This is sort of like miles per gallon) Generally this is a better comparison of solar products as it better accounts for real world performance where lesser products may appear similar in lab tests but given time will produce less.

Load - This is a device that consumes energy. Examples: Toaster/AC unit/Microwave/Lights/Water Heater.

Battery - An energy storage device. Typically lead acid but newer chemistries are gaining traction.

Note: Most PV systems do not need or include any batteries.

Generator - A device that converts one form of energy into another, typically electricity. Sometimes we refer to solar systems as power generators. Commonly gasoline, natural gas or diesel generators consume fuel to generate electricity for loads when not connected to the grid or when the grid is down.

Solar Noon - when the sun is perpendicular to a solar array such that the most intense sunlight is striking the array.

Efficiency - This is measurement of energy generated from (potentially) available light as compared to the surface area of your solar module/s. With crystalline silicon solar modules it is about 14-16%. Typically crystalline silicon modules produce nearly 50% more energy than comparably sized thin film modules. Be sure to compare solar systems by overall performance, reliability and value.

STC - This stands for Standard Test Conditions which is a set of specifications that solar manufacturers use to test and compare products.

1,000W/m^2, 25°C, AM 1.5. Most PV systems are bought or sold based on STC DC wattage but actual PV system AC output is reduced due to site variables, wiring and conversion losses.

PV 101

Basics of electricity

AC stands for *alternating current* and refers to electrical systems where the voltage and current are constantly changing between a positive and negative value. Common residential electrical service is 240 volts AC split phase to 120 volts AC.

DC stands for *direct current* and refers to electrical systems where the voltage and current are steady over time. PV modules produce DC electricity.

Voltage is electrical potential, in units of volts (V). Analogous to hydraulic pressure (current multiplied by resistance = I x R).

Current is the flow of electrical charge, in units of amperes (I). Analogous to hydraulic flow (wattage divided by volts = W/V).

Power is an instantaneous quantity, the rate of transferring work or energy. Electrical power is expressed in units of watts (W) or kilowatts (kW) (current (amps) multiplied by voltabe - I x V).

Energy is the total amount of work performed, accumulated over time.

- Electrical energy is expressed in units of watt-hours (Wh) or kilowatt-hours (kWh).
- Energy (Wh) = Avg. Power (W) x Time (h).

Example (power consumption):
A 100 watt light bulb on for 10 hours would consume a total amount of energy of 100 watts x 10 hours = 1,000 watt-hours or 1 kWh (kilo - 1,000).

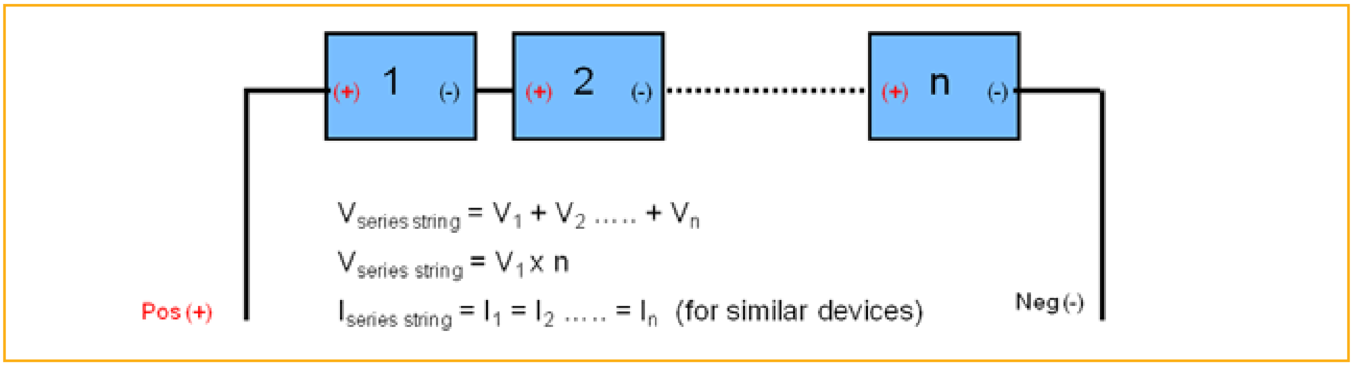
Example (power generation):
A solar array producing 1,000 watts and operating at this rate for 5 hours would generate a total amount of energy of 1,000 watts x 5 hours = 5,000 watt-hours or 5 kWh.

Summary:
$V = I \times R$
$P = I \times V = I^2 \times R = V2 / R$
$E = P X T$

Series and parallel

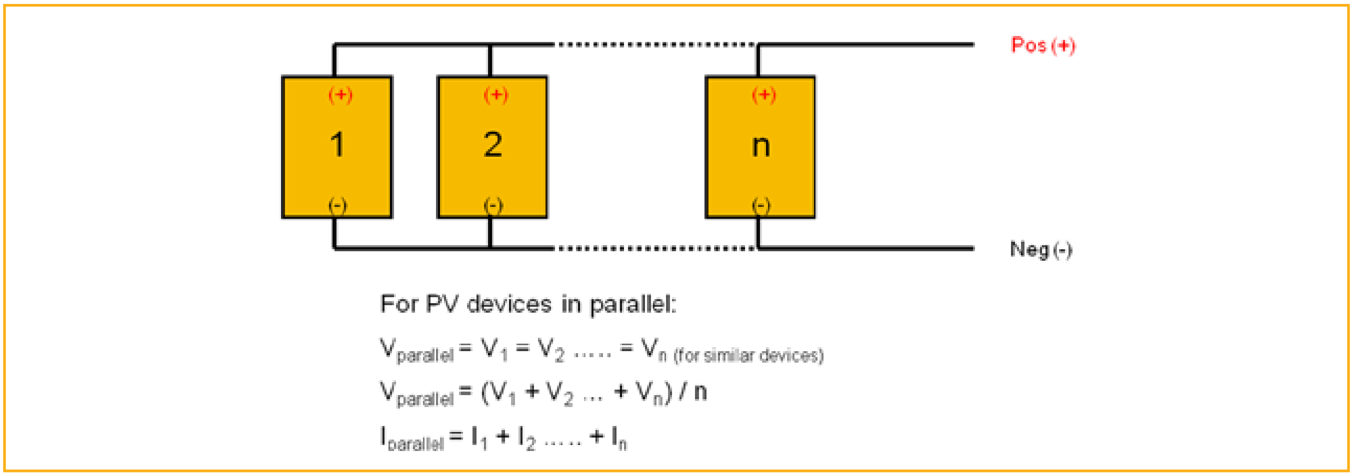
Series

When connecting devices in series the positive of one source is connected to the negative of another. The voltage of each component adds to the next while the current flow is constant through all of the components (voltage increases, current remains the same).



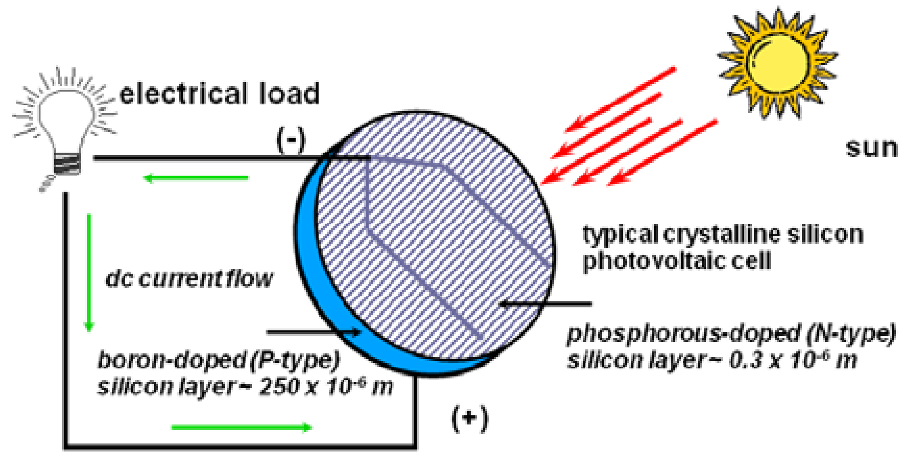
Parallel

When connecting devices in parallel the positives of all sources are connected together and the negatives are all connected together. The current of each component adds to the next while the voltage remains constant (current increases, voltage remains the same).



PV basics

Photovoltaic (PV) technology is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect.



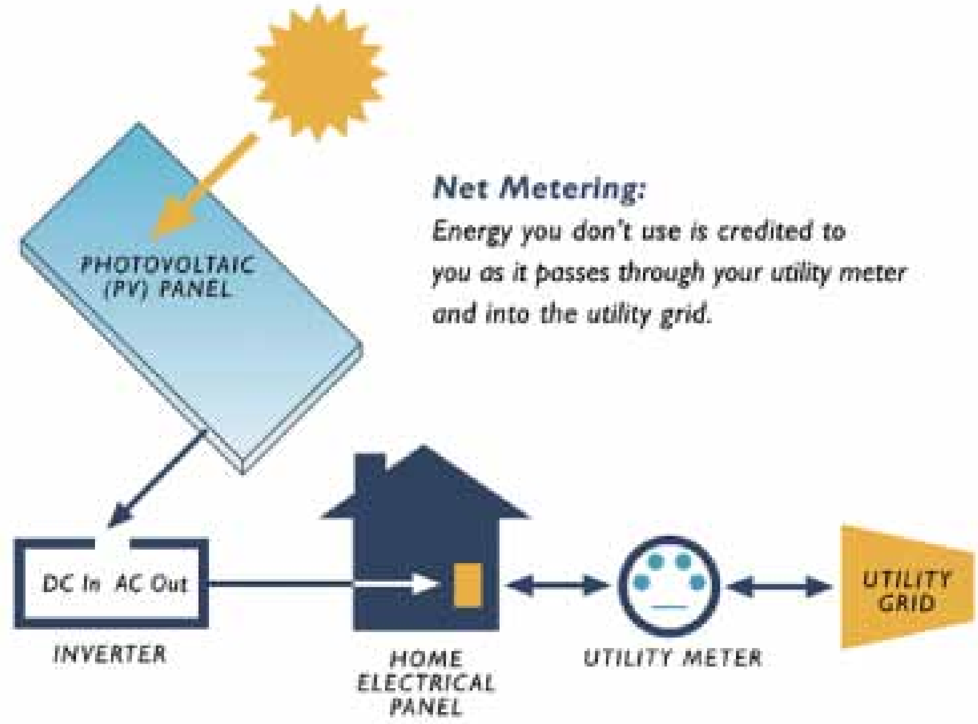
The building blocks that make up a photovoltaic system start at the cell level and build to an array.

	Cell	The photovoltaic cell generates DC electricity when exposed to sun light. A typical silicon solar cell produces about 0.5 volts and up to 8 amps. These devices are the basic building block of a PV module.
	Module (Panel)	The PV module is the smallest practical unit that can do work in real world applications. SolarWorld modules come in 36 cell and 60 cell versions.
	Array	A mechanical integrated assembly of modules with a support structure, foundation, and other components, as required, to form a direct-current power-producing unit.

Types of PV systems

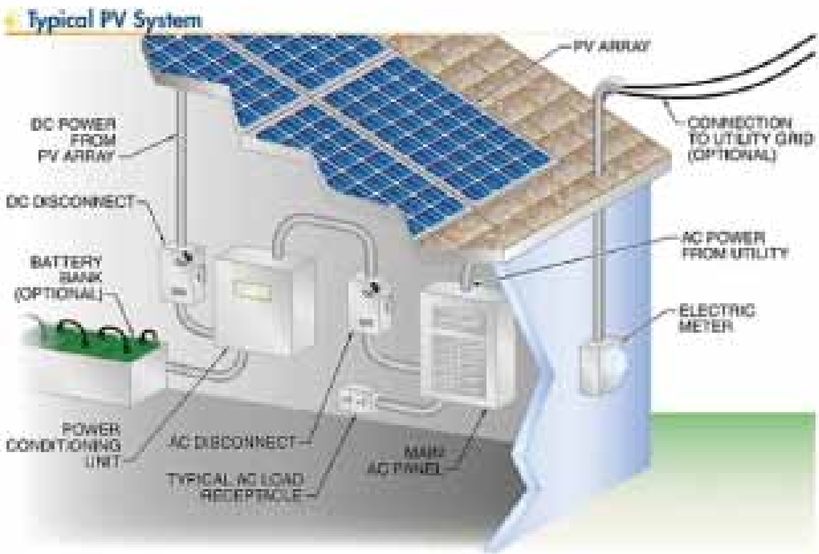
Stand-alone or off-grid systems operate independent of the utility grid. These systems are commonly used when the costs of extending utility service and other power generating means are not practical such as for a recreational vehicles, temporary traffic signs and/or cost-prohibitive as in remote locations such as telecommunications or oil and gas pipeline monitoring. These systems may or may not use energy storage devices, such as batteries, and may power DC and/or AC loads.

Grid tied or utility-interactive systems
These systems are interconnected, in parallel, with the utility grid.



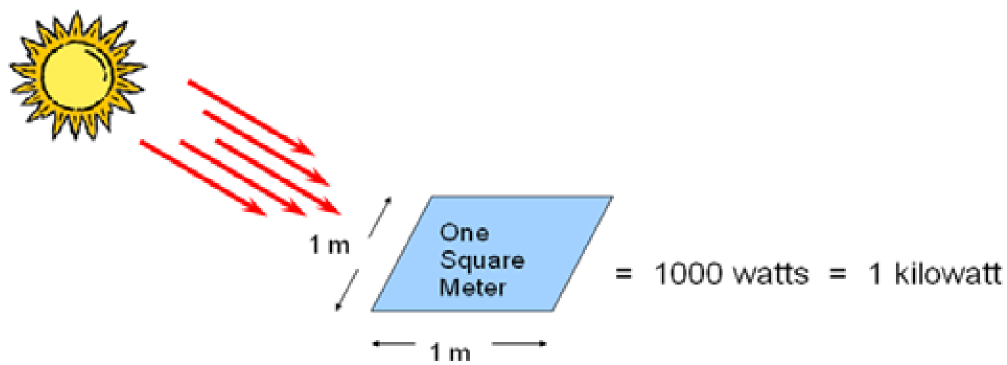
Residential | **Commercial** | **Utility**

Bi-modal systems
These systems may operate in either utility-interactive or stand-alone mode, but not concurrently.

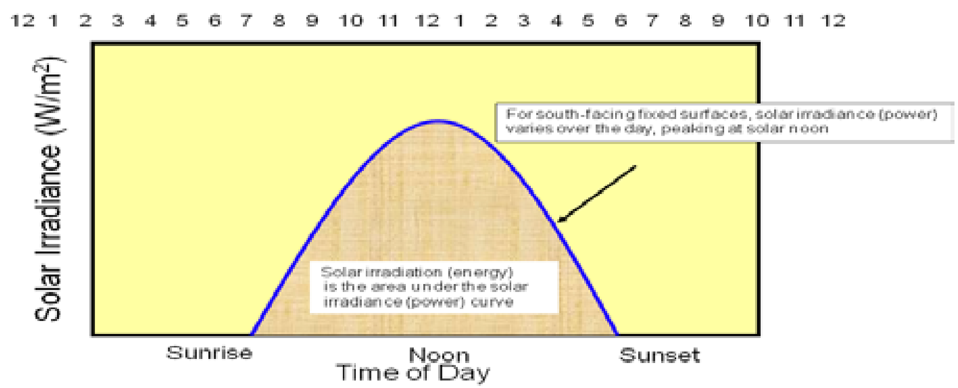


Solar resource

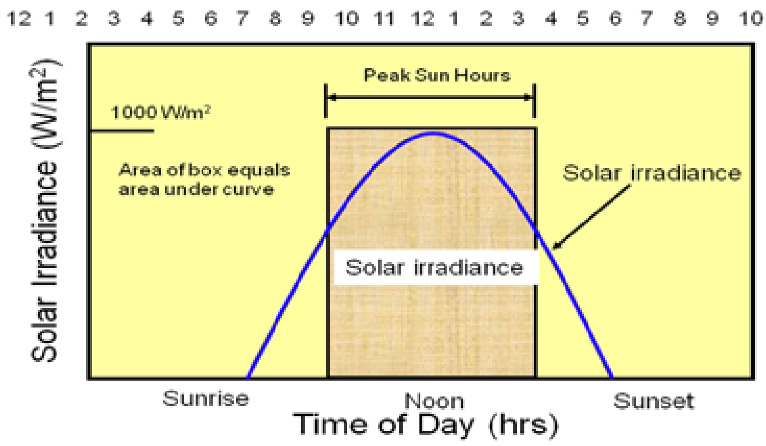
Irradiance is the intensity of solar power and is commonly expressed in units of watts per square meter (W/m^2). Typical peak value is 1000 W/m^2 on a surface facing the sun at solar noon and is referred to as “Peak Sun.” This value is used to rate PV modules and arrays.



Irradiation is the total amount of solar energy accumulated on an area over time and is commonly expressed in units of watt-hours per square meter (Wh/m^2). Insulation is the measure of energy collected over the period of the day.



Peak sun hours are a tool for solar production extimation purposes. Actual system performance increases and decreases in response to solar intensity, (increasing from sunrise to noon and then decreasing to sunset) this amount of energy is reformatted to imagine a system at full production for a given amount of hours at a given site. To estimate a given solar systems output, several resources list each regions historical measurement of solar resources expressed as sun hours, this can be used along with specific design factors to estimate production.



Example:

The solar power incident on a surface averages 400 W/m^2 for 12 hours. How much solar energy is accumulated?
400 W/m^2 x 12 hours = 4800 Wh/m^2 = 4.8 kWh/m^2 = 4.8 PSH

A PV system produces 6 kW AC output at peak sun and average operating temperatures. How much energy is produced from this system per day if the solar energy received on the array averages 4.8 Peak Sun Hours?
6 kW x 4.8 hours/day = 28.8 kWh/day

I-V characteristics

The current-voltage (I-V) curve defines the electrical performance characteristics of a photovoltaic device. The curve represents an infinite number of current-voltage operating points, and varies with solar radiation and cell temperature.

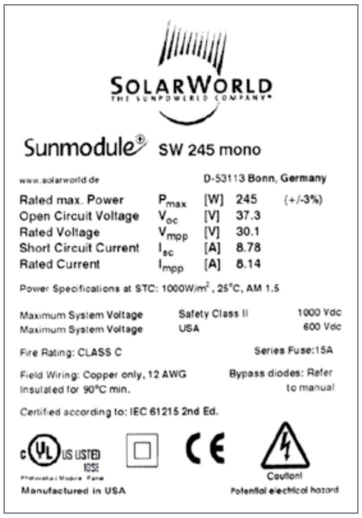
PV device performance is given by the following IV parameters:

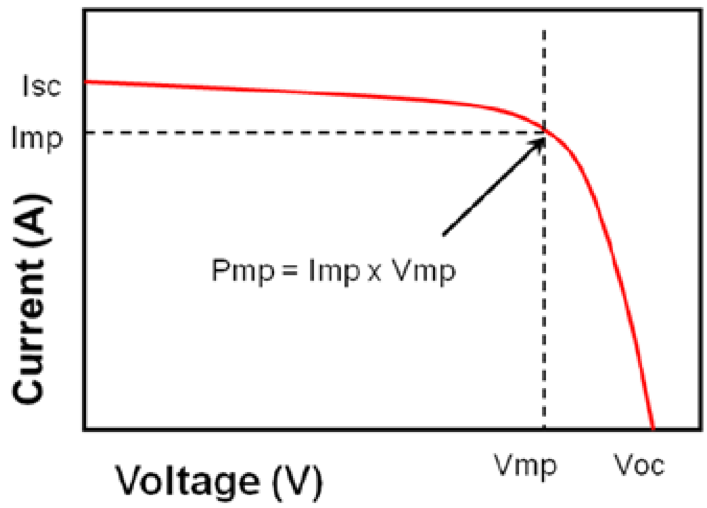
- Voc open-circuit voltage
- Isc short-circuit current
- Vmp maximum power voltage
- Imp maximum power current
- Pmp maximum power

Sunmodule™ SW 245 mono

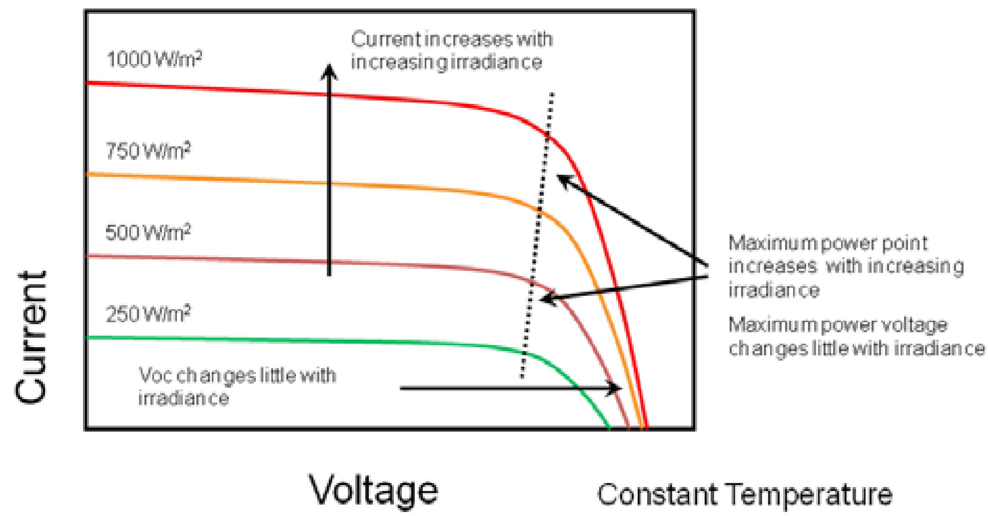
PERFORMANCE UNDER STANDARD TEST CONDITIONS (STC)*

		SW 245
Maximum power	P_{max}	245 Wp
Open circuit voltage	V_{oc}	37.7 V
Maximum power point voltage	V_{mpp}	30.8 V
Short circuit current	I_{sc}	8.25 A
Maximum power point current	I_{mpp}	7.96 A





Response to solar irradiance



Example:

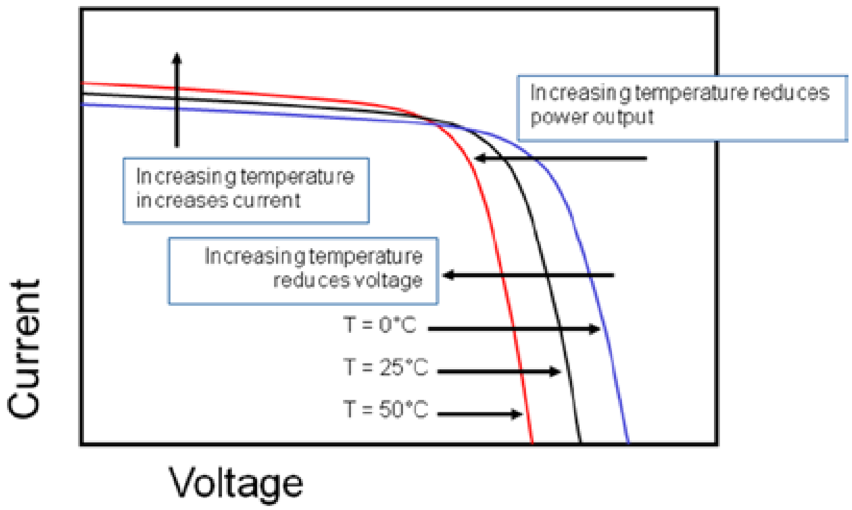
Q: The Sunmodule SW245 produces 245 watts maximum power at 1,000 W/m^2. What would the maximum power output be under 600 W/m^2 irradiance?

