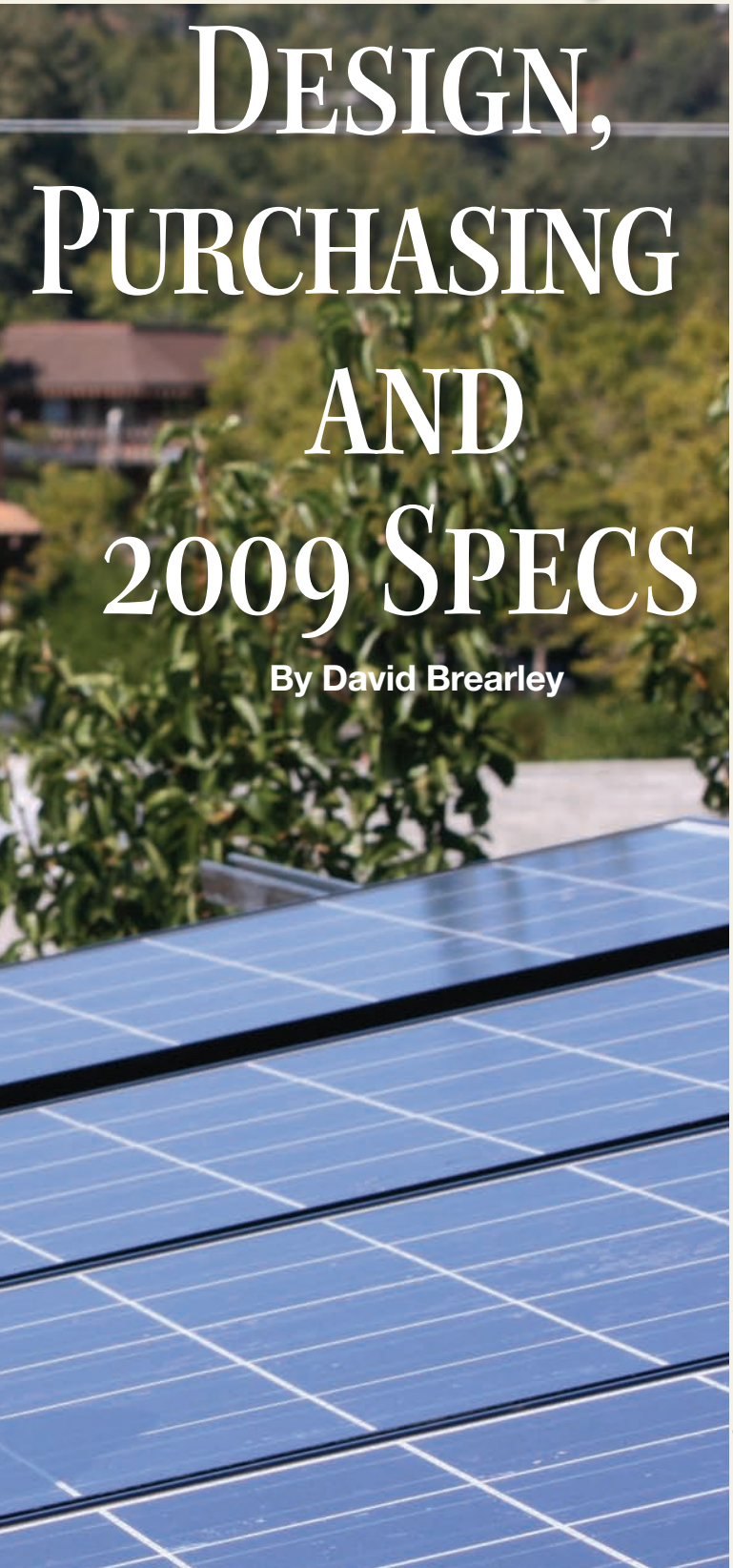
c-Si Photovoltaics:

Trends, Design, Purchasing and 2009 Specs

By David Brearley



Courtesy spgsolar.com

According to the Solar Energy Industries Association's *2008 US Solar Industry Year in Review,* the installed capacity of grid-tied PV in the US increased an astonishing 81% for the year. Of the 342 MW of capacity that the US added last year, 292 MW was connected to the grid.

