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# Design Guide for SolarWorld Sunkits® Systems


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# Sunkits® System Design Guide

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## Table of Contents

## 1. Purpose

Define the rules and guidelines for successful design of a qualified SolarWorld Sunkit.

## 2. Scope

Including modules, projects and Sunkits systems, SolarWorld is committed to providing the best products and best solutions for system owners. The best 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. The Sunkit 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 Sunkit brand should adhere to SolarWorld standards of system design and installation practices to ensure quality for current and future system owners. A Sunkit, and any PV system, is intended to last a minimum of 25 years. In reality, SolarWorld anticipates the module array may produce valuable energy for twice as long. Such a term of operation must be understood during system design and installation process.

## 3. 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 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.

### 3.1 NEC and IBC codes

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

### 3.2 Local Codes

Local codes must also be considered for details above and beyond those considered in the National Code requirements. 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.

### 3.3 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)
- 4ft 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.
- Other requirements may be adopted or enforced outside of those listed in this document.

### 3.4 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 manner is inappropriate without prior stamped engineering approval.

### 3.5 Installation guides and manuals

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.

### 3.6 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 or certification of that Sunkit system.

### 3.7 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.

## 4. 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.

### 4.1 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.

### 4.2 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. Particularly for smaller systems, tracking options are generally considered a last resort by SolarWorld.

### 4.3 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 systems that increase payback time due to decreased efficiency of the design when there are more efficient and cost effective options available.

## 5. System Efficiency

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

### 5.1 SolarWorld modules

SolarWorld modules are plus sorted and have very tight power tolerances. This ensures when modules are connected together in a system, they work optimally with each other. SolarWorld takes great care designing and producing modules to perform well for the lifetime of a system.

### 5.2 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.

### 5.3 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 critical. 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, adds up to 30 C to the average local high temperature for pitched roof installation. This design factor adjustment accounts for higher temperatures that can arise due to limited cooling airflow behind the modules. 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. SolarWorld, and many inverter manufacturers, have generated similar guides to efficient system design.[1]

**Note**: This is not intended to limit choices. Much of this is the art of system design. The first question is will it be code compliant and safe. 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.

### 5.4 Array Orientation

Orientation of the array is the compass direction that the array is angled. In general, the most southern facing orientation (in the northern hemisphere) at an angle close to the latitude is the goal. However, there are always caveats to this rule and >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 affect the ability to meet this goal and peak optimum orientation, but SolarWorld system designers strive to get as close as possible without detrimentally affecting the other criteria.

1 SolarWorld Americas: Engineering Bulletin 1003-210 - String Sizing

### 5.5 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 to individual modules, rather than an entire series string of modules.
- Choose a different location for the system, either ground mounted or an 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.

### 5.6 Row Spacing

Row spacing on flat roofs (generally commercial buildings) or ground mounted array with tilted modules can be complex. 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.

## 6. 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 before 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. Customers should also 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.

## 6.1 Compound tilts

No tilted modules on roofs pitched greater than 2 degrees. 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.

### 6.1.1 Aesthetic impact

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 are required 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.

### 6.1.2 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

### 6.1.3 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.

### 6.1.4 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, generally surpassing the $/kWh of a system installed parallell to the roof plane.

### 6.1.5 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 system output. 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%. More often it is as little as 5% performance reduction from optimum due to micro climates and geography (like consistent morning fog, or a mountain range to the west).

### 6.2 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.

#### 6.2.1 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.

#### 6.2.2 Safety impact

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

#### 6.2.3 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.

#### 6.2.4 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. This combination will likely not meet engineering and code requirements.

#### 6.2.5 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 result in underperforming penetrations.

## 7. 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.

### 7.1 Approved materials

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

### 7.2 Engineering

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

### 7.3 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 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 cost increases. Additionally, this thinner material can corrode at key intersection points that have lost the galvanized coating, significantly reducing integrity and increasing the potential safety hazard over the life of the system.

## 8. 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, troubleshooting, or technical support. If SolarWorld does not supply the designs for the system, SolarWorld requires that those designs submitted and approved for permitting are provided to SolarWorld for our records and meet the design criteria set forth in this document.

### 8.1 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 and records.

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

### 8.2 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 not 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 and records.

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

## 9. Customer Provided Designs

Any documents provided for the purposes of certifying a system design in the Sunkit program must be submitted to SolarWorld in PDF document format. The ideal submittal for certified Sunkit systems designs would be the same plan sets that are submitted for permitting at the local permitting office for the site of the installation. All Sunkit systems must be permitted installations by the local AHJ. When supplying designs, consider that in 15 years, there is a call from a Sunkit owner who is the 3rd owner of the system (home or building) and doesn't know who originally installed the system, but SolarWorld will be able to troubleshoot issues and contact the original installation company or the closest approved installer in the area to support that customer. This is part of the value added benefits of supplying Sunkit solutions to your customers.

### 9.1. Submittal Form

A SolarWorld Certified Sunkit submittal form must be filled out for each requested system seeking to be qualified as a Sunkit. The form must be fully completed to avoid delays in processing. Filling out a Submittal form does not automatically guaranty that the system will be accepted as a Certified Sunkit.

### 9.2. Mounting documentation

At a minimum, the mounting documentation should show:

- The physical layout of the modules
- The type of mounting solution being used (manufacturer/model, or descriptive drawings of connections if not a common manufactured solution)
- The roof area and distances from obstructions and edges where applicable
- Any supporting stamped engineering documentation for the mounting solution provided

### 9.3. Electrical Design

At a minimum, the electrical documentation should show:

- A single line with components included in the system (manufacturer/model/ratings)
- String calculations, voltage drop calculations, and other key electrical calculations required for permitting Solar Electric systems installations
- Table of key component characteristics
- RFP/RFQ/LQ/BOM

When applicable, any Request for Quotation, Request for Proposal, site analysis, and or list of PV materials to be installed should be provided with the rest of the system documentation. Any documentation that supports the system design, requirements, or characteristics should be supplied as a current and future resource. There is no such thing as too much information.

## 10. Applicable Documents

NEC Code (latest revision)
IBC Code (latest revision)
SolarWorld Americas: Engineering bulletin 1003-210 – String Sizing