A: Power output is generally proportional to irradiance, therefore the maximum power at 600 W/m^2 irradiance would be:

245 W x 600 / 1,000 = 147 Watts

Response to temperature

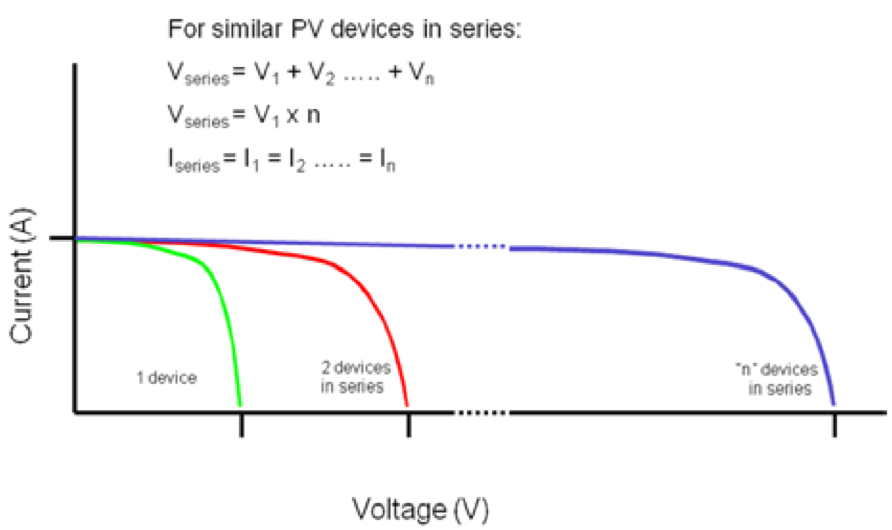
Solar module voltage has an inverse relationship to temperature changes. This means an increase in temperature results in a decrease of voltage where as a decrease in temperature results in an increase in voltage. Solar module current changes as well, but not very much. Current increases as temperature increases and decreases as temperature drops.



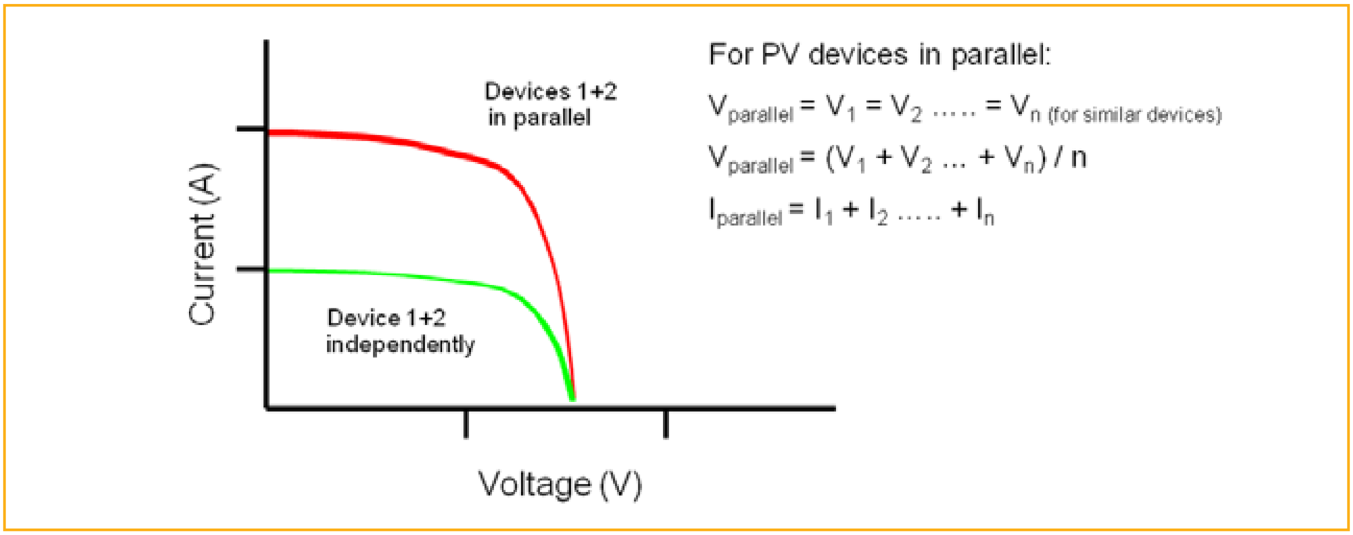
Example:

- **Q**: What would the open-circuit voltage be for the SW245 module operating at 0°C?
- **A**: The open-circuit voltage at 0°C is calculated by:
  = 37.7 V + [-0.0033/°C x (0 - 25)°C x 37.7 V]
  = 37.7 V + 3.11V = 40.81 V

I-V curve for similar PV devices in series



I-V curve for similar PV devices in parallel


Devices 1+2 in parallel
Device 1+2 independently
Current (A)
Voltage (V)
For PV devices in parallel:
$V_{parallel} = V_1 = V_2 \ldots\ldots = V_n$ (for similar devices)
$V_{parallel} = (V_1 + V_2 \ldots + V_n) / n$
$I_{parallel} = I_1 + I_2 \ldots\ldots + I_n$

Qualifications

Accurately qualifying a site is the best way to increase sales per sales call and avoid time delays proposing systems that are doomed from the start. The below questions can help determine if the customer is a prime candidate for a new solar system. By answering “yes” to the majority of the questions in this section would be a good indication that the customer has the best chances of being a qualified solar customer.

Customer qualifications

Solar electric systems have can have very high initial costs. An average residential system (5 kW) cost is about $25,000 prior to rebates and incentives, larger commercial systems (> 25 kW) can be $100,000 and above.

Does the customer have a clear financial solution for the installation (cash or credit)?

Is the average monthly electric bill greater than $ 100+ per month?

Is the customer expecting utility rates to increase significantly in the future?

Is the customer willing to install solar strictly from an environmental benefit perspective?

Site qualifications

Solar electric systems require maximum sun exposure for best performance (southern exposure with little or no obstructions).

Is the customer willing to put solar panels on the optimum solar exposure roof, even if that means the front of the house?

Is the area free from trees, utility poles, chimneys, satellite dishes, antennae or other buildings invading the solar view?

Is the customer willing to move or remove any obstructing objects?

Will the current roofing material last at least 15 years before requiring replacement?

Is the roofing material tough enough to handle the installation process (e.g., Spanish tile roofs are easily breakable)
If either of the two above responses are “no,” is the customer willing to pay for the re-roof of the array area and/or entire roof?

Is the building structure substantial enough to handle the added loads of the solar modules?

**Most pre-fabricated structures are not designed to have added loads retrofitted to the structure.*

If the roof structure is not sufficient, is there satisfactory area available for a ground mounted system?

**Flat roof and metal structures often require additional structural engineering, particularly when joist spacing is greater than 4 ft.*

If flat roof installation requires bracing, are the joists easily accessible?

Site upgrades/cost adders

Main panel source circuits can be equal up to 120% of the rated Amps of the buss bar.

Is there sufficient space in the existing breaker panel to add the required system breaker?

If no to the question above, is there room and funding available for a panel upgrade or line or load side tap?

Is there a clear solution for roof access if required?

Is there a clear solution for terrain modification if required?

Is there room on site, and in the budget, for large equipment if required?

Other considerations

Metal roofing, particularly corrugated metal roofs, are very difficult to waterproof during retrofits.

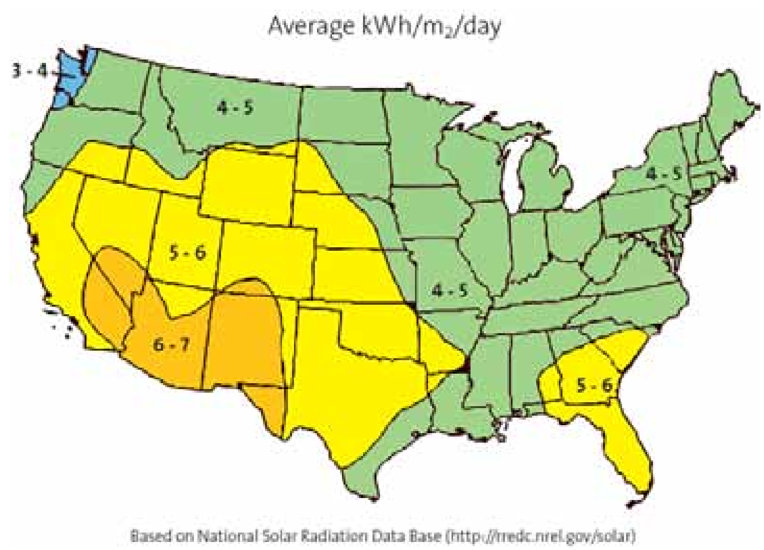
The customer should be aware that grid connected solar electric systems DO NOT provide power if the utility power goes out.

Site assessment

Once the site has been generally qualified as a potential installation deeper assessment is required to help determine what size system is best for that location. The key factors for site assessment are:

- Solar resource – how much sun?
- Site demand – current energy consumption and rates
- Area limitations – roof or ground area

Solar resource



There are a number of ways to determine Solar Resources below are three of the most common solar resource solutions in increasing detail.

PV Watts

"PV Watts" is a program developed by the National Renewable Energies Laboratory (NREL) to help determine solar resources throughout the United States. There are 2 versions of the tool Version 1 and 2. Version 1 is the simplest to use and is generally fairly accurate. Version 2 extrapolates more detail for specific areas based on the same data found in Version 1, but is more complicated to work with and doesn't give significantly more detail. Version 1 can be found here: **http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/.**

For general estimating in your area it is good to look at a 1 kW system with a tilt equal to the latitude facing due south. PV Watts defaults to a 77% derate factor but for SolarWorld systems we would recommend entering 85% system efficiency for the reasons below.

PV Watts default

Calculator for Overall DC to AC Derate Factor

Component Derate Factors	Component Derate Values	Range of Acceptable Values
PV module name-plate DC rating	0.950	0.80-1.05
Inverter and Transformer	0.920	0.97-0.98
Mismatch	0.980	0.97-0.995
Diodes and connections	0.995	0.99-0.997
DC wiring	0.980	0.97-0.99
AC wiring	0.990	0.98-0.993
Soiling	0.950	0.30-0.995
System availability	0.980	0.00-0.995
Shading	1.000	0.00-1.00
Sun-tracking	1.000	0.95-1.00
Age	1.000	0.70-1.00
Overall DC to AC derate factor	76.979 %	

Notes
Due to Plus sorting, minimum is 100 %
CEC *average* inverter efficiency is 94.62 %. Current SMA inverters average is 99 %
Due to Plus sorting, average is > 99 %
1.5 % voltage drop standard
This can vary by site; high rain = less issue
Site specific
Linear Guaranty is 7 % per year

Benefits of SolarWorld's Sunmodule Plus sorting
Adjustments due to actual module and
system performance

Calculator for Overall DC to AC Derate Factor

Component Derate Factors	Component Derate Values	Range of Acceptable Values
PV module name-plate DC rating	1.000	0.80-1.05
Inverter and Transformer	0.950	0.88-0.98
Mismatch	0.990	0.97-0.995
Diodes and connections	0.995	0.99-0.997
DC wiring	0.980	0.97-0.99
AC wiring	0.990	0.98-0.993
Soiling	0.950	0.30-0.995
System availability	0.980	0.00-0.995
Shading	1.000	0.00-1.00
Sun-tracking	1.000	0.95-1.00
Age	1.00	0.70-1.00
Overall DC to AC derate factor	84.523 %	

The output will give general information of how many kWh/kW a SolarWorld PV system will produce over 1 year and can be used as a rule of thumb for your area. Below is an example of Colorado Springs, Colorado.

Station Identification	
City:	Colorado Springs
State:	Colorado
Latitude:	38.82° N
Longitude:	104.72° W
Elevation:	1,881 m
PV System Specifications	
DC Rating:	1.0 kW
DC to AC Derate Factor:	0.850
AC Rating:	0.9 kW
Array Type:	Fixed Tilt
Array Tilt:	38.8°
Array Azimuth:	180.0°
Energy Specifications	
Cost of Electricity:	8.4 ¢/kW

Results

Month	Solar Radiation ($kWh/m^2/day$)	AC Energy (kWh)	Energy Value ($)
1	4.81	131	11.0
2	5.30	128	10.75
3	5.84	152	12.77
4	6.09	149	12.77
5	5.94	146	12.26
6	6.18	141	11.84
7	5.97	139	11.68
8	6.23	147	12.35
9	6.32	147	12.35
10	6.03	150	12.60
11	5.15	130	10.92
12	4.44	118	9.91
Year	5.69	1679	141.04

The PV Watts table shows that in Colorado Springs, an optimum system would produce about 1,700 kWh/kW which can be used as a good rule of thumb for system production in that area.

Energy production may decline slightly from the basic estimate when micro climates, shading, orientation and tilt angle are actually assessed. Often the decrease is not as much as would be expected for orientation and array tilt adjustments. These are worth investigating through the PV Watts calculator for deeper knowledge of those impacts. Below is the same location and system size facing Southeast at a 22.5 degree tilt (5-12 pitch roof) and only shows a decrease of ~100 kWh/kW.

Station Identification	
City:	Colorado Springs
State:	Colorado
Latitude:	38.82° N
Longitude:	104.72° W
Elevation:	1,881 m
PV System Specifications	
DC Rating:	1.0 kW
DC to AC Derate Factor:	0.850
AC Rating:	0.9 kW
Array Type:	Fixed Tilt
Array Tilt:	22.5°
Array Azimuth:	135.0°
Energy Specifications	
Cost of Electricity:	8.4 ¢/kW

Results			
Month	Solar Radiation ($kWh/m^2/day$)	AC Energy (kWh)	Energy Value ($)
1	3.64	98	8.23
2	4.34	104	8.74
3	5.31	139	11.68
4	6.12	152	12.77
5	6.46	161	13.52
6	7.15	166	13.52
7	6.66	157	13.19
8	6.51	155	13.02
9	5.96	140	11.76
10	5.10	128	10.75
11	3.96	99	8.32
12	3.23	84	7.06
Year	5.37	1583	132.97

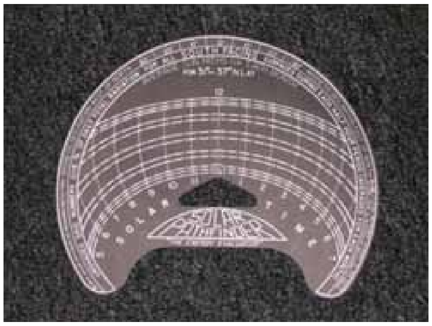
Significant shading can have a much greater impact on performance and is harder to estimate without the proper tools.

Solar pathfinder

Many rebate incentives require a detailed shade analysis to approve the rebates for the system. The *Solar Pathfinder* is one tool for determining solar resources at a site. While it tends to be a more manual process, it has the ability to provide real time feedback and help with array location choices.

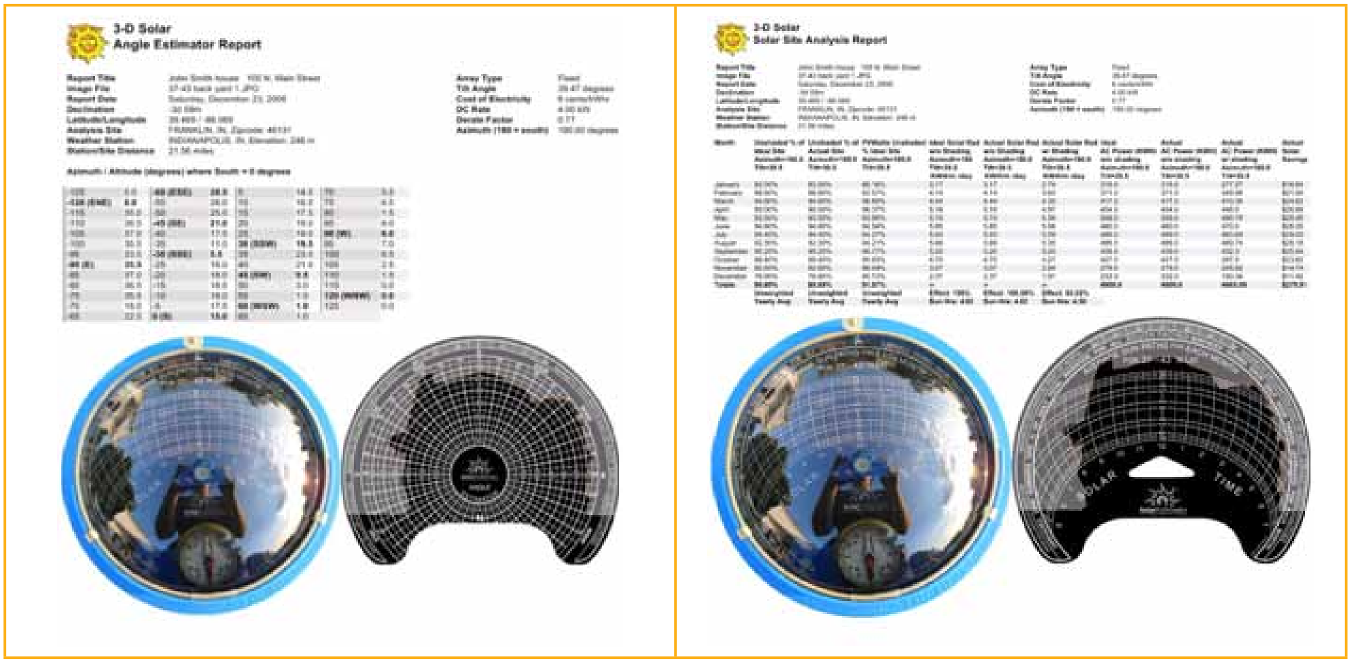
The solar pathfinder:

- Set-it-and-forget-it magnetic declination correction
- Equipped with a compass and bubble level for orientation calculations
- Allows for continual shading percentage calculations for a specific location
- Provides you with a hard copy of each skyline taken immediately
- Instantaneous read outs of time of shading issues



Optional software that calculates all your solar needs just by uploading a picture.

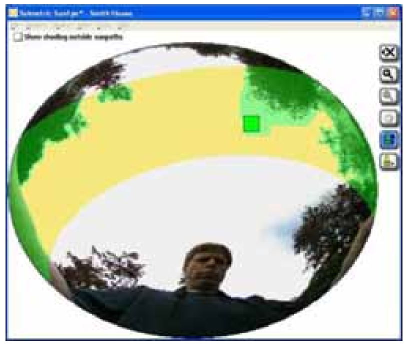
- Provides before-and-after shading contrast for obstacles
- Solar insolation (in kWh/m^2/day)
- Percentage of sunlight
- Altitude and azimuth (orientation)
- AC energy (kWh)
- California rebate compliant

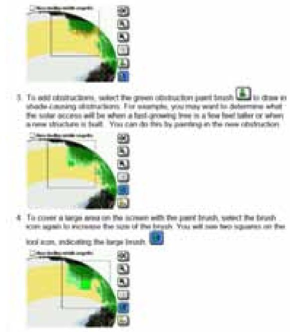


Solmetric SunEye™

The Solmetric SunEye™ uses a digital camera to automatically provide shading analysis for an installation. The outputs are compatible with many rebate programs.

- A compass and bubble level for orientation calculations
- A fish eye camera lens incorporated with a PDA
- Software that overlays the picture you've taken with the sun path chart for your location
- Multiple, instantaneous shade results





Software is computer compatible

- Usage is simple
- Large storage and ease of edit ability.
- Straightforward calculating and report generation
- As well as basic computations:
- Tilt or pitch
- Azimuth
- Magnetic declination

Site demand

Utility rate structures can be extremely complicated but there are 3 basic forms of rate structure that can have different impacts on PV system payback.

- Tiered rates
- Time of use (TOU)
- Demand based

Tiered rate

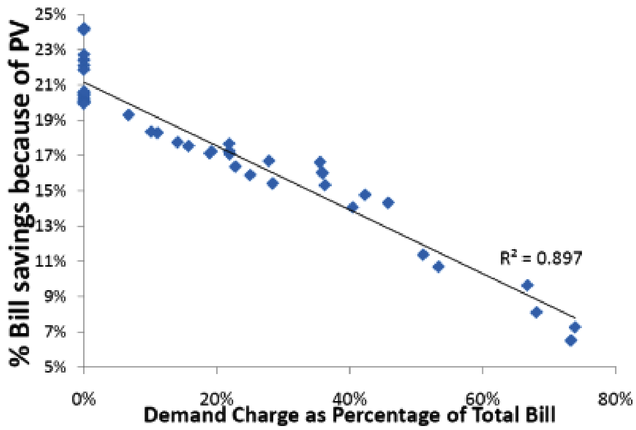
Tiered rate structures are the most common residential rate structure. Some utilities use them differently. In many states, the more energy consumed above a set base rate are charged higher $/kWh. These tend to be the most cost effective rate structures for PV systems. By offsetting the more expensive power in the higher tiers, the payback time for the PV system can be accelerated.

Time of use (TOU)

Time of use rate structures generally vary the $/kW cost by time of day and time of year usage. This is also very common among both residential and commercial billing. Close attention should be paid to these types of rates and can be very difficult to predict payback value since the site generated energy will vary in value based on the time of production.