Cumulative grid-connected PV capacity in the US eclipsed 1 GW in 2008. The global PV market was even stronger, reaching 110% growth according to the *Marketbuzz 2009* report from Solarbuzz. Spain accounted for 2.4 GW of the 5.95 GW installed worldwide in 2008, while Germany installed 1.86 GW, with the US finishing a distant third in added capacity. In spite of this record growth at home and abroad, the PV industry is now bracing itself to face the effects of a module oversupply and a global recession.

To help integrators navigate the unprecedented bounty of crystalline silicon (c-Si) PV modules, the table that accompanies this article on pages 62–73 lists comprehensive specifications for all of the mono- and polycrystalline PV modules rated at 100 W STC or greater that are available in North America for grid-connected applications. This article provides business owners, sales personnel, and system designers and installers with insights into how best to put these products to use, especially concerning optimal design and installation practices. It also discusses changes in standards, codes and market conditions that will have short- and long-term impacts on c-Si product listing and availability and your business model.

MARKET TRENDS

As a technology, c-Si PV modules are elegant in their simplicity, reliability and predictability. Despite the material and fabrication challenges that manufacturers must constantly overcome, they succeed in delivering incrementally improved products year after year—PV modules that last for decades in the most challenging environmental conditions. Nonetheless, the most exciting developments in the industry right now are not driven by technological breakthroughs, but rather global market conditions. This is a time of both feast and famine—the best of times or the worst of times, depending on your perspective.

After 5 years of supply constraints due to a global shortage of polysilicon feedstock, the oversupply of PV modules is undoubtedly a welcome relief to many readers. Gone are the days when installers had to suffer through 6-month lead times, last minute system redesigns due to product unavailability and blown margins caused by price increases that seemingly came every month without warning. More modules are available now than ever before, in terms of models, manufacturers and sheer quantity. It is, at long last, a buyer's market.

For c-Si module manufacturers, the outlook is more challenging. While polysilicon prices have dropped over the last year, some module manufacturers are locked into long-term feedstock delivery contracts. SunTech Power, for example, the highest capacity cell and module manufacturer in the world, announced in February that it had renegotiated the terms of a 10-year supply contract with MEMC, increasing purchase volume in order to decrease material costs.

An additional challenge facing manufacturers is that many industry analysts predict a global market contraction in 2009, a result of both the global economic crisis and the caps that Spain put on its feed-in tariff program. According to one analyst, Dr. Hennig Wicht, the senior director and principal photovoltaics analyst at iSuppli, PV module supply in 2009 will exceed demand by an estimated 168%, up from a 102% oversupply in 2008. Wicht believes that while the PV market may see modest growth in 2009, resulting revenue will still be down overall, something the market has not seen in the last decade.

The gap between supply and demand has led to lower wholesale and retail module prices in 2009, a trend that is expected to continue throughout the year. Those farthest down the supply chain will benefit from this the most: customers, PV installers and integrators. Distributors also stand to benefit, assuming they are not sitting on too much inventory purchased at higher prices. As module oversupply is forecast to continue through 2009, installers and integrators who were wise to inventory product as a hedge against scarcity may find this business model less advantageous. On demand ordering and on time delivery may finally be practicable, even profitable.

While lower module pricing should benefit installers and integrators in general, it makes for difficult times elsewhere in the supply chain. Faced with reduced revenues or operating losses, as well as a tight global credit market, module manufacturers are cutting staff, closing facilities and even going out of business in some cases. Many industry experts anticipated these manufacturing losses; but even these so-called short-term losses have long-term implications for installers. Module manufacturers that go out of business tend to leave behind a legacy of 25-year product that no longer has warranty support. This is unfortunate for everyone involved.

Some experts see light at the end of this tunnel. New Energy Finance analyst Nathaniel Bullard, solar associate for North America, takes a cautiously optimistic view. As Bullard concludes his podcast on February 3, 2009 (NEF Podcast 81), "Though the PV landscape may have fewer players a year from now, those that remain may be world leaders, not just in renewable energy, but in technology agnostic power generation."

REGULATORY CHANGES

The California Energy Commission (CEC) requirements that take effect on July 1, 2009, a result of California Senate Bill 1, will have an immediate impact on the c-Si PV products available for sale in North America. After July 1, the manufacturers of every PV module listed by the CEC on the Go Solar California Web site as rebate eligible must have completed and reported the results of third-party performance verification tests. This is not unlike the independent performance parameter testing that the CEC has required of inverter manufacturers since April 2005.

Previously, the CEC based PV module rebate eligibility on whether the product was listed to UL 1703. The Nationally Recognized Testing Laboratories (NRTL) that can perform the tests required for UL listing include: CSA, Intertek (ETL), TUV Rhineland of North America CONTINUED ON PAGE 52

Qualification testing The CTS walk-in environmental chamber that Siliken Renewable Energy uses to randomly test its solar modules is the same type used by TUV and UL testing laboratories. The temperature and humidity controlled climatic chamber simulates extreme weather conditions.

Courtesy silikenusa.com

and Underwriters Laboratories. But UL listing is an imperfect tool for a program that desires to guarantee certain performance standards. As Carl Osterwald of the National Renewable Energy Laboratory notes in the *Practical Handbook of Photovoltaics,* edited by Tom Markvart and Luis Castaner, "as a safety standard, UL 1703 does not require a module to retain its performance at a certain level; rather it simply must not become hazardous as a result of the test sequences."

The additional PV module performance parameter testing that the CEC will soon require can be performed at any test laboratory affiliated with the International Laboratory Accreditation Cooperation (ILAC). This includes the laboratories listed previously, as well as a host of testing facilities located around the world. Starting in July, CEC rebate eligible modules must be independently tested at one of these laboratories to Standard 61215 of the International Electrotechnical Commission (IEC), the standard for terrestrial c-Si PV modules, or IEC Standard 61646, the equivalent standard for terrestrial thin film modules.

Courtesy meridiansolar.com

Perfect fit Believe it or not, the roof came first. But Meridian Solar's Andrew McCalla chose the right tools for the job, Sharp Solar ND-72ERUC, ND-72ELUC and ND-N2ECUC modules, rated at 72 W, 72 W and 142 W respectively. Designers can use the "2009 c-Si PV Module Specifications" table to find their perfect fit.

Per California Senate Bill 1, the CEC requires independent verification of the following parameters: maximum power, temperature coefficients, nominal operating cell temperature (NOCT), performance at STC and NOCT, and performance at low irradiance (200 W/m^2). The module PTC rating that the CEC subsequently uses to determine rebate amounts is calculated using STC rated power, NOCT, the temperature coefficient of power and cell aperture area.

Bill Brooks, principal engineer at Brooks Engineering, is optimistic that the CEC's new module testing requirements will benefit the US market in the long term. "California has been hesitant in requiring the IEC qualification test, even though it is currently required in Europe," Brooks says. "Unfortunately, by not requiring the IEC testing, the US market has become an easier path to market entry for small, underfunded new PV manufacturers." Third party performance parameter verification is a step in the right direction, one that may encourage more manufacturers to get their products qualified to IEC 61215. But as Brooks points out, "While July 1, 2009 is the current deadline for the new module testing, this date has been moved on at least two prior occasions."

Whatever the final deadline, no modules will be grandfathered, meaning that products that have not completed testing at an ILAC-affiliated laboratory will no longer be eligible for rebates. After years of increasing in length, the CEC list of rebate eligible PV equipment is about to get a lot shorter. Even if CEC listing is not required for your project or in your major market, it is probably in your company's best interest to do business with manufacturers that list their products with the CEC. Not only are the performance parameters for these modules independently verified, but also any manufacturer that does not invest in testing that allows its products to compete in the largest PV market in the US is sending mixed signals.

USING THE SPECIFICATIONS TABLE

The table on pages 62–73 , "2009 c-Si PV Module Specifications," is a comprehensive listing of more than 275 products available in North America from 23 manufacturers. All of these modules are listed to UL 1703 and applicable for use in grid-tied applications in North America. Check the Go Solar California Web site to confirm rebate eligibility, since products will be added and removed from the eligible equipment list when the new test requirements take effect after press time.