Demand based

Demand based utility charges actually charge more for the kW and only very little for the kWh. These do not generally work as well for direct payback, since the PV provides kWh and may not significantly affect the kW demand of a site. This rate schedule is most common for commercial and industrial customers since the rate schedule allows for a more leveled monthly bill for ongoing business.



Correlation between demand charges and potential savings from PV. NREL Technical Report, NREL/TP-6A2-46782, June 2010. The Impacts of Commercial Electric Utility Rate Structure Elements on the Economics of Photovoltaic Systems.

For both TOU and Demand based rate schedules, it may be worth investigating alternative rate schedules that the local Utility might provide. Many utilities have adopted Solar Rate schedules for these customers to help balance out the inefficiencies of those rates for payback on PV systems that overall help the Utility provide power to their customers. The goal would be to reduce the percentage of the bill that is attributed to demand and shift that percentage to the energy (kWh) usage.

Area limitations

Limitation of available space for mounting the PV modules can be a major limiting factor. In each of the three basic types of installation, pitched roof, flat roof, and ground mount, there are space limiting factors that need to be considered and can reduce the options for installation. These can be in addition to the external shade structures like trees and other buildings avoided in the shade analysis.

Pitched roof limitations

Avoid minimum of 3 ft around edges, eaves, and ridges for fire safety and access. Be aware of site shading concerns that may not be obvious like vent pipes, chimneys, higher roofs satellite dishes, and antennae. Even small shading of these can have greater detrimental impact on system performance than a shade analysis will determine.

Rafter locations and faux rafters can limit the area of penetrations and therefore the array size as well.

Flat roof limitations

For commercial flat roofs, the edge spacing may need to be greater due to parapet walls shading and local access requirements.

Be aware of roof top obstructions that can cause large shading arcs to avoid, like skylights, air-conditioning and compressor units.

Note water shed points and drains to be sure the array will not impede the water flow off of the structure.

Many jurisdictions require maintenance paths of 6 ft for every 50 ft of array area, these should be considered whether required by local code or not.

Ground mounted limitations

Due to the low height of ground mounted arrays, tall obstructions will have greater impact on performance. Note tree lines and buildings. A good rule of thumb is to keep the array a distance of *2x the height of an object* away from that object.

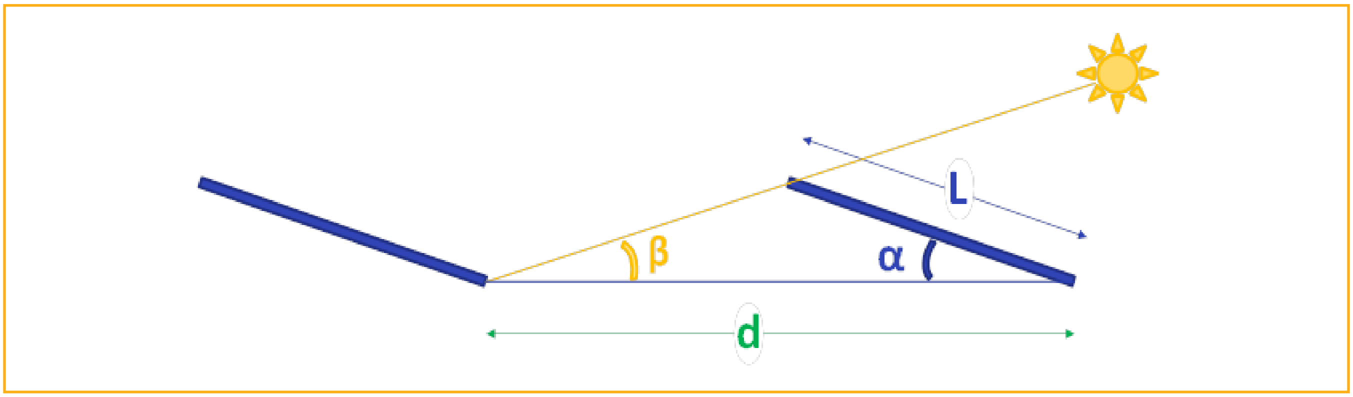
Be aware of underground utility concerns like water, gas, sewer, and power lines before assessing array size options Water management needs to be considered for ground mount installations as well; how water will drain and how it will be managed.

Many ground mount installations require barriers to entry for safety and security of the system. This should be noted during assessment as well since any fence will need to be a certain distance away from the array to avoid shading.

Array layout for all situations is best started by choosing rectangular areas and maximizing the array sizes based on simple geometry. Once a rectangle is determined, use the dimensions of a module plus mid clamps as a simple rectangle dimension.

For pitched roof installations, how many module rectangles will fit in the available array rectangle is the easiest way to determine maximum potential array size.

For flat roof and ground installations, it is important to size the array in conjunction with the mounting solution choice. Since tilted modules in consecutive rows may cause shading from row to row, some basic trigonometry can help evaluate the unit rectangle. The safest assumption is that a tilted module will cast a shadow straight back, elongating the "module rectangle" used for array size calculation. Worst case scenarios for row to row shading will be determined by the Sun angle in the sky on the shortest day of the year at the time of day you want to be sure the modules will be receiving full Sun. 10 AM is an acceptable time of day but many will use 9 AM as a worst case scenario. Sun angle can be determined via web based tools like **www.nrel.gov/midc/solpos/solpos.html**. Once determined, the Sun angle can be used in a local area with general confidence on all layout estimates.



Latitude (°N)	49.3	47.0	44.8	42.5	40.3	38.0	35.8	33.5	31.3	29.0	26.8	24.5	22.3	20
Nearby example city	Lake of the Woods, Minnesota	Lewiston, Montana	Bangor, Maine	Burley, Idaho	Pittsburg, Pennsylvania	Lexington, Kentucky	Raleigh-Durham, North Carolina	Bruminghan, Alabana	Santa Ana, Californai	Grand Isle, Louisiana	Palm Beach, Florida	Key West, Florida	Kilaea Pt, Hawaii	Wiamea-Koha, Hawaii
Module lengh (L) 66 inches														
Distance from front of 1 row of modules to the front of the next row of modules (inches, d)														
Array tilt (degrees, α)	Altitude angle of the Sun at 10 AM at sea level on December 21st, (degrees, β)													
	12	14	16	18	20	22	24	26	28	30	32	34	36	38
5	93	89	86	83	82	80	79	78	77	76	75	74	74	73
10	119	111	105	100	96	93	91	88	87	85	83	82	81	80
15	144	132	123	116	111	106	102	99	96	93	91	89	87	86
20	168	153	141	131	124	118	113	108	104	101	98	95	93	91
25	191	172	157	146	136	129	122	117	112	108	104	101	98	96
30	212	190	172	159	148	139	131	125	119	114	110	106	103	99
35	232	206	186	171	158	148	139	132	125	120	115	110	106	103
40	250	221	199	181	167	156	146	138	130	124	118	113	109	105
45	266	234	209	190	175	162	151	142	134	128	121	116	111	106
50	280	245	219	198	181	168	156	146	138	130	123	117	112	107
55	292	255	226	204	186	172	159	149	140	131	124	118	112	107

Site details/location questionnaire

Once the site is assessed as a viable solar installation site documenting and recording key bits of information is extremely important. Below is a review of the SolarWorld Location Questionnaire and it's contents.

Instructions:

All fields must be filled in by a certified and bonded contractor. Extra information relating to Sunkits System Installation is welcome. Appropriate design is based upon accurate information provided. If you are unsure of an appropriate response, please refer to the Location Questionnaire Guide for more details and training. Enter "DNK" (Do Not Know) or "NA" (Not Applicable), for item not related to this specific installation. SolarWorld America will only respond to requests submitted via approved Sunkits distributors and that are responsive to the instructions or requests herein.

System location information

1. System Location Information				
Location Type:	☐ Residential*	☐ Commercial*	☐ Municipal	☐ Non Profit
Project/Homeowner Name:				
Address:		City:	State:	Zip:
County:		Phone:		

The system location information is required for general information. This is the actual site of the proposed solar array. It is specifically used for design calculations and to allow SolarWorld to use satellite map data to assist in the design of the system tax rate are important to most accurately determine the rebates and tax credits. SolarWorld will always default to the best financial solution.

System installer information

2. System Installer Information			
Installer Company Name:			
Installer Contact Name:			
Address:	City:	State:	Zip:
Phone:	Email:		
Contractor License Number:			

Distributor Name:	Distributor Contact Name:
Branch/Location:	Phone #:
SolarWorld Sales Representative:	

The installer information is required in order for SolarWorld to use as a primary contact and to accurately assign job numbers and shipping information. An active contractor license and approved classification or type is required for SolarWorld to proceed. The type of license required may vary by region so check with your local building department. The distributor information is required for pricing, shipping, etc.

Pricing information

3. Pricing Information		
Installation Price of ($/DC Watt):	Default ($7.25)	Total Installed Price:
Federal Income Tax Rate:	Defaut to 28%	**Customer tax rate information is used for accurate financial analysis only**
State Income Tax Rate:	Default to 9%	

This is the price per watt or the total installed amount the installer is intending to charge for the full installation of the Sunkit. This price will be used to calculate financial information for any Return on Investment/Payback Proposals supplied by SolarWorld.

- The default amount will be $7.25/W if no alternative is provided
- Sample: 3,185 W x $7.25/W = $23,091.25 installed system price
- Or 13 modules x 245 W/module x $7.25/W = $23,091.25

Tax rates are important to most accurately determine the rebates and tax credits. SolarWorld will always default to the best financial solution.

Utility bill information

4. Utility Bill Information - for Return On Investment / Payback Proposal

Utility/Provider (required for Proposal):

Current Rate Schedule (required for Proposal):

Rate Type (found on your electric bill or statement, i.e., “domestic,” TOU-1?); (required for Proposal):

Supply as much usage information as possible for each month. At least 1 full year of information preferred. If only one month supplied, enter in correct month of the year. Demand infomation for Commercial billing only (required for Proposal).

	This Year			Last Year		
	Kwh	Total $	KW (demand)	Kwh	Total $	KW (demand)
Jan						
Feb						
Mar						
Apr						
May						
Jun						
Jul						
Aug						
Sep						
Oct						
Nov						
Dec						

This information is required for any return on investment/proposals supplied by SolarWorld, in addition to accurate sizing and designing of the system to offset the customer’s utility bill. Generally, the prospective system owner can obtain a year-long historical data from their utility website. Filling in the table makes for expedited processing and sending a copy of an electric bill to accompany the questionnaire is helpful.

A. Utility/Provider – Found on Utility Bill
B. Current Rate Schedule – Found on Utility Bill
C. Rate Type – Found on Utility Bill, i.e., “Domestic,” “TOU-1”

This information is used to determine current rates and rebates available.

System characteristics

5. System Characteristics			
Module Mounting: ☐ Roof	☐ Ground* (For ground mounted, enter requested angle, default to 20, and use true N-S direction, not compass reading)	Tilt Angle:	Orientation:
Requested Number of Modules:			
Proposed System Size:	DC Watts (Total number of modules multiplied by the module STC Watts; see LQ Guide for suggested system sizes)		

Module Mounting
This information is used to determine if the arrays will be roof or ground mounted. For ground mounted solutions enter this information (i.e., 20°, 180°) and skip questions 6, and 7.

Requested Number of Modules
This information ensures that all of the expectations are consistent and provides the opportunity to request multiple systems at one site.

Proposed System Size
The DC Watts expected. See Appendix A and use the table in order to calculate best solutions using standard 245 W modules for total DC watts in a specific region. Availability of module types may change from request to final delivery, but modules will be in the same class as requested.

Roof characteristics

6. Roof Characteristics					
Roof Pitch (i.e., 5-12) or Tilt Angle (22.6º):			True Orientation (in degrees 0˚-360˚):		
☐ Asphalt/Composition Shingle	☐ Concrete Flat Tile	☐ Spanish Tile	☐ Flat Roof	☐ Concrete S-Tile	☐ Other:
☐ Metal (Standing Seam) Gauge:	Manufacturer:				

Roof pitch:
Roof Pitch is the slope of the roof. In the U.S. this is typically given in inches of rise per 12 inches of span. For example, a 4:12 pitch is 4" of rise for every 12" of span. See graph below for standard pitches. For more information on Roof Pitch, see Appendix B of the Location Questionnaire Guide.

Slope	Angle (degrees)	Pitch
0.25	14°	3:12
0.33	18.4°	4:12
0.42	22.6°	5:12
0.50	26.6°	6:12
0.58	30.3°	7:12
0.67	33.7°	8:12
0.75	36.9°	9:12
0.83	39.8°	10:12
0.92	42.5°	11:12
1.00	45°	12:12

True orientation

Orientation refers to the compass direction the roof the solar array will be mounted on faces (North = 0°, East = 90°, South = 180°, West = 270°). For maximum performance in the Northern Hemisphere, solar arrays should face a southerly direction. See Appendix C of the Location Questionnaire Guide for accurate compass reading and other methods.

Note: Satellite TV dishes point to the southern sky, and most online mapping sites default with true north up, and true south down.

Roofing material

The existing roofing material is important to determine the type of roof mounting solution for the solar array. It is also important to note the age and condition of the roof material. If the roof is in poor condition, it is recommended to repair or replace the roof prior to installing a solar array.

Metal (standing seam)

The gauge and manufacturer are required to ensure the mounting solution has been approved by the manufactures. Panel seams must have sufficient flexural strength to carry these loads when clamp is used mid-span. Panel attachment and building structure must also be sufficient to carry these loads. It is the responsibility of the user to verify this information, or seek assistance from a qualified design professional, if necessary.

Rafter information

7. Rafter Information		
☐ Vertical Rafters	☐ Horizontal Rafters	Rafter Spacing (inches on center):
Rafter Cross Cut Dimensions (2 x 4, 2 x 6, 2 x 8):		Material:

The rafter spacing is required for loading calculations and mounting hardware. Most residential roof systems utilize vertical rafters installed either as stick framing or truss systems. Stick framed rafters consist of dimensional lumber (2 x 6, 2 x 8, 4 x 6, etc.) sized appropriately for spanning from the top plate to the ridge. Truss systems consist of a pre-engineered 2 x 4 truss that spans from top plate to top plate. The easiest way to determine the rafter spacing is to measure the rafter tails that extend past the exterior wall. *Note: This will not work with faux rafter tails*. Although less common in the U.S. some structures are built with horizontal rafters that span from gable to gable.

Stick Framing

Truss System

Structure information

7. Rafter Information		
☐ Vertical Rafters	☐ Horizontal Rafters	Rafter Spacing (inches on center):
Rafter Cross Cut Dimensions (2 x 4, 2 x 6, 2 x 8):		Material:

The basic structure information is used in equations for IBC load calculations. Inaccurate or incomplete data can lead to inspection failure.

Loading requirements

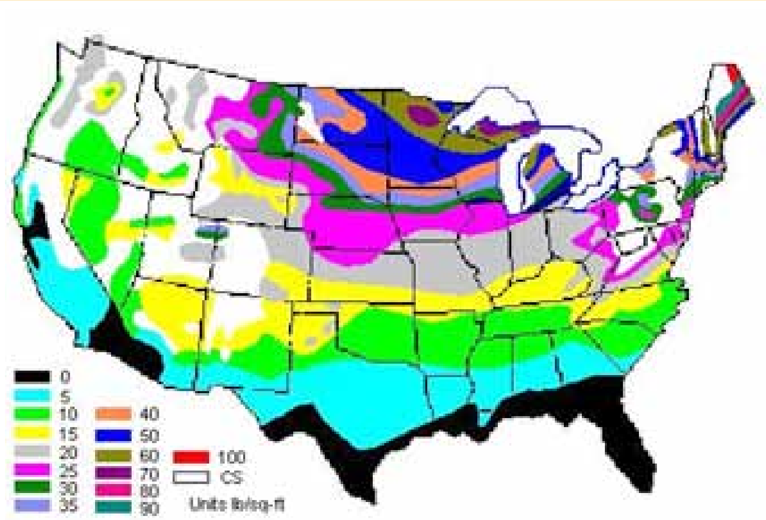
9. Loading Requirements (per ASCE 7-05, IBC)	
Wind Loading Class: ☐ B ☐ C ☐ D Wind and Snow Data	Max Wind Speed (mph):
Seismic Loading Zone: ☐ 0 ☐ 1 ☐ 2A ☐ 2B ☐ 3 ☐ 4 ☐ 5 Seismic Map	Snow Load (lbs/ft^2):

Loading requirements are important to confirm the roof structure can withstand the additional weight and loads possible with the addition of the solar array, as well as to be sure the solar array can handle the local structural demands, i.e., wind, snow and seismic loading. This data is especially important in areas with high wind, snow, or seismic loads. If the solar array is to be installed in one of these high load areas, contact the local building department for the required load data. SolarWorld will use default data based on zip code and the IBC unless noted otherwise. The ultimate responsibility is on the installer to ensure that all building requirements are satisfied. See links and maps on the following page for general information. Contact your local permit office for more accurate local requirements in your area.

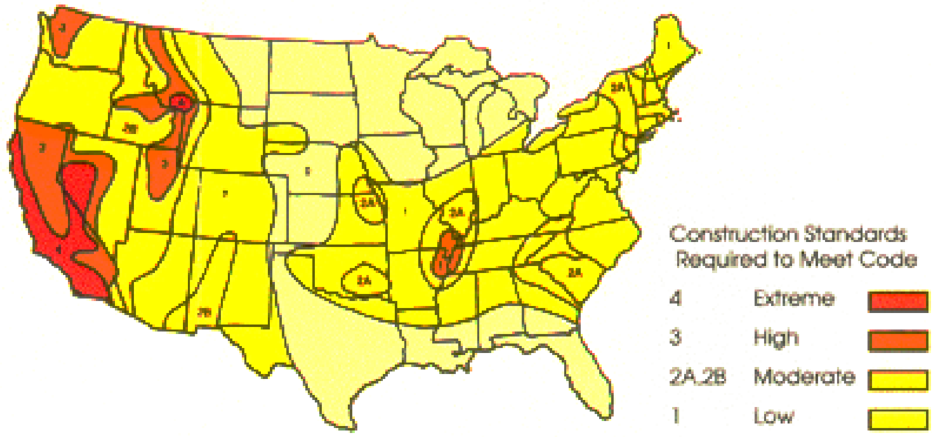
Links: site map

Wind data

Snow data



Seismic zone map



Wiring requirements

Grid voltage is of paramount importance for appropriate inverter choices and string sizing. Wiring requirements are important to properly determine the type, size, and length of the wiring. The distance from the array to the inverter location, junction box, or combiner box is important to determine the length of the PV wire. If routing the wire through the building, the PV wire is only required for the environmentally exposed portion of the run. From a junction box and metallic conduit, standard THWN, 90º C wiring can be generally be used.

Note: NEC code requires that all DC wiring be in METALIC conduit inside of structures for fire safety.

Temperatures are important to properly determine the type and size of wire. Temperature is also a key variable to determine module string sizing. While low temperatures can permanently damage the inverter and void warranties, high temperatures can cause the inverter to shut down at peak production times. There are a variety of inverter technologies and sizes which can be leveraged to produce the most efficient system for the lowest long-term cost.

Specific request/adders

11. Specific Requests/Adders (specific requests may effect pricing, and may be adjusted to ensure appropriate system, mounting, or availability requirements)

Module:	☐ Black	☐ Mono	☐ Poly		
Mounting:	☐ Sunfix®	☐ ProSolar®	☐ UniRac®	☐ Other	
Standoff Height:	☐ 3 Inches	☐ 4.5 Inches	☐ 6 Inches	☐ 7.5 Inches	
Inverter Request:	☐ SMA®	☐ PV Powered®	☐ EnPhase®	Quantity:	
Monitoring:	☐ Suntrol®	☐ SMA Web Box	☐ SMA Sunny Beam	☐ PVM 1010	☐ Envoy

If there are specific requests associated with the system that are requested or required, please note them. Although unlikely, SolarWorld reserves the right to refuse the request based on safety and system functionality requirements. Some specific requests may create longer lead and delivery times due to product availability. Without specific input, SolarWorld will default to the "standard" solution using SolarWorld standard modules, SMA inverters, and Sunfix mounting solutions, defaulting to the appropriate Sunfix penetration solution for the roofing material indicated. Monitoring equipment is not included in the price of a Sunkit and will be added. Check with your local distributor or dealer for pricing.

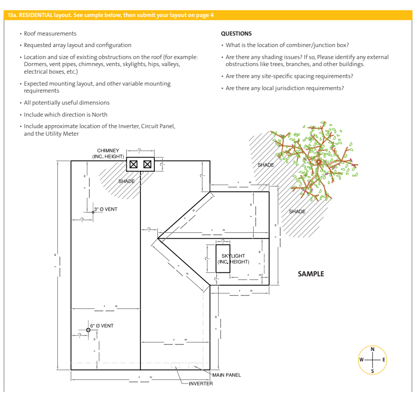
Additional information

12. Additional Information
In the area below, please enter any information regarding the structure relevant to the Sunkits® installation, concerns, special requirements, or special requests. Please print clearly in order to avoid delays in processing.

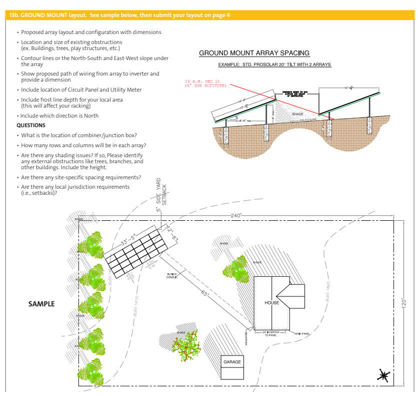
Additional information is any information unique to the installation location that can affect the sizing, mounting, performance of the solar array. Use this section for any comments or requests. Our highest priority is to provide the system owner with the best possible solution meeting their needs.

Array layout

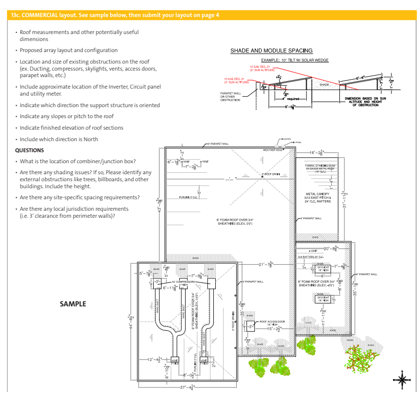
The sketch of the roof layout is important for SolarWorld to provide an accurate proposal and include the correct mounting hardware and wire lengths, etc. It is also important to make sure there are not shading issues that will seriously affect the performance of the system. See Appendix D of the LQ Guide for appropriate and accurate dimensioning. Digital photos of the roof and surrounding area can be the most useful tool to help SolarWorld or your system designer understands the installation location.



Pitched Roof



Ground Mounted



Flat Roof

Signature

Information is gathered for purposes of providing Products and Services to SolarWorld Americas Customers and for our system records. While most information is required for the appropriate structure and physical installation of the Sunkits® system, some information is collected to provide the best possible electrical solution for your location and specific needs. SolarWorld will not supply or share any information provided with any entity except certain SolarWorld California affiliates dedicated to making your purchase operate at maximum efficiency and durability. The tests performed on the materials included in the Sunkits® are standard testing for such materials. There is no specific testing done for your individual system and location. Designs are based on the provided information and SolarWorld accepts no risk due to faulty or false information provided in this document. The system installer is finally responsible for supplying any uncommon factors in the system requirements. The System Installer is ultimately responsible for installing the system according to all state and local codes and regulations. It is possible that after examining the information provided, SolarWorld Americas, LLC may conclude that your specific location is inappropriate or not conducive to installing a Sunkits® Solar Electric System. Part of our commitment to our customers is high quality products, and if the location specified is not appropriate for solar installation due to the structure, direction, angle, external obstructions or other variable, we may recommend finding an alternate location or solution to satisfy the customers energy needs. I hereby certify that all information provided is complete and accurate to the best of my knowledge. Further, I hereby absolutely, irrevocably and unconditionally release and hold harmless SolarWorld Americas LLC and its affiliates, partners, and/or subsidiaries, and each of their successors, assigns, directors, officers, shareholders, employees and agents, from any and all claims, demands, actions, suits, damages and expenses of any and every nature whatsoever, known and unknown, that arise out of or relate to this document, subsequent documents, the information provided in this document and/or subsequent documents that may be provided in the course of this Sunkits® system design process.	
14. Signature:	Date:

Signature of licensed contractor is *required* to process documents.

Design rules

Safety

Safety is of paramount importance for SolarWorld in all facets of system integration. SolarWorld may adhere to requirements adopted in some locations and affect them throughout the nation as they may be deemed as a best practice. California, Oregon, New Jersey, Colorado, and Florida for example have had considerable experience with PV installations and have adopted new requirements for system safety above and beyond the latest National Codes. It is understandable that Snow load requirements in Colorado, should not be required in Florida, or wind load requirements in Florida be adopted for Colorado market. But some additions make universal sense when it comes to system designs and safety of all parties involved.

NEC and ICC codes
First default for system design safety begins with the latest national code requirements. All systems use the latest published NEC and ICC code requirements as a basis for electrical and mechanical system design, even if the local adopted code is still only requiring an older revision.

Local codes
Local codes must also be considered for details above and beyond those considered in the model codes. In many installations, this may require a local professional engineering approval and stamp for local code compliance. While it is difficult for SolarWorld to categorize local code requirements for PV systems, systems will be adjusted to meet local requirements based on input from the installing company, and local AHJs. SolarWorld will keep a record of local requirements, but as those requirements change and since PV is far reaching to every corner of the US, it is ultimately the responsibility of the Sunkit Installer to ensure that local requirements are followed and communicated to SolarWorld for key issues to be recorded.

SolarWorld non-standard requirements
SolarWorld may adopt some non-standard requirements in an effort to support safe practices. Examples of adopted design requirements:

- Much of California and Oregon currently require a 3 ft accessible area around residential rooftop arrays. (fire safety, access and pathways).
- 4 ft walkways for every 50 linear ft of array section on flat roof installations. (fire safety, access and pathways) Minimum of 3 ft. radius from any exhaust vent opening.

Suitable materials
SolarWorld will only supply designs and materials that are approved for the installation method defined by the manufacturers. Using components in an unintended or untested manor is wholly inappropriate without prior stamped engineering approval.

Installation guides
Installation guides and manuals must be read, understood, and followed. Any contradicting instructions or instructions incongruent with local codes should immediately be brought to SolarWorld technical support's attention prior to installation.

At risk structures
Some structures (i.e., many pre-fabricated metal buildings) are not suitable for system installations. If for any reason there is concern for structural and safety integrity, SolarWorld reserves the right to refuse design and sale of that Sunkit.

Grounding
While there are several methods in the marketplace for grounding a PV system, Sunkits defaults to the generally accepted method of incorporating tin plated grounding lugs approved for outdoor use as noted in the module installation guide.

Financial investment

SolarWorld asserts that it is in the best interest of the system owners to have the best financial return and most effective system for their money. Sunkits are priced on a $/W basis, so adjustments to balance of system costs are incorporated in the price of the Sunkit and wholly reliant on the number and type of modules provided.

System size impact
A Sunkit solution is intended to provide the system owner with what they need, rather than how much they can fit. Offsetting 100% or more of the system owner's energy demand is not generally the best practice for the financial investment. In many cases, particularly with tiered utility rate structures, a smaller system will provide a better financial offering and return on investment than a larger system.

Array tracker options
Tracking options are often considered to increase energy generation, however, in many cases, that equivalent money spent on a larger system with more PV modules will generate more kWh/$ spent and require little to no ongoing maintenance costs.

Rebates and incentives
System designs that void a rebate or incentive program should be avoided. A system that does not meet rebate requirements is considered a poor design. SolarWorld reserves the right to refuse design and sale of system that increases payback time due to decreased efficiency of the design when there are more efficient and cost effective options.

System efficiency

System efficiency is a look at all of the components of a system design and their lifetime effect on energy production. Choosing the right components to work together appropriately is of importance, not only for code requirements, but for lifetime energy production of the system.

SolarWorld modules
SolarWorld modules are plus sorted and have very tight tolerances. This ensures when modules are connected together in a system, they work optimally with each other.

Array configuration
Array configuration is important to the effective lifetime operation and efficiency of the inverters. Connecting modules in significantly different orientations in a single series string of modules to a string inverter is considered bad system design since the lower performing orientation will drag down the potential of the higher performing orientation, and reduce overall energy performance.

String sizing
String sizing is important for safety and inverter integrity. The number of modules connected together in series to generate the appropriate voltage required by the inverter is tricky. Local factors must be considered to maximize inverter uptime and efficient production. Temperature ranges tend to have the largest impact on the electrical design of the system and may limit sizing options in a specific area. Oregon's ETO (Energy Trust of Oregon), for example, ads up to 30° C to the average local high temperature for pitched roof installation. The design factor adjustment accounts for higher temperatures that can arise due to a smaller gap for cooling airflow behind the module. Additionally, Oregon requires the inverter low voltage window to be increased by 15% to avoid potential future degradation in the module voltages which could reduce inverter daily uptime down the road. While SolarWorld may not hold the rest of the nation to the stringent requirements of Oregon, particularly due to the quality of the modules being used in a Sunkit system and the limited impact on voltage due to degradation, the concept is sound and SolarWorld and many inverter manufacturers have generated similar guides to efficient system design.

Note: This is not intended to limit choices. Much of this is the art of system design. The first question is will it work. Then, will it work efficiently for a long time. Customers should understand the impacts of different system designs that may influence their decision on system size.

Array orientation
Orientation of the array should be considered. Choosing the best location for the system can be tricky, but in general the most southern facing orientation at an angle close to the latitude is the goal. However, there are always caveats to this rule and in > 99% of systems installed are NOT installed at this optimum angle and orientation. There are many other factors that go into the system design that effect the ability to meet this goal and peak optimum orientation but SolarWorld system designers strive to get as close as possible without detrimentally effecting the other criteria.

Array shading
Shading is of considerable importance to Sunkit systems. In some cases, if shading is significant enough, there are some clear options.

- Limit the size of the system to reduce or eliminate the impact of the shading
- Remove the object(s) causing the shade.
- Use the micro-inverter solution available to limit the shade impact on individual modules, rather than an entire series string of modules.
- Choose a different location for the system, either ground mounted or and alternate roof location (often a non-ideal roof orientation is preferred to a shaded roof in a more ideal orientation).
- Choose not to go solar for that customer, offer energy efficiency upgrades and appliances to reduce the energy consumption of the customer.
- In reality, this should be done first anyway. The most valuable kWh is the one not needed.

Row spacing
Row spacing on flat roofs (generally commercial buildings) can be tricky. It requires a balance of optimum tilt to maximum rows (minimize row spaces) for maximum performance. This is a bit of the art of system design and is a function of each site. In general, maximizing inverter efficiencies often becomes the deciding factor. If a 5 degree reduction in tilt can add another row of modules, but require an additional non-maximized inverter, it may not be the right choice. Similarly, if the 5 degree reduction does not allow for more rows, perhaps it is possible to increase the tilt by 5 degrees, use the same inverter, and increase system performance. This “requirement” is more subjective but should be investigated during system design.

Aesthetics

While aesthetics is generally a subjective portion of system design, there are some simple design parameters that have proven to be more beneficial in the long run. SolarWorld wants to be sure not to unduly sacrifice aesthetic value in pursuit of the maximum performance. It is important to keep in mind that most homes will be resold prior to the life of the solar electric system runs out. A Sunkit solar electric system should add value and not inhibit the resale of a home, and of course, customers should be happy with their system, including the appearance, so they will recommend systems to others in the community. The following are some basic guidelines to system design aesthetics that SolarWorld follows in the Sunkit program.

Compound tilts
No tilted modules on pitched roof slopes greater than 2-12 pitch. This is what is known as a compound tilt angle. It is understandable that one might make an effort to tilt modules on an eastern or western facing roof to face more south and closer to the optimum tilt. Tilting the array to the south on a north facing roof should NEVER be considered. There are a number of reasons why these are considered a poor design.

Aesthetic impact
First and foremost, it has been generally accepted that the saw tooth appearance of tilted modules on pitched roofs is very unattractive. This same phenomenon was noted in the 80s with solar hot water panels that have to be tilted due south, and the general consensus was that the aesthetics where unsightly. SolarWorld and installing companies alike will want the potential customers driving by to like what they see.

Aesthetic impact
These tilts will require that multiple rows be spaced very far apart to avoid shading concerns, so may only be using 1/3 to 1/4 of the available roof space with large gaps between rows.

Safety impact
Most tilted mounting solutions are not designed to be mounted on an angled plane (non-level); this changes the loads on the components and can put the system in danger of not being safe or secure.

Financial impact
By titling the modules, it is creating a much higher wind loading on the array (like a sail on the roof), and more materials and installation expense will likely be required to meet the new loads.

Efficiency impact
While theoretically the "more" due south facing modules will receive more of the Sun's energy, the cost increase to the system and the detrimental aesthetics outweigh the increase in efficiency. In many cases choosing the east or western facing roof will only reduce the energy performance from the optimum performance by a maximum of 20%. It could be as little as 5% performance reduction from optimum.

Protruding modules
Sunkits will always avoid modules overhanging ridges, eves and roof edges (not to include specially designed and engineered window awnings and shade structures). While this may reduce system sizes for individual customers, there are significant impacts of designing systems with such characteristics.

Aesthetics impact
Overhangs outside of the general building envelope or protruding from the apex of a roof tend to draw the eye unnecessarily and can take away from the overall look of a building.

Safety impact
Installing systems with overhanging components makes it difficult or impossible for the homeowner to perform basic home maintenance safely.

Safety impact
If the structure were to have a fire, the safety of the fire fighters trying to secure the home could be in jeopardy when trying to traverse the overhanging portions of the solar array.

Safety impact
The penetrations would tend to be very close to the edge of the roof in order to meet mounting requirements of the live loads (wind and snow), and will likely not be mounted to structural components, but faux rafter tail or façade edging.

Design impact
Over hanging edges of arrays tend to have a minimum of 3x the wind loading requirements of array portions located centrally on a roof. This will require more penetrations, or not strong enough penetrations.

Mounting solutions

Not all Sunkits are supplied with all of the structural materials required for installation. In fact, a no mounting option is available and the structural and material supply responsibility lies with the installer. SolarWorld recognizes that there can be uncommon situations where the standard mounting components supplied by SolarWorld are not sufficient for a specific installation, or not cost effective due to solutions commercial availability. In such cases, SolarWorld will not be able to provide engineering or design support for the structural portion of that system. There are some guidelines SolarWorld adheres to for our own structure designs and that our long experience and quality requirements recommend for constructing such systems. Safety and system life should be a priority for any structural solution.

Approved materials
Only use designs and materials approved by qualified professional engineers and approved by local building code requirements for specific installation.

Engineering
A qualified engineer providing stamps for the structure should have all qualifications required for permitting and stamping in the local area of the installation.

Structure
Structural elements should be constructed with suitable materials for the environment. The below are not strict limitations but will offer the best chance of success for successfully navigating the structural engineering requirements.

Examples:

- Anodized Aluminum and Stainless steel hardware should be used whenever possible to reduce material fatigue over the long life of the system in harsh environments. In particular those locations close to corrosive environments like salt and byproducts of industrial processes.
- If steel is used it is recommended to use hot dipped galvanized coating; ASTM A123, which can be maintenance free for 75 years.
- Do not use "standard" galvanized metal strut materials for structural mounting. These prefabricated components tend to be weaker as individual units and require considerably more material, as well as thinner material that can corrode at key intersecting points that have lost the galvanized coating, significantly reducing integrity and increasing the potential safety hazard over the life of the system.

SolarWorld provided designs

Electrical single line and mechanical layout drawings can be provided by SolarWorld for systems that include the purchase of the mounting components and inverter and are supplied with a fully completed questionnaire. Part of the customer benefit of SolarWorld Sunkits is that SolarWorld will have a record of the system in our data base for future inquiries, trouble shooting, or technical support. If SolarWorld does not supply the designs for the system and the system is based off of system designs by alternate sources, SolarWorld requires that the designs submitted and approved for permitting are supplied to SolarWorld for our records and meet the design criteria set forth in this document.

No mounting option
SolarWorld recognizes that there are many different mounting solutions available, or required by a customer, which is not provided by SolarWorld. If a Sunkit is purchased with a "No mounting" option, SolarWorld requires that the Mechanical plans submitted for permitting and/or inspection are supplied to SolarWorld for approval.

> SolarWorld will not provide mechanical layout drawings for Sunkit systems which SolarWorld does not supply the full mounting solution.

No inverter option
SolarWorld recognizes that there are many different inverter options available or specifically requested by a customer. SolarWorld has teamed with the highest quality inverter manufacturers in the industry and there is frequently an alternate solution with an inverter available through SolarWorld. However, if an inverter has been procured through a different route or is no available through SolarWorld, the "No inverter" option is available. If a Sunkit is purchased with a "No inverter" option, SolarWorld requires that the Electrical plans submitted for permitting and or inspection are supplied to SolarWorld for our approval.

SolarWorld will not provide electrical drawings for systems which SolarWorld does not supply the inverters.

Mechanical integration

PV modules have a 25 year performance warranty but can be expected to produce energy for 30 plus years and the system components should be designed to last as long. The workmanship of the installation should not only meet local and national code requirements but should exceed the customer's aesthetic requirements.

SW Installation Best Practice: The condition of the roofing material should be checked during the site evaluation and is a critical factor in minimizing the potential for leaks during the 30-40 year life of the system. Repair or replace any damaged areas where the array will be installed prior to installing the modules as this area will become inaccessible.

Be sure to review the documentation provided with the racking system and solar modules.

Steps

- Layout
- Roof Penetrations
- Racking Installation

Safety

Fall protection
Standard measures to protect against falling from roofs should be followed, including wearing fall restraint equipment. An anchor system needs to be put in place on the roof peak or other suitable point, and each person working on the roof needs to be trained in the proper use of the equipment and should always utilize it.

Exposure
Persons working on exposed rooftops for many hours must drink water and wear sun protection, and take adequate breaks.

Ladders
Frequent use of ladders can lead to carelessness and improper climbing technique. Have both hands free to grip the ladder and secure tools to a proper tool belt instead of carrying by hand. Ladders should be secured at the top to the surface they are resting against. Proper tilt angles must be used as well.

Working in enclosed spaces
It is sometimes necessary to work in attic spaces that can be confined, dark and hot. Follow proper procedures for a buddy system and install adequate lighting. Lay down plywood or other materials to protect against stepping through ceiling areas. Wear proper breathing equipment when working around dust or insulation.

Falling objects
Hard hats should be worn by all persons working on a solar installation. Tools and other heavy and sharp objects can be dropped from the roof on people working or walking below. The area immediately below the roof should be taped off or in some equivalent way made accessible only to the installation crew. The homeowner and family and friends should not be allowed to walk or stand near the roof edge while work is being conducted on the roof.

Tools (general)

Item	Comments
Tape measure	
Chalk line	Roof layout
Lumber crayon	Marking standoff locations
Drill	
Impact Driver	
Drill bits	
Socket drivers set	Racking installation
Multi-meter with DC current clamp	
OSHA approved safety glasses and footwear	
OSHA approved safety fall protection	Ex. harness and anchor
Roofing bar	Pulling nails from roofing material
Roof sealant/caulking	Seal penetrations
Adjustable Pliers 1-1/2” jaw capacity	
Utility knife with hook blade	For cutting comp shingles
First aid kit	Keep stocked regularly

Tools (Sunfix plus)

Item	Comments
7/32” long drill bit	QM pilot holes
1/2” and 9/16” socket drivers	Racking installation
Multi-meter with DC current clamp	
3/8” carbide masonry drill bit	Breaking through comp shingle surface only, not pilot hole

Bolt table

Bolt Diameter		
Fraction	Decimal	Socket
#6 / #8		1/4
#10 / #12		5/16
1/4	0.25	7/16
5/16	0.3125	1/2
3/8	0.375	9/16
7/16	0.4375	5/8
1/2	0.5	3/4
9/16	0.5625	13/16
5/8	0.625	15/16
3/4	0.75	1-1/8
7/8	0.875	1-5/16
1	1	1-1/2

Layout

Review the system design and installation documents when measure and mark the jobsite
Proper layout will reduce drilling extra holes and having to reposition an installed array. Prior to getting on the roof, the system layout should be defined on paper in the form of a drawing or sketch. This will minimize the number of chalk lines on the roof and speed up the layout process. The drawing or sketch should define the overall dimensions of the array as well as the roof plane the array is to be installed on. To define the overall dimensions of the array, SolarWorld modules are 39.4” wide x 66” tall. The space between the modules needs to be accounted for and this varies depending on the racking manufacturer.

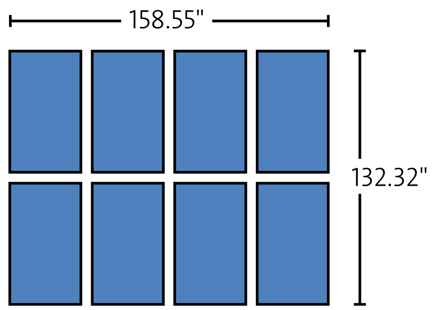
Pitched roof

Manufacturer	Mid Clamp	End Clamp
SolarWorld Sunfix Plus	0.315”	2”
Pro Solar	0.6”	2”
Unirac	1.0”	2”

Therefore the overall dimensions of an array of 4 modules in portrait by 2 rows using Sunfix Plus would be:

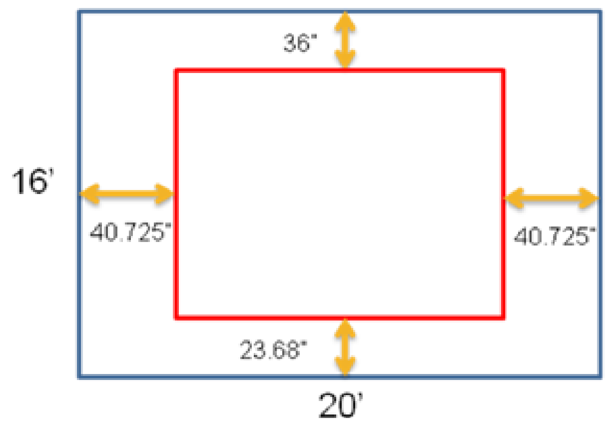
Width = 2” + 39.4” + .315” + 39.4:” + .315” + 39.4”+ .315” + 39.4” = 162.545” (includes end clamps)
Height = 66” + .315” + 66” = 132.315

Note: A clamp is not used between rows, but a matching space is recommended.



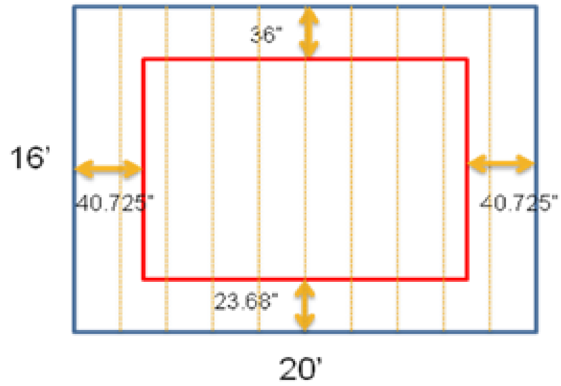
The next step will be to layout the array on the roof plane. The required clearances between the edge of the roof and the array vary by AHJ and should be understood for the particular market. The default is to leave a minimum 36” on the sides of the array as well as from the ridge to provide access for firefighters to vent the roof. In most applications, centering the array on the roof plane is the best for aesthetics. Subtract the array width from the total roof plane width and divide by two. This will give you the clearance on either side of the array. Using the chalk line, mark these dimensions on the roof. Repeat these similar steps for the top and bottom of the array. Subtract the array height from the total roof plane height and divide by two. This will give you the clearance on the top and bottom of the array, be sure to maintain ridge clearances.

For example:
The roof plane measures 16’ x 20’. Center the array on the roof measuring 36” from the ridge.
Change feet to inches (20’ x 12”) – 158.55” (solar array width) = 244” – 158.55 = 81.45 (unused space)
81.45 ÷ 2 = 40.725 = clearance between array and edges of roof plane.