Depending on their role in their respective organizations, readers can make use of this table in different ways. Owners and managers of solar businesses may notice previously overlooked companies and decide to explore potential business opportunities. Now is a good time to build relationships with companies new to the North American market, as well as established businesses. It is likewise a good time to shop around for competitive prices and diverse suppliers. Large scale PV project developers will find unprecedented opportunities for partnerships. Smaller shops that have historically purchased products through distributors may be able to build relationships with manufacturers; integrators

with direct relationships with one or two manufacturers may benefit from shopping farther afield, building an even more diverse supplier base.

One question that will undoubtedly be asked around the conference table is, "Which manufacturers should we buy from?" This depends on your level of risk aversion, according to Brooks, who sums up the potential risks and rewards: "Contractors unwilling to take much risk should only install modules from larger, more established companies that are likely to be in existence for the duration of the module warranty period," he advises. "Less than a dozen companies in the world meet this criterion. For those willing to take some additional risk, the question that must be answered is how reduced a price a product should sell for compared to the related risk. Presently only a few products actually sell for enough less than those from more established companies to justify the corresponding risk."

Regardless of what companies you decide to buy modules from, you can choose from more products than ever before. Residential sales personnel may discover that the profusion of modules with black frames and backsheets provides them with new solutions for aesthetically sensitive applications. They may also find it convenient to have the rated power tolerance or materials warranty for every PV module in one place. Savvy salespersons will use characteristics like these to frame their bids in the most positive light or to differentiate them from competing proposals.

Design and installation personnel can save hours of time searching for and printing PV module cutsheets by keeping the table at their desks or in their trucks. Innumerable uses for it will present themselves. Looking for a product in the proper dimensions to fit a given roof? Need a shorter or a longer module? Looking for modules with low open-circuit voltages for building arrays with the longest series strings? Looking for high-power modules or modules with the highest power density? Need product dimensions for a CAD layout or to lay rail out on a roof? Look no farther.

Whatever your quest, be it dimensional, electrical, aesthetic or a combination of all three, the specifications table puts answers at your fingertips. Readers can also print out the table, or any other article published by *SolarPro* magazine, by accessing the PDF version of the article online. This will allow you to keep the magazine at your desk as part of your professional reference library, while you travel in the field with an encyclopedic binder of up-to-date product specifications.

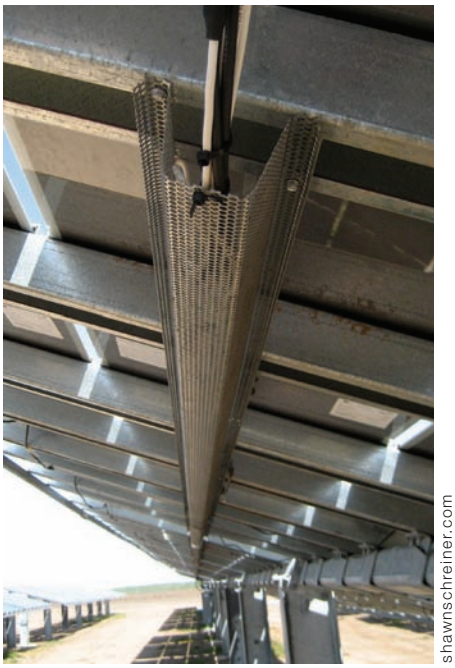
USING PV MODULES

While the table puts a great deal of useful information in one place, some of the most important considerations for designers, installers and sales staff are not found on product cutsheets or in tables. This is particularly true when it comes to using PV modules in a manner that guarantees the safety of installation and maintenance personnel, preserves product warranties and ensures optimal long-term array performance.

In general, exercise caution and common sense when designing and installing systems using c-Si PV products. This is especially true when it comes to safety concerns. Nothing is more important to the success of your business, and to the success of the PV industry in general, than personal safety on the job and the safe operation of systems over time. Furthermore, it is much easier than one might think to violate the instructions—and possibly the warranty terms—for one PV product by substituting it in a design for a module with different terms of use.