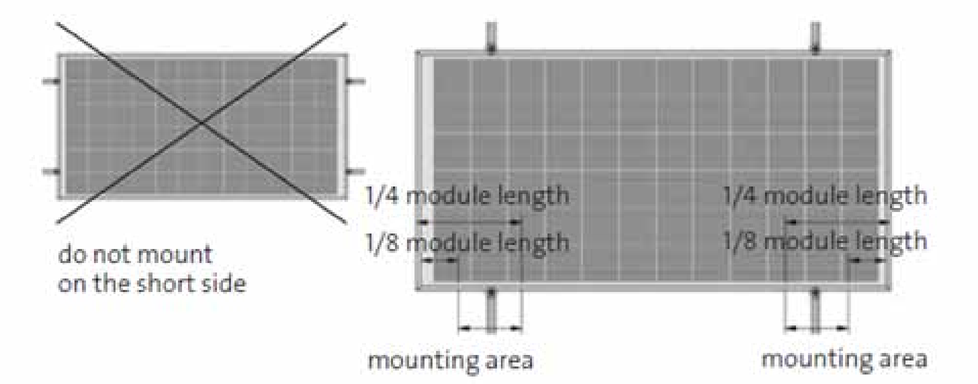
The next step is to find the rafters and mark them on the roof. Stand-offs used to support the array racking must be attached to structural members. Typical rafter spacing is 24” on center and most racking systems are designed to span 48” o.c. maximum.

SW Installation Best Practice: For aesthetics try to avoid installing penetrations outside of the array.

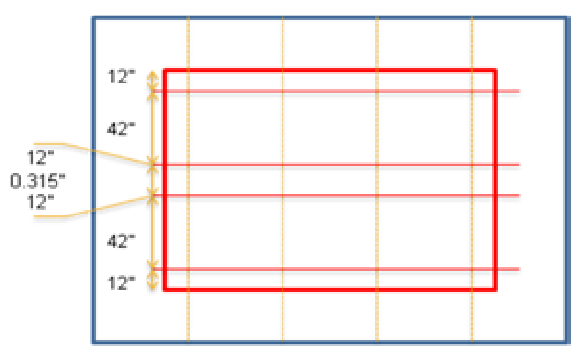


The next step is to layout where the penetrations for the rails will be located. Mark the rafters that will be used, standard spacing for the penetrations is 48" o.c. Also do not make penetrations outside of the array envelope. Then measure out the rail spacing on the edge rafters. Small adjustments may be made to help position flashings or footings for a smoother more reliable install. For example: it may be useful to move a row of penetrations up an inch so that they better fit in line with roof shingles.

SolarWorld modules must be securely fastened at a minimum of 4 points on the long sides between ¼ and 1/8 of the module length or between 8.25" and 16.5" from the edge.



Using the middle of this range, layout the rails at 12" from the edge and 42" apart. Where the rows of modules meet, add the width the modules are spaced. This will provide a uniform appearance of vertical and horizontal spacing. This is a good time to review the positioning of the array on the roof!



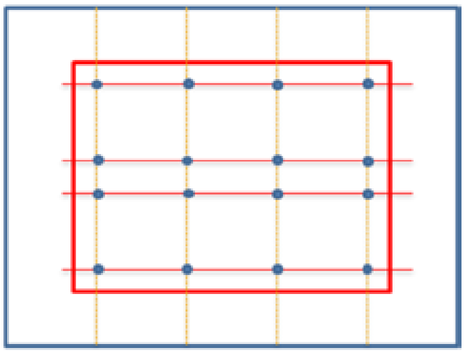
Penetrations

Once approved and the layout on the roof matches the drawings the next step is to install the mounting system to the roof.

SolarWorld recommends that all roof penetrations are properly flashed.

SW Installation Best Practice: It is important to make sure that the penetrations are properly attached to structural members. If possible, from the attic confirm the penetrations did not miss the rafters or blow out the side. The options are to reposition the penetration or add blocking between the rafters.

Once the locations of the mounting system have been marked, follow the manufacturer's installation guidelines. The type of roofing material will determine the proper roof penetration. There are many racking manufacturer options, but SolarWorld has selected key partners whose quality, performance, and value compliment the SolarWorld brand. Table 1.0 shows the roof type and the racking manufacturer used in SolarWorld systems. Always read and follow the manufacturer's installation guidelines prior to installing on the roof.

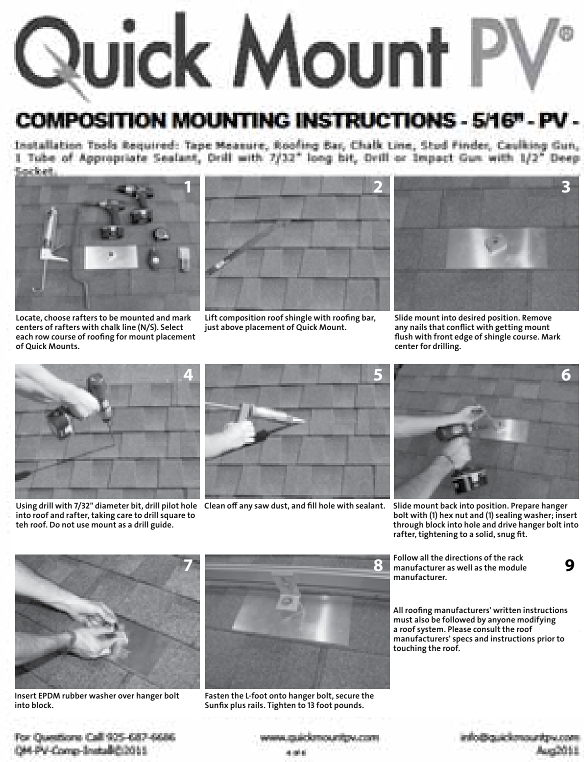


Pitched Roof Solutions

	Composition	Flat Tile	S-Tile	Standing Seam
Sunfix Plus w/ QuickMount	X	X	X	
ProSolar	X	X	X	
Unirac	X	X	X	
S-5!				X

Composition

QuickMountPV®



Quick Mount PV®

COMPOSITION MOUNTING INSTRUCTIONS - 5/16" - PV -

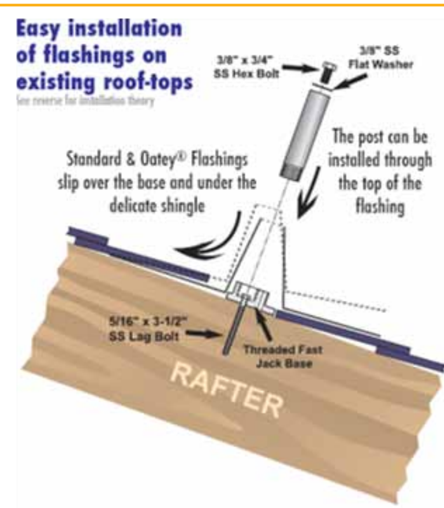
Installation Tools Required: Tape Measure, Roofing Bar, Chalk Line, Stud Finder, Caulking Gun, 1 Tube of Appropriate Sealant, Drill with 7/32" long bit, Drill or Impact Gun with 1/2" Deep Socket.

1. Locate, choose rafters to be mounted and mark centers of rafters with chalk line (N/S). Select each row course of roofing for mount placement of Quick Mounts.
2. Lift composition roof shingle with roofing bar, just above placement of Quick Mount.
3. Slide mount into desired position. Remove any nails that conflict with getting mount flush with front edge of shingle course. Mark center for drilling.
4. Using drill with 7/32" diameter bit, drill pilot hole into roof and rafter, taking care to drill square to teh roof. Do not use mount as a drill guide.
5. Clean off any saw dust, and fill hole with sealant.
6. Slide mount back into position. Prepare hanger bolt with (1) hex nut and (1) sealing washer; insert through block into hole and drive hanger bolt into rafter, tightening to a solid, snug fit.
7. Insert EPDM rubber washer over hanger bolt into block.
8. Fasten the L-foot onto hanger bolt, secure the Sunfix plus rails. Tighten to 13 foot pounds.
9. Follow all the directions of the rack manufacturer as well as the module manufacturer.

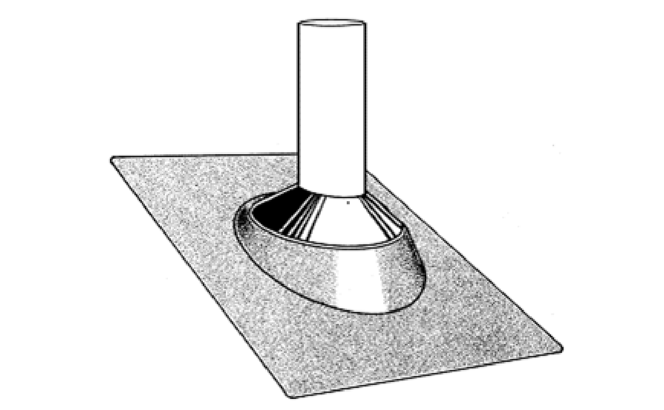
All roofing manufacturers' written instructions must also be followed by anyone modifying a roof system. Please consult the roof manufacturers' specs and instructions prior to touching the roof.

For Questions Call 925-687-6686
QM-PV-Comp-Install©2011
www.quickmountpv.com
info@quickmountpv.com
Aug2011

Professional solar Fast-Jack®



SW Installation Best Practice: The ProSolar Fast-Jack system does not include roof flashings and the type of flashing is selected by the installer. Use the best flashing for the roofing type ad region.



SW Installation Best Practice: One popular method is the no-caulk flashing (Oatey is one manufacturer). A common mistake is to allow the neoprene seal to become inverted around the penetration, resulting in a source for pooling water and eventually leaks.

Make sure roof is clean and free from any major protrusion before roof covering is installed:

> No tar, asphalt-based roof cement or “pitch” should be applied to the collar portion of any metallic No-Calk flashing or the base or collar portion of any Thermoplastic or Flexible No-Calk flashing. At the discretion of the installer, flexible roofing sealant can be applied over all exposed nails or staples. Sealant can also be applied to the underside of the base to increase sealing power to the roof and is recommended in areas where frequent or heavy precipitation is common.

Place correct size No-Calk flashing over stand-offs with angle facing down slope of the roof. Push firmly to base of stack until flashing lies flat on the roof. Flashing size should be equivalent to pipe diameter size (e.g., 1 ½” flashing for 1 ½” pipe, 2” flashing for 2” pipe size, etc.). The Oatey logo printed on the flashing represents the front or down slope side of the flashing.

The top of the flashing will be covered one-quarter to one-half of the way down with roofing shingles. The bottom edge of the flashing should overlap the shingles beneath it so it sheds, not traps, water.

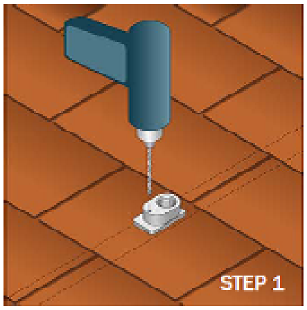
Oatey thermoplastic base flashings are designed to fit roof angles from flat to 45 degrees. Flexible, galvanized, aluminum and copper base flashings are designed to fit roof angles from flat to 38 degrees. Oatey All-Flash High-Rise Thermoplastic Roof Flashings are designed to fit roof angles from flat to 60 degrees.

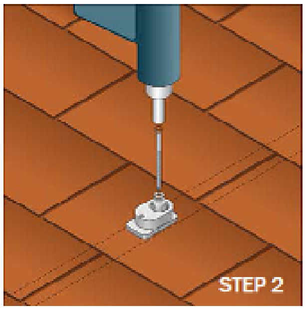
professional SOLAR products

FastJack®
Installation Manual

Date Modified: 09/10/2007

Step 3: Attaching / Sealing FastJack to Composition Shingle





The 1/4" masonry bit is to be used to break through the rough composition tile surface only to avoid premature pilot hole drill bit wear. Do not drill pilot hole with 1/4" masonry drill bit.

STEP 1: Locate rafter center by using precision stud finder or other means. Using a 3/8" masonry bit, break through the comp shingle over the rafter in the center of the shingle. Position FastJack® drill guide over the hole location and drill your pilot hole using a 3/16" drill bit.

STEP 2: Insert the 5/16" stainless steel lag bolt and washer through the FastJack® base. Install the lag bolt through the FastJack® using a ½" socket and electric impact wrench.

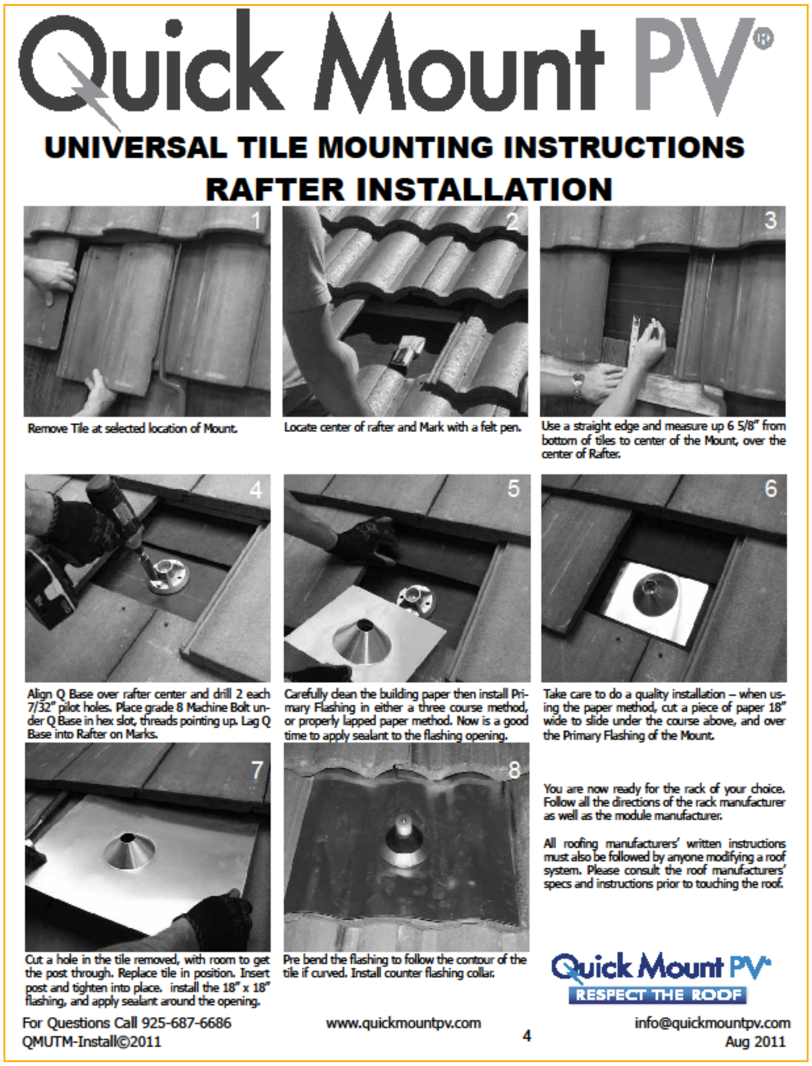
Use the Flashing Template (Oatey® flashing template #TEMP-OAT; standard flashing template #TEMP-STD) to cut in flashings on a composition rooftop to save labor and frustration. The template is an easy tool that enables the installer to quickly and cleanly cut in a flashing with no guessing or struggle.

STEP 3: Using a FastJack® flashing template (optional), and a utility knife with hook blade, cut composition shingle. The template will cut the shingle to the size needed for a standard or Oatey® flashing. (TEMP-STD illustrated)

Tile

QuickmountPV® - universal tile mounts

Tile roofs present unique challenges during the installation of roof mounts. Depending on the condition of the tiles and the number of required penetrations, an alternative is to remove the tiles where the array is to be installed, install composition roofing, and then replace tiles around the perimeter.



Quick Mount PV®

UNIVERSAL TILE MOUNTING INSTRUCTIONS

RAFTER INSTALLATION

1 Remove Tile at selected location of Mount.

2 Locate center of rafter and Mark with a felt pen.

3 Use a straight edge and measure up 6 5/8" from bottom of tiles to center of the Mount, over the center of Rafter.

4 Align Q Base over rafter center and drill 2 each 7/32" pilot holes. Place grade 8 Machine Bolt under Q Base in hex slot, threads pointing up. Lag Q Base into Rafter on Marks.

5 Carefully clean the building paper then install Primary Flashing in either a three course method, or properly lapped paper method. Now is a good time to apply sealant to the flashing opening.

6 Take care to do a quality installation – when using the paper method, cut a piece of paper 18" wide to slide under the course above, and over the Primary Flashing of the Mount.

7 Cut a hole in the tile removed, with room to get the post through. Replace tile in position. Insert post and tighten into place. install the 18" x 18" flashing, and apply sealant around the opening.

8 Pre bend the flashing to follow the contour of the tile if curved. Install counter flashing collar.

You are now ready for the rack of your choice. Follow all the directions of the rack manufacturer as well as the module manufacturer.

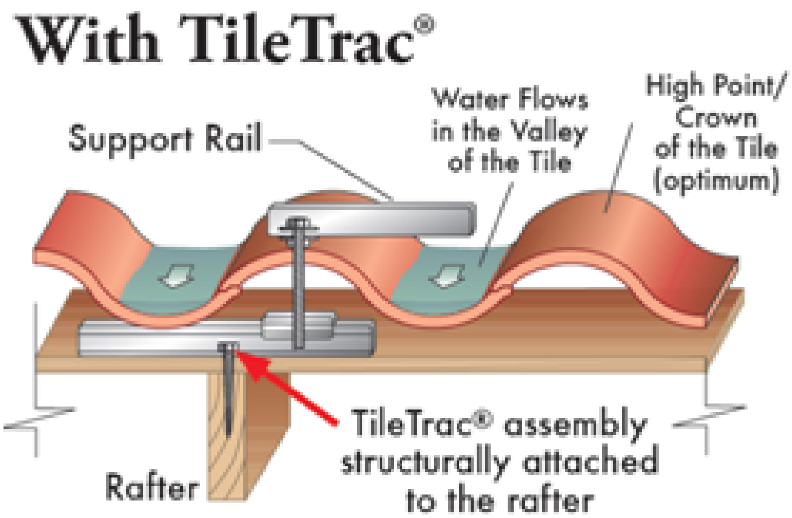
All roofing manufacturers' written instructions must also be followed by anyone modifying a roof system. Please consult the roof manufacturers' specs and instructions prior to touching the roof.

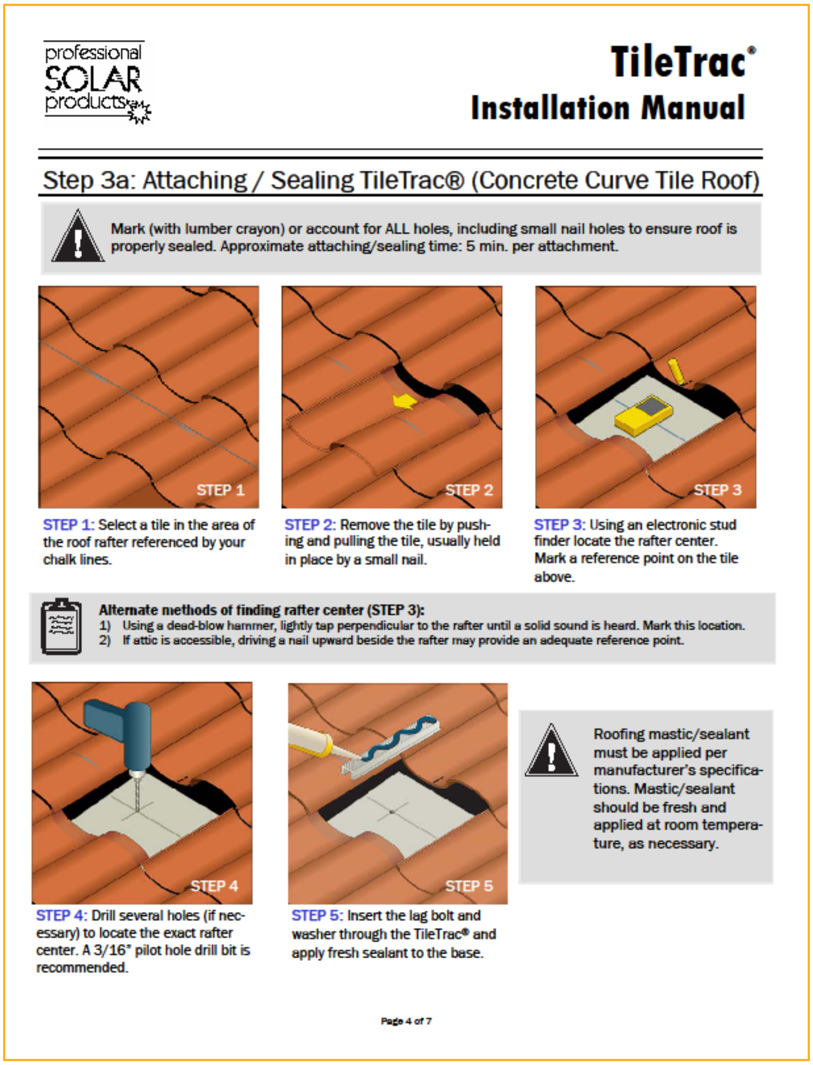
Quick Mount PV® RESPECT THE ROOF

For Questions Call 925-687-6686 www.quickmountpv.com 4 info@quickmountpv.com

QMUTM-Install©2011 Aug 2011

Professional solar Tile Trac®




professional SOLAR products

TileTrac®
Installation Manual

Step 3a: Attaching / Sealing TileTrac® (Concrete Curve Tile Roof)

Mark (with lumber crayon) or account for ALL holes, including small nail holes to ensure roof is properly sealed. Approximate attaching/sealing time: 5 min. per attachment.

STEP 1

STEP 1: Select a tile in the area of the roof rafter referenced by your chalk lines.

STEP 2

STEP 2: Remove the tile by pushing and pulling the tile, usually held in place by a small nail.

STEP 3

STEP 3: Using an electronic stud finder locate the rafter center. Mark a reference point on the tile above.

Alternate methods of finding rafter center (STEP 3):
1) Using a dead-blow hammer, lightly tap perpendicular to the rafter until a solid sound is heard. Mark this location.
2) If attic is accessible, driving a nail upward beside the rafter may provide an adequate reference point.

STEP 4

STEP 4: Drill several holes (if necessary) to locate the exact rafter center. A 3/16" pilot hole drill bit is recommended.

STEP 5

STEP 5: Insert the lag bolt and washer through the TileTrac® and apply fresh sealant to the base.

Roofing mastic/sealant must be applied per manufacturer's specifications. Mastic/sealant should be fresh and applied at room temperature, as necessary.

Page 4 of 7

Sunfix standing seam metal roof

The Sunfix SSMR allows the modules to be mounted directly to the roof in landscape or can be used with rails to install the modules in portrait.

SW Installation Best Practice: In many cases S-5 and SolarWorld recommend utilizing clamps on nearly every seam that the modules cross.