Kyocera modules, for example, have relatively high current characteristics and require a minimum PV source circuit conductor size of 10 AWG, whereas most manufacturers allow the use of 12 AWG conductors. There is no way to ensure that a PV system performs optimally in the long term unless product warranties remain inviolate during installation. Observing warranty conditions for all of the PV modules on the market requires that you know what those conditions are. This requires reading product instructions.

If your company does forge new relationships with module manufacturers in this buyer's market, make sure that company personnel understand the limitations of use for these products. This is especially true the first time your company works with a product. This article discusses a variety of conditions of use, conditions that vary from manufacturer to manufacturer according to the terms described in the product installation manual. Because veteran designers and installers may be the least inclined to read instructions, inadvertent misuse of PV modules is a pitfall that new and old companies alike may be subject to.



shawnschreiner.com

Wire management While appropriate personal protective equipment ensures installer safety during installation, good wire management, as practiced here by the Conergy Projects Group, is required to ensure the safe operation of the system in the long term.

PERSONAL SAFETY

In some cases, directives contained in safety and installation manuals for PV modules are simply not practicable. Ironically, one of the least practical safety tips is also the most ubiquitous: "Cover all modules in the PV array with an opaque cloth or material before making or breaking electrical connections." As quoted here from a SunPower manual, this precaution shows up in every PV installation manual, and for a good reason.

As long as a PV module is exposed to light, it generates dc voltage at hazardous levels. The potential for injury increases as modules are connected in series and parallel. There is no off switch, and thus a shock hazard is always present during daylight hours. This represents a real and constant challenge to jobsite safety.

Arguably, the opportunity for personal injury due to an electrical shock increases in direct proportion to the severity of the consequences. It is essential, therefore, that installers not only have procedures in place to minimize shock hazard as an array is wired, but that they also wear the appropriate protective equipment. To work safely on PV systems, installers need insulated tools, voltage rated gloves, safety shoes with rubber soles and appropriate eye protection. Although commonly required only of workers on commercial projects, hard hats are appropriate at all times on PV installation sites.

Installers need safety training that is specific to the hazards associated with PV systems, yet general enough to include normal jobsite hazards. Every new project must be reviewed for specific hazards that may require additional training or certification. All trainings and certifications must be renewed at appropriate intervals. To keep track of these certifications, every crew needs a dedicated safety officer who holds regular meetings.

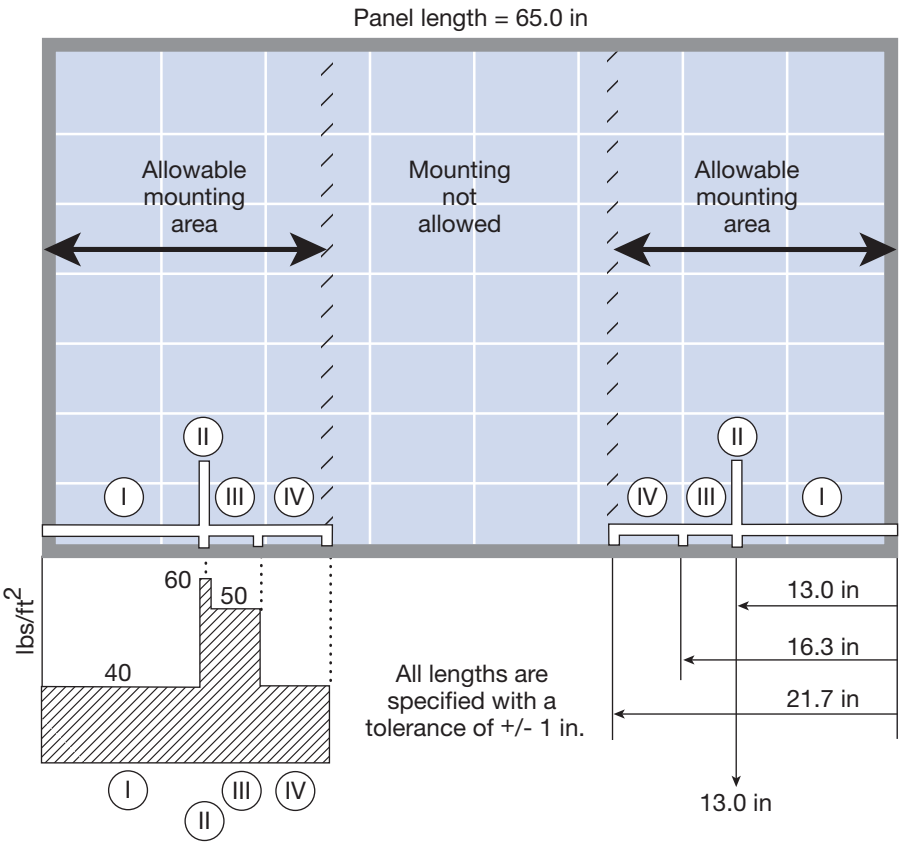
This is common knowledge and common sense. But there is room for improvement on every jobsite and at every organization. Downtime between projects and periods of bad weather are excellent times for crews to complete safety trainings.