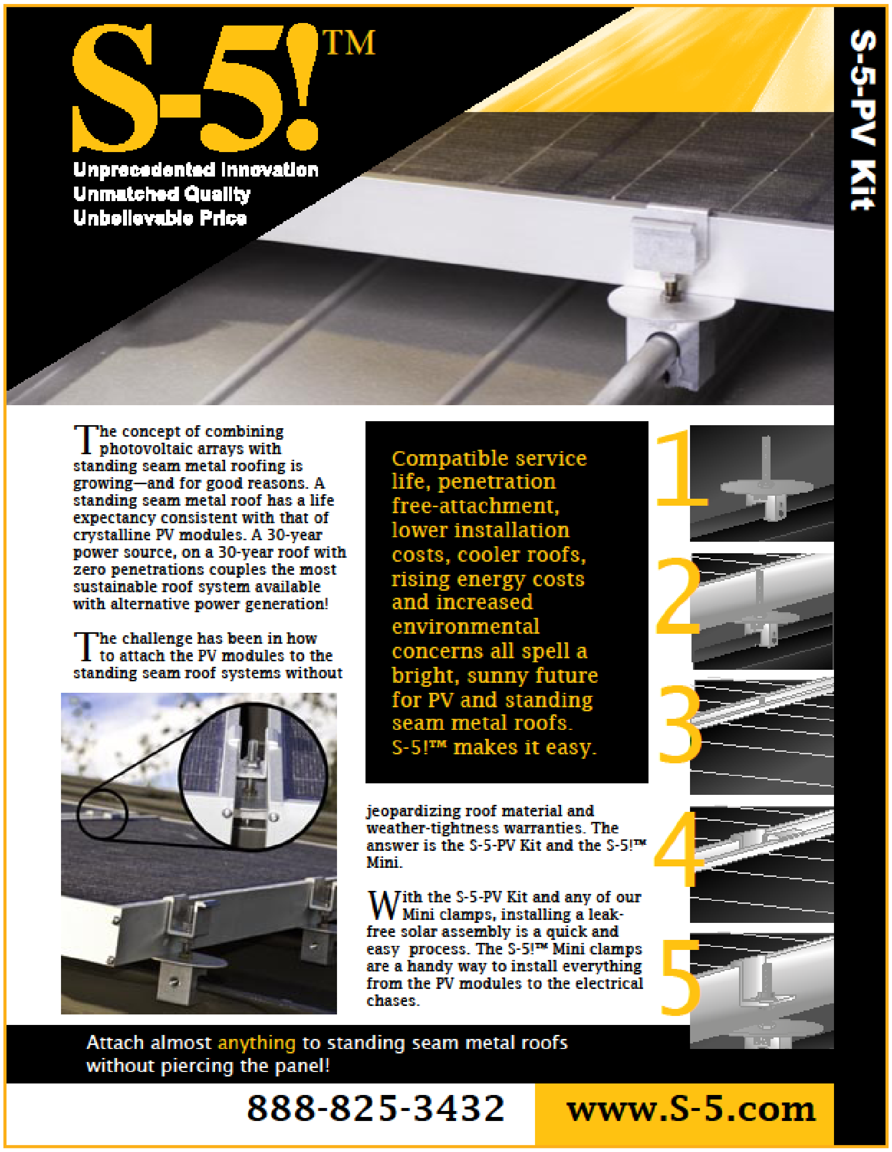
When installing directly to the roof there are two layout methods:

1) Seam Alignment: Modules are aligned on the roof so that the seams support the modules at the recommended quarter points. Depending on the spacing of the seams, this typically results in a larger spacing between modules.
2) Module Alignment: Modules are aligned on the roof so that the module spacing is approximately 3/8" apart. As a result the seams may not land at the quarter points. The solution is to install additional clamps the module to meet the loading requirements.

SW Installation Best Practice: SolarWorld does not endorse the S-5! PV Kit as it requires field adjustment of a jamb nut to achieve proper clamping force on the modules. We recommend using SolarWorld Sunfix clamping hardware with S-5 clamps.

CAUTION

Metal roofs can be HOT! Common practice is to place a piece of cardboard or carpet on the surface to prevent getting burned while working on roof.



Racking installation

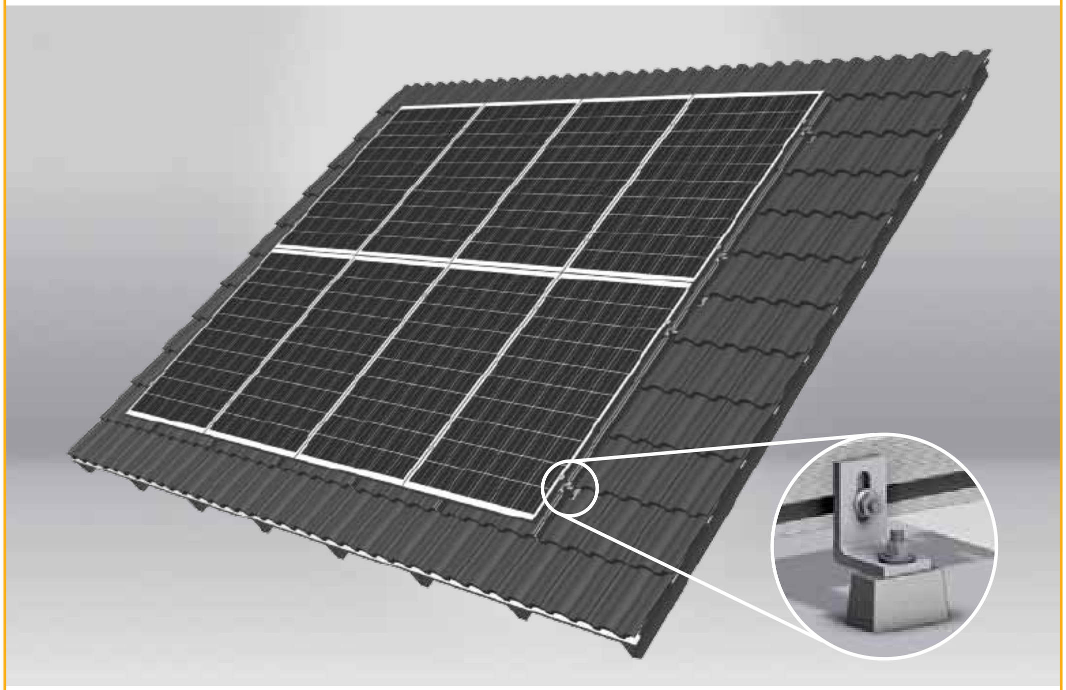
It is important that the racking system is designed and installed to meet the site specific conditions, including loading and environmental conditions. Areas with higher wind or snow loads may require additional roof mounts or rails. More corrosive environments, such as coastal installations, require all hardware to be anodized aluminum or stainless steel. SolarWorld supplies racking that has been specifically designed for PV installations.

SW Installation Best Practice: PV modules will last 25 plus years and it is important that all components of the systems be designed to last as long.

Sunfix plus®

February 2012

Pitched roof mounting system planning and installation guide

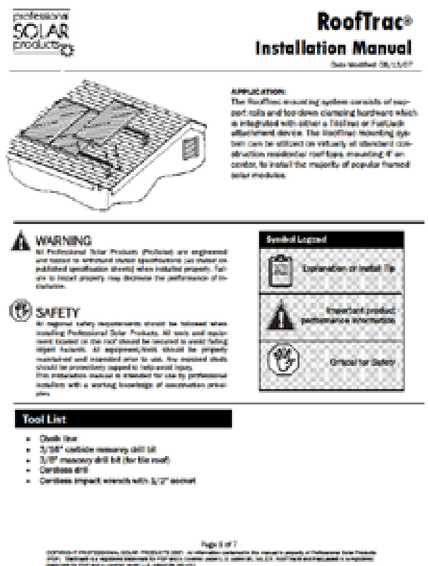


America's largest solar manufacturer since 1975

SolarWorld

UNIRAC SolarMount	Prosolar


SOLARMOUNT
Code-Compliant Installation Manual 227.3
Table of Contents
UNIRAC
Unirac Code-Compliant Installation Manual


professional SOLAR products
RoofTrac®
Installation Manual
APPLICATION:
WARNING
SAFETY
Symbol Legend
Tool List

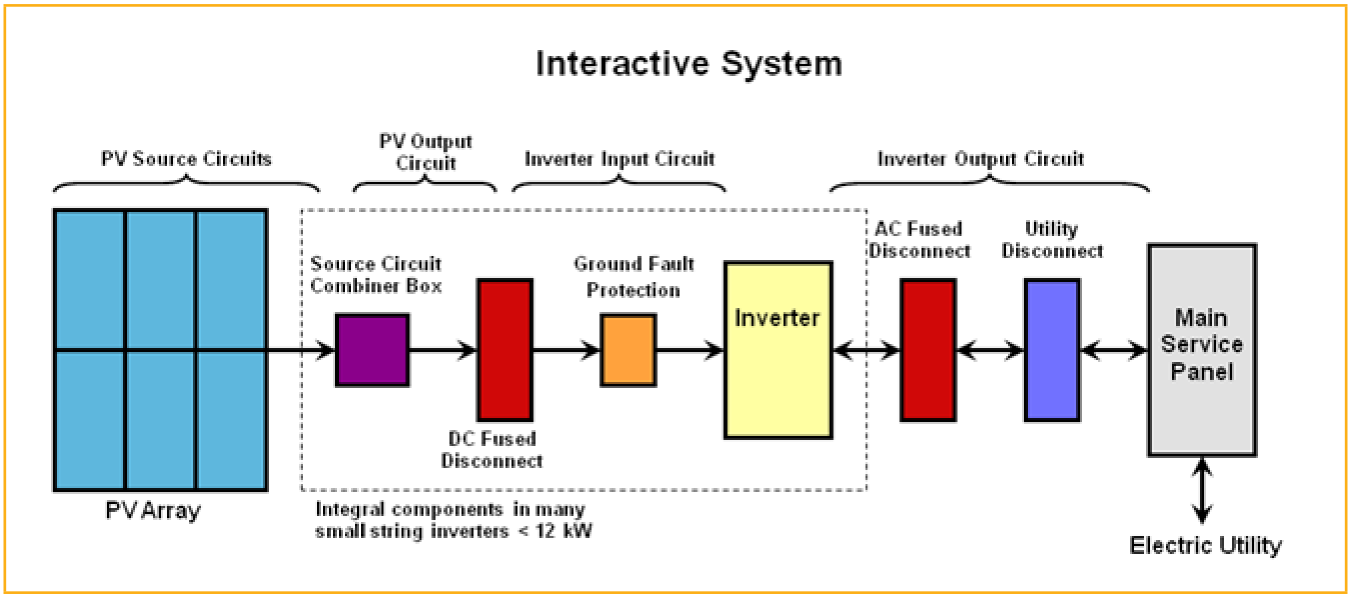
Solar module handling/installation

- Do not drop module or allow objects to fall on module.
- Do not stand or step on module.
- It must be assured that other system components do not generate any hazard of any mechanical or electrical nature to the module.
- Never leave a module unsupported or unsecured. If a module should fall, the glass can break. A module with broken glass cannot be repaired and must not be used.
- Work only under dry conditions, with dry module and tools.
- Module installation and operation should be performed by qualified personnel only. Children should not be allowed near the solar electric installation.
- If not otherwise specified, it is recommended that requirements of the latest local, national and/or regional electric codes be followed.
- Use module for its intended function only. Follow all module manufacturer´s instructions. Do not disassemble the module, or remove any part or label installed by the manufacturer. Do not treat the back sheet with paint or adhesives.

Electrical integration

Electrical integration involves connecting the PV modules to each other, creating PV source circuits, and wiring the balance of system electrical components such as J-boxes, combiner boxes, AC/DC disconnects, inverters and a utility interconnection. As the scope of this document covers residential and small commercial systems, the maximum system voltage is 600 V DC. Since PV systems involve working with DC and AC systems, most jurisdictions require the electrical portion of a PV installation to be performed by a licensed electrician or contractor. The system is also inspected by the local authority having jurisdiction (AHJ) for code compliance as well as the utility. The majority of the regulations governing electrical installations, including PV systems, are found in NFPA 70: National Electrical Code (NEC). Article 690, "Solar Photovoltaic Systems," specifically addresses the requirements for all PV installations covered under the scope of the NEC.

PV circuits diagram



Steps

- Electrical component installation
- Array installation
- Final Inspection
- System Activation

Electrical safety

The installation & testing of solar modules requires a great degree of skill and should only be performed by qualified licensed professionals. The installer assumes the risk of all injury that might occur to persons or damage to property including, without limitation, the risk of electric shock when working with live electrical components. All instructions should be read and understood before attempting to install, wire, operate and maintain the photovoltaic module.

Be sure to refer to documentation provided with your solar equipment BEFORE TAKING ANY ACTION.

***** WARNING *****

Contact with electrically active parts of the module can result in burns, sparks, and lethal shock whether the module is connected or disconnected.

Photovoltaic modules produce DC electricity when exposed to sunlight or other light sources. When modules are connected in series, voltages are additive. When modules are connected in parallel, current is additive. Consequently, a multi-module system can produce high voltages and current which constitute an increased hazard and could cause serious injury or death.

CAUTIONS

- Avoid electrical hazards when installing, wiring, operating and maintaining the module.
- When installing or working with module or wiring, cover module face completely with opaque material to halt production of electricity.
- Do not touch terminals while module is exposed to light or during installation. Provide suitable guards to prevent contact with 30VDC or greater
- Always use proper PPE (Personal Protective Equipment) including but not limited to gloves, eye protection, hard hat, fall protection, boots etc...
- Electrical arcing may occur when connecting or disconnecting module circuits under load. An arc may emit intense light that can damage vision and can cause burns or sparks.
- It must be assured that other system components do not generate any hazard of any mechanical or electrical nature to the module.
- Since sparks may be produced, do not install module where flammable gases or vapors are present.
- Work only under dry conditions, with dry module and tools.
- Use properly insulated electrical tools
- Module installation and operation should be performed by qualified personnel only. Children should not be allowed near the solar electric installation.
- If not otherwise specified, it is recommended that requirements of the latest local, national and / or regional electric codes be followed.
- Use module for its intended function only. Follow all module manufacturer´s instructions. Do not disassemble the module, or remove any part or label installed by the manufacturer. Do not treat the back sheet with paint or adhesives.
- Always measure conductors and terminals BEFORE working with them, to insure there is no voltage on the line when making connections. Do not pull apart module MC connectors under load. Ensure there is no current flowing in an array circuit before working with MC connections. Cover the solar array with an opaque blanket or other material to de-energize them.

Electrical components

This section describes how to install the BOS electrical components, including the inverter, disconnects, J-boxes, and connection to service panel.

Note: Before getting started, please read over all component guides/manuals for all the equipment used in installing your system.

Array installation

This section describes how to install the solar modules to the racking. Connecting the modules electrically to each other, the use of an array (rooftop) junction box, and grounding.

Planning/layout grounding & "homerun" circuits
Now that the racking material are in place you are ready to install your modules. However, before doing so you will want to plan the paths for your grounding and homerun circuits. This includes at the array and from the roof array through the attic, to the DC disconnect, etc. Typically you should use a mechanical or accurate layout drawing of the site and:

- Mark where you want to place your (rooftop) junction box, this will vary site to site. Often it is located nearest to the ridge and under a module secured to solar mounting rail.
- Mark your Equipment Grounding Conductor (EGC) wire run with consideration for both grounding and aiding in wire management.
- Mark any needed homerun or jumper wires.

After completing the above assessments you are now ready to mount your modules.

Note: If using micro inverters they will be installed and grounded prior to modules..

Junction box/combiner box installation
An array (rooftop or other location) junction box is used to transition from "free air" PV Wire or USE-2 conductors to more common conductors that can be easily run in conduit, such as THHN orTHWN-2. A combiner box is a junction box (J-box) used to combine or parallel source circuits into fewer larger output circuits, reduce the number of conductors that must be run to the disconnect and inverter.

Transitioning to standard PV electrical wire (THHN or THWN-2)
Transitioning from PV Wire to THHN or THWN-2 can be done a number of ways.

- Using a J-box attached to a mounting rail or
- Through the use of a SolaDeck that is flashed into the roof.

Proper wire colors/labeling
From the solar array each wire will transition into its respective standard electrical wire (THHN or THWN-2) or be run the whole way with PV cable. Proper wire color and or labeling is essential.

SW Installation Best Practice: The standard for PV cabling colors/labeling is generally similar to household wiring standards and should not be confused with automotive or other basic low voltage DC standards.

- Grounding / Bonding wires should be green or bare copper
- Negative (DC) wire should be white (or taped white) as most systems are Negative Grounded (this is a grounded current carrying conductor)
- Positive (DC) wire should be black
- (this is an ungrounded current carrying conductor)
- Additional positive DC wires may be Red or other colors not including green, grey or white
- Often additional DC wires are the above colors and labeled with a number or letter to indicate an additional string circuit

Note: The appropriate transitional wire gauge should be used and will be listed on your electrical line drawing, it should always be double checked by the appropriate licensed electrician in charge of the job. The transitional wires are also recommended to be course stranded instead of solid copper for easier workability in relation to pulling wire through conduit.

Proper wiring sequence
It is recommend that the first and last module string connectors to the "homerun" circuits are left OPEN or disconnected until after the wiring runs are completed.

1. The bare copper grounding/bonding wire should be installed first and usually attaches to the grounding conduit lock nuts and grounding / din rail itself or a terminal bars. attached to the SolaDeck unit followed by
2. Next the PV negative/white wires
3. and lLast the PV positive black or /red wires.

This wiring order is always recommended

- **SolaDeck**

  When using a SolaDeck the grounding bare copper wire, along with the positive and negative homerun circuits from the array, should be brought into the SolaDeck, inside you will transition from the array grounding and PV cabling via a terminal block or insulated lugs to the appropriate colored THHN or THWN-2 wires.

- **All weather box**

  When using an all weather box (AKA junction or bell-box) the grounding wire, along with the positive and negative homerun circuits from the array, should be brought into the J-box, through the appropriately sized gland/compression fittings or (strain reliefs). Inside you will transition from the array grounding and PV cabling via an insulated terminal strip/block or insulated lugs to the appropriate colored THHN or THWN-2 wires (the Polaris lug is a common brand/item) or equivalent.

  SW Installation Best Practice: Wire nuts may be allowed by code, however due to the nature of the outdoor conditions, SolarWorld does not recommend them. Terminal strips and insulated lugs can be torqued and wired with confidence. Exceeding code minimums for material used throughout the PV array will only increase the safety and longevity of the system.

Note: Depending on where the J-box is located and how it is mounted it should be NEMA rated appropriately. For example: J-boxes in an outdoor environment should have at least a NEMA 3 rating.

- **Weather head**

  In certain PV systems no transition from PV wire to standard electrical wire is needed (no complex jumpers when the wire is short) if the DC disconnect and inverter is nearby. When using a weather-head you can simply pull the PV wire "homerun" circuits – as well as the EGC – through the weather-head and down to the DC disconnect.

Note: Once solar circuits leave the solar array they must be run in proper conduit. For rooftop systems the conduit must be metallic. Ground mount systems may utilize PVC or appropriate conduit materials.

When metallic conduit is run through an attic, be sure to follow code for the appropriate distance from the rafters if out from under the location of the array (10 inches; NEC 690.31E1). If run directly under the array, mounting directly to the rafters is fine.

An additional option to the attic is to run the wires in conduit through the eave and out along the wall/home to the DC disconnect.

Note: Remember to properly mark or label the conduit as required by NEC code (690.31E3 and 4) and go no more than 10 ft. in between a label and/or a marking.

Grounding

Note: Depending on your jurisdiction, additional Grounding Electrode Conductors (GEC) may be required at the array (i.e., ground mounted system) and/or at the inverter.

- **Modules**

  Functional grounding of the solar module metal frame is essential. If an exterior lightning protection system is present, the PV system must be integrated into the protection concept against a direct lightning strike. Local building code requirements shall be observed. For grounding in the US and Canada the modules with a "2.0" and "2.5" frame can be grounded to by using any one of the four grounding holes in the corners of the frame. A lay-in lug and a socket head cap screw shown below are the recommended hardware (Fig. 1). For the "2.5" framed modules, grounding can be achieved by either the corners of the frame, as listed above, or through the four additional grounding holes located in the frame flange.

The hardware needed for the grounding in the flange are:

- A lay-in lug
- A bolt
- A serrated washer
- A washer
- A nut (Fig. 2)

We recommend using the components as listed below. However, any compatible UL approved PV grounding method and components are also acceptable in the US and Canada.

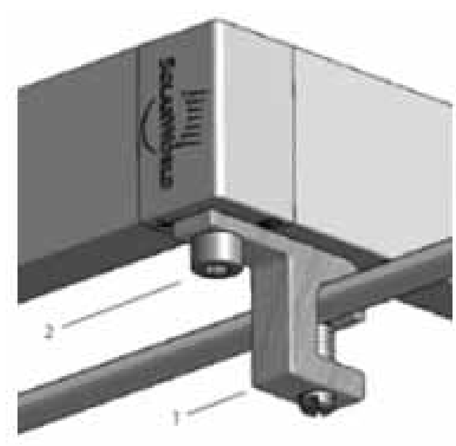


Fig 1. Lay-in lug.

Item	Manufacturer/Description	Tightening torque
Lay-in lug	Ilsco GBL-4DB (E34440)	35 lbf-in, 4-6 AWG str 25 lbf-in, 8 AWG str 20 lbf-in, 10-14 AWG sol/str
Socket head cap screw	10-24, 5/8", SS 18-8	62 lbf-in (7.0 Nm)

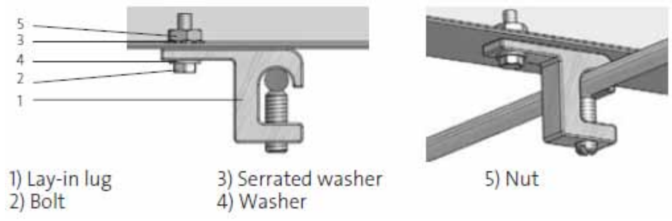


Figure 2.

Item	Description	Manufacturer/Distributor	Manufacturer Part Number
Grounding lug	Lay-in lug	Ilsco	GBL-4DBT
Bolt	#6-32, SS		
Serrated washer	M5, SS		
Washer	ID 9/64", OD 3/8", SS		
Nut	#6-32, SS		

See: www.ilsco.com; www.mcmaster.com

Once you have located all the modules in place onto the racking system, with the appropriate grounding/bonding mechanisms (tin plated copper lugs/grounding clips), then you can proceed to bond and electrically connect the modules.

- **Method (module grounding)**

  While you place each module onto the racking/mounting system, using one continuous bare copper wire (known as the Equipment Grounding Conductor (EGC) or Protected Earth (PE), connect the copper wire into the grounding lugs and tighten the set screw to the proper torque rating, then proceed to mount the module and hardware (clamps, bolts etc.) using the appropriate method the racking system calls for. Next, reach under and plug the modules together with the provided wires and connectors. Continue the said steps for the next module until you get your appropriate numbers of modules in a series string.

- **Grounding clip alternatives (WEEBs or equivalent)**

  Instead of using lugs for each module, place the grounding clips as the modules are installed; ground the rails/racking as usual.

Note: Always check with your AHJ and local inspector/s to see if grounding clips are acceptable in your area. The grounding clps used for the job will depend on the racking system.

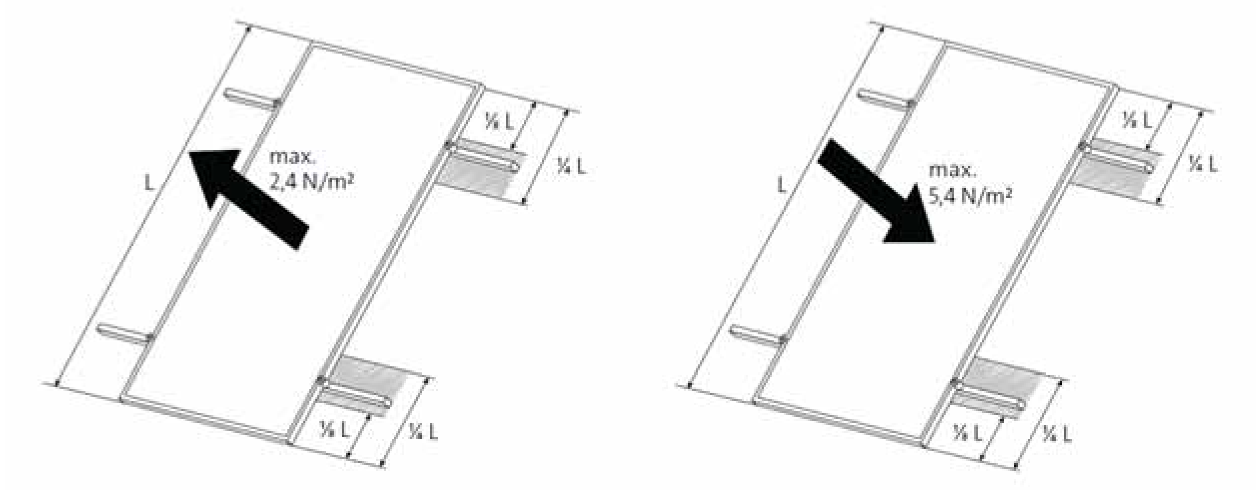
Note: Follow all instructions for the WEEBs themselves on proper use on them.

- **Microinverters**

  The grounding location of the micro inverter is located on the top side of the micro inverter itself and will need to be tied into the continuous EGC/GEC being run from module to module, module to rail and rail to rail if using the bare copper and lugs method. If using the WEEB method, then the micro inverters will have to be incorporated in to the bare copper wire used to run/ground rail to rail on the array. Please consult the micro inverter installation guide below for the exact means and torque values to use in grounding them appropriately.

After fully grounding/bonding the modules and rails/racking system, you will then connect the modules into series strings. Some sites may need jumper (extension) cables, which are outdoor rated cabling that has the proper solar connectors on the ends. Next to run the PV circuits to the DC disconnect and inverter you will need "homerun" cabling to get to the (rooftop) transition J-box/weather-head. "Homerun" cables are outdoor rated PV cables with an MC4 connector that will connect to the end of the module series string and the other stripped wire end connects to either the (rooftop) transition J-box or all the way to the DC disconnect.

Module mounting
The modules must be securely at a minimum of 4 locations on the substructure. Mounting is only allowed in designated areas located on the long sides of the module frame. They are located between 1/9 of the module length and 1/4 of the module length (8 ¼" to 16 ½"), measured from the module corner. Mounting the module on its short sides is not permissible. In regards to clamping the modules from the front/top, the clamping area on the module frame must be at least 130 mm^2 for each mounting point. The required clamping force is 20 N/m 14 lb/ft. Do not drill any holes into the module or modify them in any way. Use corrosion-resistant mounting materials. Some sites with high loads may require additional support.



Cable management
In order to secure, protect and organize the solar cabling you will need to utilize tie wraps (zip ties) or cable clips. Loop the cables in a bow shape remembering not to make the bends too tight. Keep the MC4 connections up towards the top off the racking and under a module. This will help provide protection from the elements.

For installations using the Sunmodule 2.5 frame, the flange on the long sides of the frame can also be used to secure the wires.

1. SolarWorld recommends securing all solar (including module) cabling to the arrays support structure (module frame, racking or rails). Securing cabling to mounting structure is typically faster and more effective than other means. In some systems you may be able to place cabling within the rails.

2. Multiple accessories can be used to secure cabling depending on the site and materials used, these include:

Tie wraps (aka zip ties) must be outdoor/UV rated in composite or stainless steel versions available from your local SolarWorld distributor.

Examples from manufacturer: stainless steel & composites nylon listed from Thomas & Betts

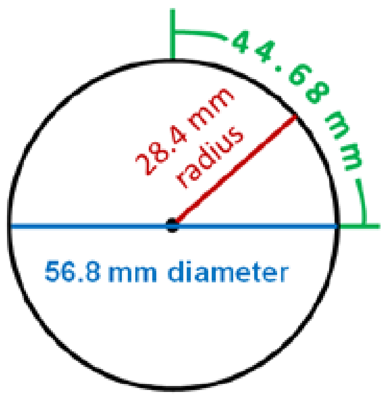
http://www.tnb.com/ps/endeca/index.cgi?a=nav&N=511+961+2661&Ntt
http://www.tnb.com/ps/endeca/index.cgi?a=nav&N=511+958+4294955757+4294954317+1324&Ntt

Cable clips must be outdoor rated and compatible with your rails/support materials. Available from your local SolarWorld distributor.

Example from manufacturer link: stainless steel listed from Wiley Tech. **http://we-llc.com/ACC.html**

3. When wrapping cables be sure to maintain a minimum bending radius of 4x cable width. For example: If the cable width is 7.1 mm, then the minumum bending radius is 28.4 mm or 1.12".

- In diameter a loop of cable would measure at least (56.8 mm) or 2.24" across.
- A 90° bend of cable would use at least (44.68 mm) or 1.76" in length.
- A 180° bend of cable would use at least (89.35 mm) or 3.52" in length.
- A full loop of cable would use at least (178.69 mm) or 7.04" in length.



PV output circuit wiring

- Splices: lugs, terminal strips, wire nuts
- Conduit: attic (10")
- Wire THHN or THWN-2
- DC disconnect: additional or supplied with inverter

Inverter installation
SolarWorld carries SMA, PV Powered, and Enphase inverters. Always refer to the manufacturer's installation guide prior to installing these components.

String inverters should be handled by two people and mounted to at least one stud.

Wiring of a separate DC disconnect
If a separate DC disconnect is required by Code for the specific AHJ of the job site, separate from the one attached to the inverter, then it should be wired as listed below.

It is recommended that the first and last module string connectors to the "homerun" circuits are left OPEN or disconnected until after the wiring runs are completed.

1. The bare copper grounding/bonding wire should be installed first and usually attaches to the grounding conduit lock nuts and grounding / terminal bars.
2. Next the PV negative/white wires
3. Last the PV positive black or red wires.

This wiring order is always recommended.

Note: Depending on the inverter you will be installing, "string" or "micro" inverter/s, there will be a slight differences in the wiring process. In this section we will be talking strictly about string inverters, micro inverters will be revisited later.

Wiring of the DC disconnect attached to the inverter

Note: Depending on the string inverter specified for the job you may have to wire and attach the DC disconnect prior to continuing with your wiring of the inverter disconnect (i.e., SMA). However, the inverter manuals will provide you with all the information you need to wire the disconnect properly.

It is recommend that the first and last module string connectors to the "homerun" circuits are left OPEN or disconnected until after the wiring runs are completed.

1. The bare copper grounding/bonding wire should be installed first and usually attaches to the grounding conduit lock nuts and to the grounding terminal designated as the PE or Protected Earth ground located on what is sometimes referred to as the AC side of the disconnect.
2. Next the PV negative/white wires
3. Last the PV positive black or red wires.

This wiring order is always recommended.

Note: Some string inverter disconnect switches are both DC and AC combined (PVPowered) however, depending on your jurisdiction you may need a separate AC disconnect switch independent from the inverter or the breaker in the main/sub-panel.

Some inverters require an AC neutral wire (Enphase) and some don't (PVPowered). SMA inverters can typically be wired with or without neutral (there are some exceptions).

AC with no neutral
If there is no neutral used on the AC side of the inverter, the AC disconnect terminals will be labeled "Ground/PE, L1, and L2." You will use a grounding conductor (green wire) then L1 is for line 1 (typically a black wire) and L2 is for line 2 (typically a red wire) (PVPowered, SMA optional).

Note: the "grounded DC" terminal is not the same as grounding/bonding; it refers to an inverter ground fault detection system that uses the negative wire connected to the grounding system via a fuse or other device to look for faults (GFDI).

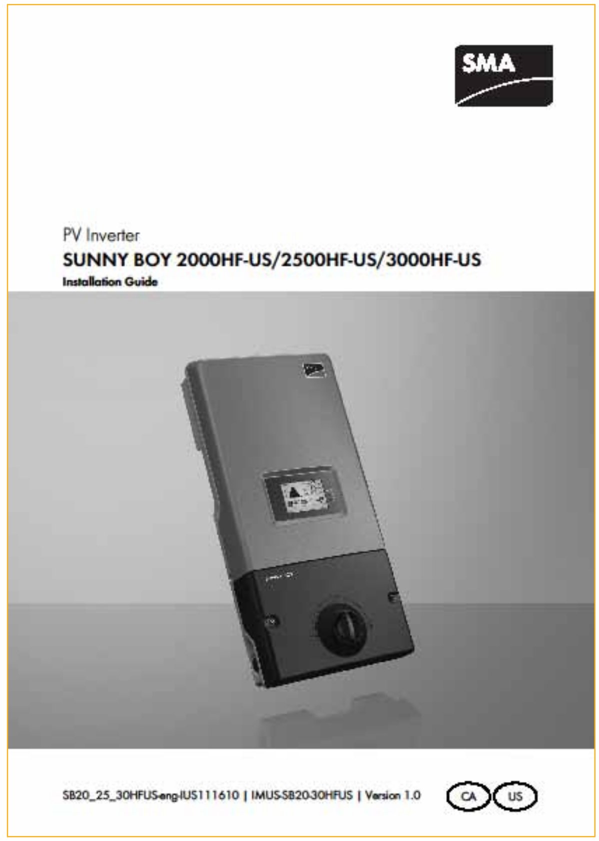
AC with neutral
If there is a neutral on the AC side of the inverter, then the AC disconnect terminals will be labeled "Ground/PE, N, L1, and L2. You will use a grounding conductor Ground/PE (green wire). N stands for neutral (white) wire; L1 is for line 1 (typically a black wire); L2 is for line 2 (typically a red wire).

Wiring of a separate AC disconnect
If the jurisdiction of the job site requires a separate AC disconnect, then the wiring of it will be similar to that of the previously mentioned items. The output from the inverter should be connected to the (touch protected) load side of the disconnect as the inverter will shut down when the service or grid is down.

Wiring to the main panel
You will bring the AC wiring, either from the disconnect connected to the inverter or from a separate AC disconnect, to the main panel and into the appropriate breakers. The back-fed PV-sourced breakers shall be positioned as far away from the main breaker as possible to reduce loads on panel bus bars.

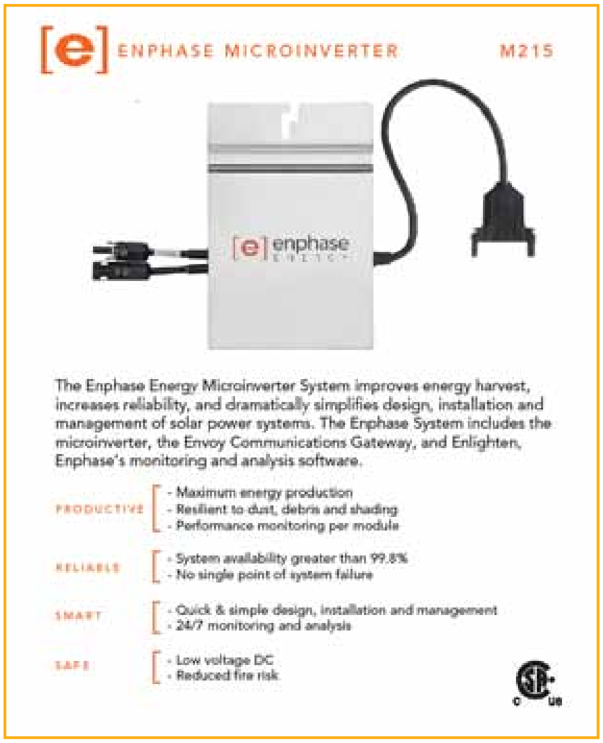
Note: For new home construction you will have to continue out of the main panel from the grounding terminal in the main panel with an additional piece of bare copper wire in another slot on the grounding terminal bar that connects to a grounding rod.

SMA



PVPowered

Enphase



Suntrol system monitoring

- SolarWorld offers an effective solar monitoring system
- Easy install and configuration
- Has no monthly or annual fee
- Mobile version available for all Android smart phones, iPhones and iPads
- Can handle 48 different inverter manufactures
- Can record data for a 30-year period with updates every 5 minutes

- Suntrol STL 200 data logger with 2 line lcd readout and can track 2 devices
- Suntrol STL 400 data logger with 2 line lcd readout and can track 10 devices
- Suntrol STL 800 data logger with large graphic LCD display and can track 100 devices
- RS485 or wireless Bluetooth versions available for each model
- (Bluetooth adds BT to the name: ex STL400BT)
- Separate Suntrol documentation and trainings are available

Suntrol® App

With Suntrol products, you can always keep an eye on the current output of your solar power system and regularly monitor its performance—on your house wall, in your living room, on your computer, or at all times on your iPad, iPod touch, or portable smart phone.

Operation & maintenance

Introduction

Sunkit solar electric systems are designed to operate reliably in a wide range of environments while providing unattended conversion of sunlight into electricity from daily startup to daily shutdown.

The Sunkit solar photovoltaic (PV) system consists of SolarWorld Sunmodules, appropriately chosen inverter(s) with compatible electrical components, and the module mounting solution and hardware.

The Sunkit has been designed to operate most efficiently in the location specified. We have taken into account many variables to ensure the Sunkit operates efficiently for many years with minimal maintenance requirements. Among the variables are 30 year historical data for wind speeds, temperatures, and the angle and orientation of the installed module array.

The DC photovoltaic circuits from all Sunmodules are electrically connected in combinations of series and parallel for appropriate electrical output characteristics required for superior operation of the provided inverter. The inverter converts the DC power into utility matched AC power and delivers it to the electrical grid via a connection point at or near the sites utility meter (generally the main service panel). Multiple inverters may be in operation at your site, acting independently, but have combined output for appropriate system performance.

DC disconnects are in your system for electric isolation of components for safety in the event that maintenance is required. Note: The PV array and DC circuits may still be energized when light is present. AC disconnects, where required, or AC breakers may be used to isolate AC components or circuits. Make note of where all disconnects for your specific system are located.

With limited maintenance, your solar system will operate at peak performance for many years. Cleaning and inspection intervals will vary depending on site specific factors like rain and soiling. It is best to consult your installer for a (or create a site appropriate) schedule and site specific methods to clean your modules. We recommend an annual inspection of the system to make sure it is operating properly and be sure to inspect all of the electrical and mechanical connections for cleanliness, tightness and damage, too.

When cleaning solar modules we recommend that you avoid using chemical cleaning products as they can damage the solar modules.

To reduce the chances of thermal damage, it is best to clean modules early in the morning or late in the day. We recommend the use of water with a soft cloth or sponge and a squeegee. Pressure washers should not be used as they may damage modules, wiring, glass or injure people.

In some cases certain stains or deposits may need extra attention. In these cases use a mild non-abrasive detergent with a soft cloth or sponge. Be sure to avoid chemicals like ammonia or lye. Some recent VINEGAR based glass cleaning products have worked well. They are dilute and formulated to be gentle. **PLEASE ALWAYS DO A SPOT TEST FIRST.** Car wash soaps tend to be very gentle, as well. To avoid mineral spotting, better results may be achieved with a nozzle that aids in a careful final rinse so that water “sheets” away. This is when larger droplets or a large stream of water is applied to the modules and the water runs off without leaving behind minerals, etc. (as opposed to fine droplets that quickly evaporate).

Snow

Sites that have substantial snowfalls need to be designed to support additional loads. It is important that large masses of ice or snow do not move suddenly as they can hurt people or damage the system. Each site will vary, so please consult your (design team, engineers or installer) for proper maintenance or service. On some sites where safety and access are a challenge it may be best to leave ice and snow alone until they shed or melt away on their own… DO NOT APPLY MELTING SALTS or other chemicals on the solar modules. When safe, snow can be gently brushed off of the solar modules.

Major system component list & definitions

The solar array consists of the following components:
(Reference site drawings, installation guides and manuals for details on components used)

- SolarWorld Sunmodules
- DC to AC grid-tied inverter(s)
- Module mounting components and hardware
- Electrical wires and connections
- Disconnecting switches
- DC fused combiner boxes (not always required)

The above components are defined below:

SolarWorld Sunmodules
The Sunmodule leads the PV industry in quality, output and reliability. The fully automated production process at SolarWorld factories ensures consistent high quality and enables tight power tolerances.

The glass is set deep into the module frame and secured with silicone adhesive, which provides exceptional rigidity for the entire module and prevents frame loosening from handling or sliding snow and ice.

The Sunmodule patented low-profile junction box provides exceptional protection against corrosion and features integral heat sinks that help maintain a lower temperature if and when any of the 25 amp Schottky bypass diodes are conducting. The junction box is connected by a solid welded bond to maximize reliability and performance life. In addition, the integrated high-quality robust cables are factory equipped with NEC 2008 code compliant locking connectors. Each Sunmodule is covered by a 25-year performance warranty and is recyclable.

DC to AC grid tied inverter(s)
The inverter is the transition device from the DC energy generated by the solar electric modules and the AC power provided from the electric utility grid. The inverter is specifically sized and chosen to match both the electrical output of the PV array (the DC input of the inverter) and the grid characteristics for the site. The inverter also provides the main data access point for the current and historical production and performance of the system. See included manual and installation guide for details on inverter characteristics for this specific site.

Module mounting components
The modules are mechanically mounted to a structure designed for the physical load based on site and location specific information. The components and hardware are designed from aluminum or stainless steel to ensure the longevity and reliability of the mechanical connections.

Electrical wires and connections
The electrical wires and module interconnections are designed to specifically operate for the life of the system in the harsh environments where solar PV modules are generally installed (e.g., rooftops, fields, and carports). Integrated high-quality robust cables are factory equipped with NEC 2008 code compliant locking connectors.

Disconnecting switches
NEC code requires that all PV systems have disconnecting means for both the AC and the DC side of the inverter. While the specific location of the switches will often depend on the local inspector and code requirements, the location should be noted and marked clearly. The inverters will have a switch (or breaker) associated which will shut down the inverter, but may or may not disconnect the conductors. Care should be taken when troubleshooting an inverter and should only be done by a trained professional (portions of the solar DC circuits remain energized when light is present).

DC fused combiner boxes
A circuit combiner box serves to collect the DC power of the source (string) circuits of the PV array. The combiner boxes are minimum NEMA 3R in construction. There are fuses in each combiner box; combiner boxes can be daisy-chained in parallel to create a branch circuit that feeds to the Inverter.

System specifications

Refer to the provided system drawings for electrical specifications for the system.

System startup & testing/commissioning

Before commissioning a PV system or operating any components within the solar system it is imperative that the installer verifies the wiring and measurements at each connection. With proper labeling and the use of a multi-meter the installer should take electrical readings and compare them to the designed specifications.

- Ensure that measured voltages are as expected
- Look for reversed polarity (as DC circuits can be wired backwards, showing a minus sign)
- Test for ground faults

After measurements are confirmed you may refer to the inverter or system manual and specifications for proper system startup sequence.

- It may be useful to measure individual solar string output with a DC clamp meter to verify proper function.

System verification

Verifying that a system is performing as expected for site conditions is needed to ensure that the system is operating properly.

It is important to note that the PV system performance is directly related to site conditions including:

- Light intensity on the solar array (clouds and time of day are major factors)
- Temperature (which is impacted by sunlight intensity and wind)
- Shade and Soiling of the solar array
- Wiring, breaker and switch losses (energy lost due to resistance)
- Conversion efficiency of the inverter (DC to AC and transformers)

To gauge if a system is performing as expected it is useful to compare the sites performance at a given moment to the expected peak AC output. PV systems have a calculated site specific DC to AC de-rate or anticipated peak AC output for a given site. We can measure site conditions and PV system operation and then compare them to the anticipated peak AC output.

1. Ensure that the solar array is clean, free of damage and not shaded in any way.
2. Position a light intensity meter along the same plane as the solar array (same tilt and heading) Irradiance = ____________W/m²
3. Measure Solar Array Temperature (you may estimate array temperature if not easily accessible typically 20-30F above ambient temp)
4. Read AC output from inverter/s. ___________Watts
5. Adjust your (previously calculated) expected peak AC output number _________AC Watts to reflect the impact of the actual site irradiance and temperature at the given moment.

A. Increase or decrease the number it as corresponds to your recent irradiance measurement. (Equation)

B. Increase or decrease the number it as corresponds to your recent temperature measurement. (Equation)

6. Compare recorded AC output __________Watts AC from the inverter at the site to your adjusted expected AC output number___________Watts AC (DC to AC watts adjusted to site conditions), if they are close it appears that the system is functioning properly.

Inverter start-up & shut-down procedures (energizing/decommissioning)

Refer to the provided Inverter Manual for additional information as required.

***** WARNING *****

Start-up and shut-down procedures for this grid connected PV system shall only be performed by authorized personnel. Operation of the system with any enclosure access doors open is discouraged. Lethal levels of current and voltage may be present in all compartments at all times regardless of whether the PV array is exposed to sunlight. A minimum of two qualified personnel equipped with appropriate safety attire shall perform these procedures.