CONDITIONS OF USE

Part of the challenge of following safety and installation instructions for various PV modules is that these instructions are seldom comprehensive or entirely relevant to the task at hand. In some cases, manuals are poorly written or translated; in others, they are simply impossible to find. It is not apparent, for example, that BP Solar or Canadian Solar post installation manuals for their c-Si CONTINUED ON PAGE 56

PV products on the company Web sites. These manuals may be distributed through the supply chain, but they need to be readily accessible to design and service personnel anywhere at any time, even for legacy products. Service personnel require ready access to installation manuals because these are seldom available when they arrive to troubleshoot or service a site. In general, a product cutsheet will suffice for most troubleshooting purposes. But installation manuals contain additional information that can aid service technicians, including limitations and exclusions of use, and perhaps explain a premature failure.

For designers, the availability and accuracy of this information is even more critical. If a system is not designed in a manner that maintains a PV product warranty, the best installation in the world cannot fix this fundamental problem. Use of a structural design that is specifically disallowed by the module manufacturer in the installation manual is an example of design failure. Similarly, the best design can be undermined by poor or unapproved installation practices. Probably the most common of these is module frame modification for grounding purposes, a practice that is almost universally prohibited in product installation manuals.



Flexible and informative The ES-A Series *Mounting Guide* from Evergreen Solar provides comprehensive engineering information for a variety of mounting options permitted by the manufacturer. Recreated here is Figure 8 (of 13 figures) that defines the maximum permissible combined wind and snow loads by rail location.

Warranty coverage is normally excluded when PV products are installed in a manner that is contrary to the manual. Limitations or exclusions of use for PV products vary by manufacturer and product line, as noted below. These observations are taken from product installation manuals found on the manufacturers' Web sites at press time.

Module mounting. PV engineers and technicians commonly complain of poorly written module installation manuals. Of the 13 product installation manuals surveyed for this article, the best example of the level of detail that PV system designers and installers need is found in two separate documents published by Evergreen Solar.

The first, the *Safety, Installation and Operation* manual for the ES-A Series PV modules, does not particularly stand out from other manufacturers' safety and installation manuals. But Evergreen's *Mounting Guide* for ES-A Series modules provides designers and installers with an unparalleled number of approved mounting options and an unprecedented amount of engineering details for these options.

In the ES-A Series *Mounting Guide,* Evergreen approves two major methods of module mounting: symmetrical support rails or support points and asymmetrical support points. Symmetrical mounting using rails or points allows for end mounting the module using a variety of structural support and clamp configurations. This method also allows for "offset mounting," which is the method most commonly practiced by installers, where support rails run parallel to and are set inside of the short side of the module frame. Depending upon where these symmetrical support rails are located, the maximum permissible combined snow and wind load permitted by Evergreen varies. If the module is supported at a distance of 13-inch offset from the module's short side, for example, corresponding to one set of the bottom mounting hole locations, the module is rated for 60 pounds per square foot. Between this point of maximum permissible loading and the second set of bottom mounting holes at 16.3-inch offset, the design for wind and snow loading is 50 pounds per square foot. CONTINUED ON PAGE 58

At other symmetrical support locations, between the end mounting option at one extreme and 21.7-inch offset at the other, the module is load rated for no more than 40 pounds per square foot.

The second major method of mounting that Evergreen approves and describes uses independent support points located asymmetrically under the module. This appears to allow for the mounting of Evergreen ES-A Series modules using the S-5! PV Kit on a typical standing seam metal roof. At least two support points are required on each half of every module. As the module planes out across standing seams, located at 24 inches on center in the example in the guide, some modules will have six independent support points. Either way, this mounting method is approved for 40 pounds per square feet of combined wind or snow loading.

Other manufacturers may approve the use of their modules in a similar variety of circumstances, but none make this explicit in their installation manuals. In some cases, the directions given are too vague to be helpful. Suntech Power's installation guide for its PV modules, for example, identifies one set of mounting holes for "normal" installation, adding that use of a second set of mounting holes is required for "high wind and snow loads." If the module is normally rated for 50 pounds per square foot of combined snow and wind loading, does the use of the additional mounting holes allow for additional loading? If so, how much more? Or is 50 pounds per square foot considered a high wind and snow load? This is the sort of language that leaves one with more questions than answers.

In many cases, module manufacturers list specific mounting methods that are excluded from use, which is very important information. If you are designing or installing a PV system that uses SolarWorld, REC or Day4Energy modules, for example, short side mounting is prohibited. This is the practice of running support rails parallel to the long side of a module frame to support the short side of the frame. While this is a common exclusion of use, Sharp ND-198 and ND-176 modules actually have four mounting holes located on the short side of the frame. So if your installers are used to practicing short side mounting with Sharp modules, be careful not to use that technique with another manufacturer's modules without first verifying that it is approved.

End mounting may also be excluded from use. For example, GE Energy, SolarWorld and REC do not specify end mounting as an option. Evergreen and SunPower, however, do allow this use, provided certain structural criteria are met.

Approved mounting height also varies by manufacturer. Evergreen and Sanyo require 4 inches of clearance between their modules and the roof deck. Kyocera, however, requires a minimum of only 0.6 inches of clearance between the module junction box and the roof. In many other instances it is unclear whether manufacturers have height or end mounting restrictions for their modules.

Suntech describes a condition of use that relates to the installed position of the module junction box. Because the J-box has a breather port that must not be exposed to rain, "the junction box should be on the higher side of the module when it is mounted." This raises the question as to whether Suntech products are appropriate for use in east to west, single-axis tracker applications.

If a mounting method is in doubt, contact the manufacturer. Jamie Skendarian, product marketing engineer for SolarWorld, explains his company's mounting requirements: CONTINUED ON PAGE 60

Thin Film Modules

As the title suggests, the "2009 c-Si PV Module Specifications" table does not list specifications for any thin film PV modules currently available in North America. This is intentional: The thin film market is so dynamic and fast growing that the editorial staff at *SolarPro* magazine decided to make thin film products the subject of a separate article. This article will run in a future issue and include a comprehensive listing of thin film PV module specifications.

According to Bill Brooks, the principal engineer at Brooks Engineering, "Large scale utility projects will proliferate over the next few years, giving thin film products a huge opportunity. While higher efficiency modules have always been preferred in rooftop markets, large scale ground-mounted systems feeding utility programs will favor newer, higher risk, lower efficiency thin film products."

The cost reduction potential using thin film products is best exemplified by First Solar; the company reports that its manufacturing costs are less than $1 per watt. As a result, thin film module market share is increasing annually, in Europe and North America, with even greater gains expected in the immediate future. (For an in-depth discussion of this trend, see "Thin Film PV Market Share Increasing," April/May 2009, *SolarPro* magazine.)