Automatic operation
If the system is performing normally after a successful start-up, no activity by the operator is necessary. In the course of a 24-hour cycle, the unit will automatically connect and disconnect from the grid as a function of the time of day, amount of insolation, and other operational parameters as required by the NEC codes.

Routine Maintenance

WARRANTY NOTICE

While the solar array system is under the warranty, only qualified personnel shall perform maintenance. Any maintenance procedures other than those expressly defined in the paragraphs below or in the included product guides and manuals are discouraged and may result in damage to the system.

Safety considerations

***** WARNING *****

Lethal levels of voltage may be present at all times. Extreme caution should be used in all maintenance activities. All product guides and manuals must be read and understood before maintenance procedures are performed. It is recommended that at least two qualified personnel, attired appropriately for safety, perform any maintenance. All mandated safety precautions for the local and national region should be followed.

Routine maintenance schedule

The SolarWorld Sunkit solar electric system is designed for unattended operation and very low maintenance. Minimum required routine maintenance must be done on a scheduled basis, unless a significant reduction in system output is discovered.

EVERY FOUR MONTHS

PV PANELS
Visually inspect the front surface of each PV modules for cracked glass, blown debris, dust, any opaque substances or vandalism. A simple rinse with pure water is all that is required for removal of any obstructions on the face of the modules, rain will most often suffice. Do not use ANY additives like soap, abrasives or power washers to clean the surface of the modules. Some cleansers may harm the modules through chemical reactions. This can permanently damage the modules and void power warranties. Follow module guides for appropriate cleaning techniques. Inspect the back of the panel for environmental debris such as bird nests and insect hives. The debris may be carefully removed by hand without the removal of the PV module

INVERTERS
Check the display on each inverter to ensure that the system is operating as expected. Fans should be checked for debris and obstructions.

YEARLY

STANDARD MAINTENANCE
We recommend that the system be inspected at regular intervals to ensure:

- All mounting points are tight and secure and free of corrosion.
- All cable connections are secure, tight, clean and free of corrosion.
- Cables are not damaged in any way.
- The conductivity of module frame to earth ground.

INVERTERS
Follow the inverter installation guide for trouble shooting and maintenance.

COMBINER OR FUSE BOXES
Open the front panel and carefully remove any debris by hand.

SUPPORT STRUCTURE
Sight down the length of each array row from either end. The continuous array should appear to be relatively straight. Some settling, shifting or shrinking can be expected over time.

Check hardware and connection points for tightness and security. Appropriately tighten, to installation guide torque specifications, any connections that may have loosened due to settling and expansion and contraction of components due to temperature.

Recommended maintenance tools

Tools Required	Quantity
Various hand tools	A/R
Fuse puller	1
Volt Meter (600 VDC min)	1
Amp meter (minimum 10 A, varies by installation	1

Troubleshooting faults

Inverter faults
Refer to the inverter installation guide for trouble shooting of inverter faults.

Module faults
Modules are designed for a MINIMUM of 25 years of low maintenance operation. If in the course of troubleshooting the inverter, it is believed that the modules or installation are causing the fault, it is recommended to contact the installing company or a comparable certified solar installer.

Warranty

Warranties are held by individual major component manufacturers and providers; modules, Inverters, and the installation company of record as required by state and local codes.

Troubleshooting

Field test/troubleshoot for grid-tied solar module applications (CreDHaprRC rev 120117)

The installation & testing of solar modules requires a great degree of skill and should (if DC voltage exceeds 30V: must) only be performed by qualified licensed professionals. The installer assumes the risk of all injury that might occur to persons or damage to property including, without limitation, the risk of electric shock when working with live electrical components.

PLEASE READ THIS GUIDE COMPLETELY BEFORE TAKING ANY ACTION. Be sure to refer to documentation provided with your solar equipment. Your authorized SolarWorld Solar distributor or dealer can provide additional sizing and system design information if necessary.

Disclaimer of Liability

Since the use of this guide and the conditions or methods of installation, operation, use and maintenance of the module are beyond SolarWorld control, SolarWorld does not assume responsibility and expressly disclaims liability for loss, damage, or expense arising out of or in any way connected with such installation, operation, use or maintenance. The information in this guide is based on SolarWorld's knowledge and experience and is believed to be reliable; but such information including product specifications (without limitations) and suggestions do not constitute a warranty, expressed or implied. SolarWorld reserves the right to make changes to the product, specifications, or guide without prior notice.

***** WARNING *****

All instructions should be read and understood before attempting to install, wire, operate and maintain the photovoltaic module. Contact with electrically active parts of the module can result in burns, sparks, and lethal shock whether the module is connected or disconnected.

Photovoltaic modules produce DC electricity when exposed to sunlight or other light sources. When modules are connected in series, voltages are additive. When modules are connected in parallel, current is additive. Consequently, a multi-module system can produce high voltages and current which constitute an increased hazard and could cause serious injury or death.

CAUTIONS

- Avoid electrical hazards when installing, wiring, operating and maintaining the module.
- When installing or working with module or wiring, cover module face completely with opaque material to halt production of electricity.
- It is recommended that the module remain secured in original packaging until time of installation.
- Do not touch terminals while module is exposed to light or during installation. Provide suitable guards to prevent contact with 30VDC or greater. As an added precaution, use properly insulated tools only.
- Always use proper PPE (Personal Protective Equipment) including but not limited to gloves, eye protection, hard hat, fall protection, boots etc.
- Electrical arcing may occur when connecting or disconnecting module circuits under load. An arc may emit intense light that can damage vision and can cause burns or sparks.
- Do not drop module or allow objects to fall on module.
- Do not stand or step on module.
- It must be assured that other system components do not generate any hazard of any mechanical or electrical nature to the module.
- Since sparks may be produced, do not install module where flammable gases or vapors are present.

- Never leave a module unsupported or unsecured. If a module should fall, the glass can break. A module with broken glass cannot be repaired and must not be used.
- Work only under dry conditions, with dry module and tools.
- Module installation and operation should be performed by qualified personnel only. Children should not be allowed near the solar electric installation.
- If not otherwise specified, it is recommended that requirements of the latest local, national and / or regional electric codes be followed.
- Use module for its intended function only. Follow all module manufacturer´s instructions. Do not disassemble the module, or remove any part or label installed by the manufacturer. Do not treat the back sheet with paint or adhesives.
- Do not artificially concentrate sunlight on the module.

Note: The word “module” as used in this guide refers to one or more photovoltaic modules.

You may use this document as a worksheet to help troubleshoot an issue. If an issue is found or resolved not all tests are needed. Please take notes as you test. All electrical tests are in DC voltage only.

☐ **1. Visually inspect the system for visible damage**. Please take several pictures (close-up and wider shots) then email them to SolarWorld for review (contact info follows below).

☐ Broken Glass ☐ Hotspot (brown marks) ☐ Damaged Cabling ☐ Other:

☐ 2. **Document how system wiring is connected.**

Take pictures, make a drawing or label the wires so you can properly reassemble everything after testing.

☐ **3. Check wiring connections and protection devices**. Make sure connections are tight and secured properly. Fuses may be enclosed in a disconnect or in a combiner box. Ground Faults as indicated by inverters are commonly caused due to pinched, frayed or damaged wiring such as module cabling OR string circuits (jumpers and homeruns).

☐ Loose Solar Connectors ☐ Fuses / Breakers ☐ Damaged Cabling ☐ Wiring Terminals

☐ Splices / Junctions ☐ Burn Marks ☐ Corrosion ☐ Other:

☐ **4. Test solar module voltage Voc (Voltage open circuit / no load):**

Be sure to isolate the solar module, and test it with no other items connected. This means that only the electrical meter is electrically connected to the solar module. Testing the module alone is essential because other parts of the system may have failed and can impact the measurements.

Turn off all loads and open appropriate disconnects. For additional safety it is recommended that you de-energize the solar modules by covering them with an opaque material, then carefully disconnect the solar module connectors from the string / circuit then test the module Voc. Now use a trusted multi-meter set to DC volts and be sure to place the solar module in full sunlight.

220 to 260 watt (60 cell) modules should test between 32 - 39 volts Voc (weather and sunlight impact voltage).

140 to 185 watt (72 cell) modules should test between 38 - 46 volts Voc (weather and sunlight impact voltage).

(Example) Module 1, top right	(Model) SW245 mono	(Serial) 408201234	(Measurement) 35 Voc (Notes) Tested good

If you get voltage, that is below the above numbers please contact your local distributor or SolarWorld customer service for additional support (contact info follows below).

☐ 5. **Comparative analysis:** If you have additional solar modules or inverters on site be sure to measure them and compare them to your suspected solar hardware. Small differences are normal so look for larger or meaningful differences. Please compare or swap devices when appropriate to verify your suspected conclusions. Examples follow:

Solar module- Module “A” measures 36 Voc. Module “B” an identical unit, measures 28 Voc. This would indicate that module “B” is likely a defective module.

Micro Inverter- If a micro inverter will not operate correctly, in full daylight swap EITHER the micro inverter or a module within the system and trace what component the problem follows.

If a micro inverter won’t work with several solar modules it is likely that the issue is with the micro inverter. If several inverters won’t work with the same solar module, the solar module is likely the problem.

☐ 6. **Short Circuit Current Test (Isc)**: *SAFETY NOTE: THIS CAN GENERATE A SPARK OR ELECTRIC ARC AND DAMAGE METAL SURFACES. IT CAN ALSO DESTROY YOUR METER or FUSE. BE SURE YOUR METER CAN HANDLE ABOVE THE MODULE’S CURRENT (Isc) OUTPUT RATING*.

Be sure to isolate the solar module, and test it with no other items connected. This means that only the electrical meter is electrically connected to the solar module. Testing the module alone is essential because other parts of the system may have failed and can impact the measurements. Testing should be carried out in bright noon time / full sun / good weather conditions.

A. Turn off all loads and open disconnects.
B. De-energize the solar module by covering it with an opaque material (or if removed, face module away from sunlight)
C. Carefully disconnect the solar module connectors from the string / circuit.
D. Using a trusted multi-meter set to DC amps (Isc) carefully make meter probe to solar wiring connections and expose the solar module to full sunlight, note your measurement.
E. Cover module (or face module away) from sunlight, then remove meter connections.

Your measurement WILL VARY depending on your module, light intensity, location, weather, tilt angle, etc

For field test quick estimation, if you get 75% of the labeled short circuit current (Isc) rating the solar module appears good.

Refer to solar module label / data sheet short circuit current (Isc) →	(___) Isc	x .75 x 75%	= (_____) Calculated number	Is (Isc) test measurement equal to or above calculated number?
(example) module 1, top right	(model) SW245 mono		(serial) 408201234	(measurement) 7amps (Isc) (notes) tested good 8.25 (Isc) x 75% = 6.19 amps

If the module doesn't improve with any of the above troubleshooting and if the module is still under warranty please contact your local installer / distributor. You may also contact SolarWorld to obtain a RMA (Return Merchandise Authorization) from us in order to send in the module. We will diagnose it and make our determination.

Contact:

SolarWorld Customer Service 805-388-6590   customerservice@solaworldusa.com

SolarWorld Technical Support 805-388-6587 technicalsupport@solarworldusa.com

SolarWorld return Merchandise Authorization form RMA#: ____________________ (issued by SolarWorld).

Customer information	Project name:		Date:
Contact name:			
Address:	City:	State:	Zip:
County/misc:			
Phone:	Email:		

Purchase Information	Distributor company name:	Purchase/install date:	
Distributor contact name:		Installer contact name:	
Address:	City:	State:	Zip:
County/misc:			
Phone:	Email:		

Return shipping information	RMA number must be issued before products are returned. All shipments with no RMA number will be refused. SolarWorld will specify return address along with RMA number.
Shipping notes:	

Return classification		Reason for return
☐ New Product Return (no damage/no defect)		☐ Defective upon arrival/install ☐ Wrong item/s
☐ Damaged/Defective Product		☐ Damaged/refused Shipment
☐ Other		☐ Defective from existing/commissioned system
		☐ Other

Conditions of items:		
☐ Unopened new	☐ Opened new	☐ Damaged/defective product

Item information		
Item brand & model:	Quantity:	Serial:
Item brand & model:	Quantity:	Serial:
Item brand & model:	Quantity:	Serial:

Notes:

Contact:

SolarWorld Customer Service 805-388-6590 customerservice@solaworldusa.com

SolarWorld Technical Support 805-388-6587 technicalsupport@solarworldusa.com

PV System Installation Audit

SOLARWORLD

Date: ___________

Installer Information

Company Name			
Address			
Primary Phone #		Other	
E-mail			
Distributor		Contact	
SW Account Manager			

Project Information

Project Name		SK #	
Project Address			
System Owner Contact		Phone #	
Utility		Rate Schedule	
Annual Usage (kWh)		Proposed System Size	

Inspector Information

Name	
Signature	
Date of inspection	
Inspection Status	

We turn sunlight into power.

1 Confidential

Installation Audit Form 110930

PV System Installation Audit

SOLARWORLD

Interconnection Information

Make & Model # of main service panel	
Meter number	
Main breaker size	
Buss bar rating	
Sub-panel model and buss rating	
Sub –panel feeder breaker	
Other POI-supply side connection, load side tap, etc.	
Other electrical sources (batteries, wind, generators, etc.	
Electrical concerns & Code Violations (690.64; 705.12)	
Other Article 230 Considerations (6 handle rule, service disconnect rules, etc.	
Comments	

Roof Information

Roofing Type (comp, masonry tile, ssmr, membrane)	
Method of sealing penetrations	
If DC conductors run through the house identify method used to address protection issues.	
Roof condition	
Roof damage	
Inspect penetrations and stand-off installation	
Comments	

We turn sunlight into power.

2 Confidential

Installation Audit Form 110930

PV System Installation Audit

SolarWorld

Racking System

Racking System Mfr & Model	
Confirm installed per Mfr instructions	
Visually inspect and use "pull test" to confirm installation to structural member	
Confirm module properly secured at ¼ points - between 8-16 inches	
Confirm non current carrying metal parts are grounded properly. (frames, racking, boxes, etc.	
Type of lugs or WEEBS	
Comments	

Photovoltaic Module/Array Information

	Array #1	Array #2
Module Model Number		
Number of modules		
Number of modules per string		
Number of strings		
Confirm modules are grounded properly		
Confirm connections are fully engaged		
Cable management		
Wire Clips/Zip ties (black are UV resistant)		
Visually inspect for damaged modules		
Stand-off height		
Confirm strings properly configured (all modules are facing same pitch and azimuth)		
Comments		

We turn sunlight into power.

Installation Audit Form 110930

PV System Installation Audit

SOLARWORLD

Inverter Information

Number of Inverters			
Inverter Make & Model			
Inverter Installation-Confirm properly mounted			
Verify ground installation to inverter (UFER, ground rod, GEC)			
Confirm Input String Voltage within Operating Voltage (use table 690.7 correction factors)			
Confirm NEC Compliant Disconnects (pyhisically-separable disconnect and wiring box from actual inverter unit			
Comments			

Wiring and overcurrent protection

Wire type is 90°C wet rated (USE-2, THWN-2)	
Electrical boxes and conduit bodies on roof reasonbly accessible?	
Electrical connections suitable for the environment?	
Confirm conductor ampacities are sufficient?	
Inspect combiner or j-boxes (confirm weep hole or other drainage)	
Verify source circuit overcurrent protection is sufficient	
Verify overcurrent protection on inverter output circuit is sufficient	
Verify point of connection meets provisions of NEC 690.64, 705.12 & verify Article 230 has not been violated	
Check that all cable and conduit is properly supported	
Verify complete system bonding to main UFER/Grounding Rod at location	
Comments	

PV system signs and labeling

Do signs have sufficient durability?	
Sign IDing PV power source (at DC disconnect)	
Sign IDing AC point of connection	
Sign at main electrical service disconnect	

We turn sunlight into power.

4 Confidential

Installation Audit Form 110930

PV System Installation Audit

SOLARWORLD

Performance/Site evaluation

Is the system in operation? If no turn on.		
Has a "smart" meter been installed?		
	Array #1	Array #2
Azimuth direction of array-True		
Tilt angle of array		
Time of day		
Ambient Temperature		
Module Temperature		
Irradiance (W/m^2)		
Watts ouput on inverter display (measured immediately after irradiance measurement)		
Voltage output on inverter display		
Total Energy production (kWh)		
Verify shading conditions-attach shade report		
Look for any environmental variables that may affect system performance (Dusty conditions, trees, animals, etc.		
Comments		

PV System Installation Audit

SolarWorld

1. Attach a copy of the customer usage data. _______
2. Visually inspect the installation at all structure entry points to insure they are properly weather sealed. (Attach Photos) _______
3. Visually inspect the installation for proper module and system grounding. (Attach Photo) _______
4. Visually inspect all external wires and connectors for damage and proper connection. (Attach Photo) _______
5. Verify modules are mounted on proper quarter points _______
6. Verify proper system labeling of all components . (Attach Photos) _______
7. Verify that all DC system grounding is installed correctly _______
8. Measure ambient temperature (degrees C) and irradiance (W/M^2) and record on the Worksheet _______
9. Take the following photos:

- DC switchgear / combiner(s) overall _______
- Close-ups of the DC switchgear / combiner(s) nameplates(s) _______
- Close-ups and overall photos of the monitoring equipment _______
- All accessible conduit runs _______
- Tape measure showing the height of the array from the roof to the _______
- bottom of the modules _______
- Close-ups of module nameplates _______

We turn sunlight into power.

6 Confidential

Installation Audit Form 110930

PV System Installation Audit

SOLARWORLD

Notes/Comments

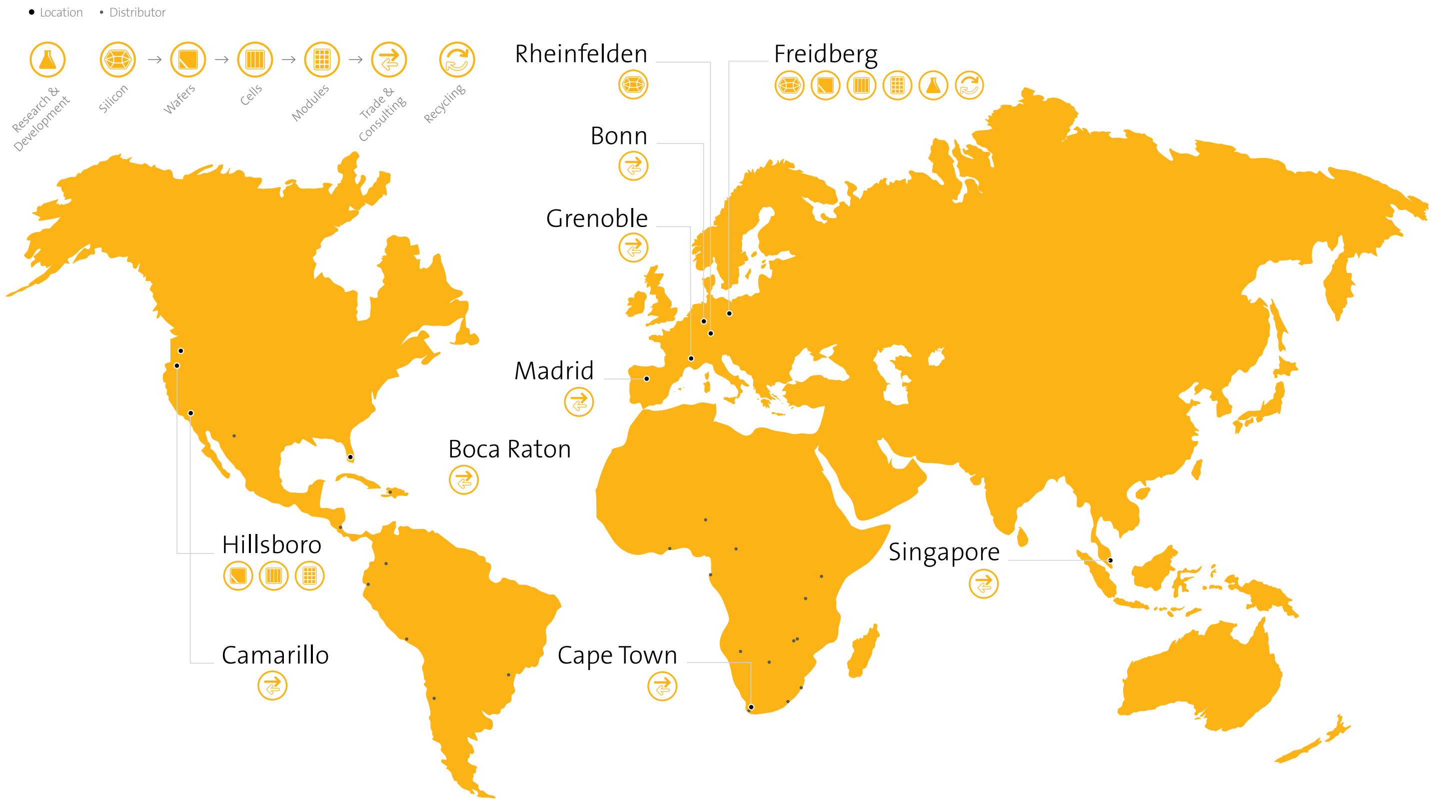
Date:______________ Project:________________________

We turn sunlight into power.

7 Confidential

Installation Audit Form 110930

Production and sales locations of the SolarWorld group



SolarWorld Ibérica, S.L.
C/La Granja 15,
Bloque B-1°B
28108 Alcobendas, Madrid
Spain

SolarWorld Americas LLC
4650 Adohr Lane
Camarillo, CA 93012
USA
customerservice@solarworldusa.com
solarworld.com

SolarWorld AG
Martin-Luther-King-Str. 24
53175 Bonn
Germany
Phone: +49 228 55920 0
Fax: +49 228 55920 99
service@solarworld-global.com
solarworld.de

SolarWorld France SAS
Hôtel de l'Entreprise, Petite Halle, Bouchayer-Viallet
31, rue Gustave Eiffel
38000 Grenoble
France

SolarWorld Africa Pty. Ltd.
20th Floor
1 Thibault Square
Kapstadt, 8001
South Africa
g.kuepper@solarworld-africa.co.za
solarworld-africa.co.za

SolarWorld Asia Pacific Pte. Ltd.
72 Bendemeer Road
#07-01, Luzerne
Singapore 339941
Singapore

SW-04-5121US 02-2012