If your company is involved in an application that seems ideal for thin film modules, you may consider contacting one of these manufacturers with products available in the US and Canada: EPV SOLAR, First Solar, Kaneka, MC Solar, SOLON, SOLYNDRA and United Solar Ovonic (Uni-Solar). Major companies like Applied Materials, Q-Cells, Sharp Solar and Suntech Power are also positioning themselves in the thin film market. Start-up companies like Heliovolt, Signet and others expect to begin US production of thin film modules in the near future. ●

"Our modules are IEC 61215 load tested to 112 pounds per square foot. According to the IEC, listing modules to 50 pounds per square foot corresponds to a wind pressure of 80 miles per hour with a safety factor of 3 for gusty winds. The mounting technique specified in SolarWorld's installation guide describes minimum requirements necessary for a UL approved installation that satisfies SolarWorld warranty requirements."

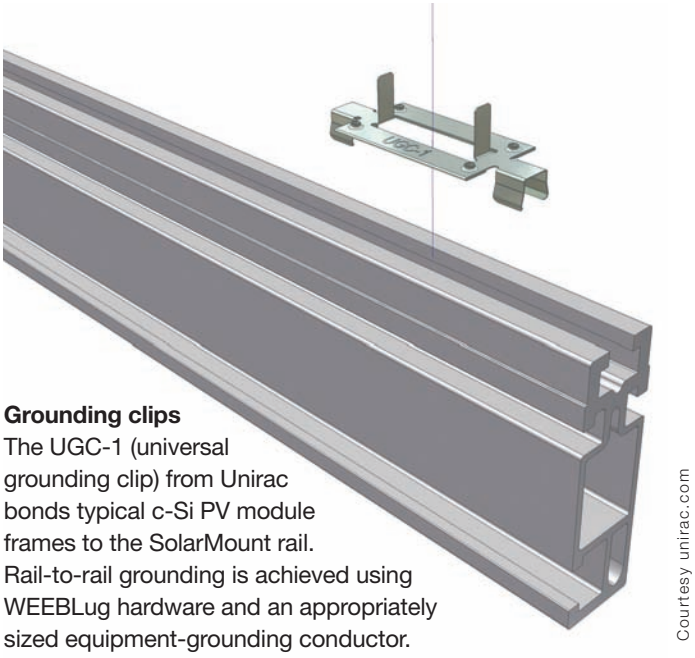
Mounting techniques that are not specifically allowed may also meet manufacturers' minimum requirements. The only way to know for sure is by contacting the company. If an applications engineer approves your use, get the approval in writing. This protects you in the long run. It may also encourage the manufacturer to build more comprehensive product literature.

Grounding. Appropriate grounding procedures and equipment are hotly debated throughout the electrical industry in general—the PV industry is not alone in this regard. But perhaps nothing exemplifies the disconnect between manufacturers and system installers better than the grounding instructions provided for PV products. Installers seldom get what they want in terms of grounding instructions. The good news is that the situation is getting better.

Blake Gleason, engineering manager for Sun Light & Power, sums up what PV system designers and installers want from module manufacturers: "Provide a flexible, comprehensive installation manual—backed by comprehensive testing—that lists many allowable grounding methods: toothed washers, grounding clips (like the WEEB products), lay-in lugs, multiple ground hole locations, use of mounting holes for grounding, field-drilled holes in the frame and so on." While none of the manuals surveyed for this article cover all of these bases, most manuals provide for more than one approved grounding method and include some of the specifications that Gleason wants. In general, the grounding methods that manufacturers list fall into three categories.

The first approved grounding method involves wrapping a ground wire around a stainless steel screw or bolt. Effective bonding to the module frame is achieved by screw threads cut into the frame or a stainless star washer that cuts through the frame's anodized coating. Dissimilar metals are isolated using combinations of stainless flat or cup washers. In some cases this is the only approved grounding method. The problem is that many projects and jurisdictions require a minimum #6 bare copper ground. (*NEC* 250.120(C) and 690.46 require that equipment grounding conductors smaller than 6 AWG be protected from physical damage.) Wrapping a 6 AWG wire around a 10-32 self-tapping screw is not really an option.

The second most common grounding method addresses these issues and involves the use of direct burial-rated, tin-plated copper lay-in lugs that are screwed or bolted to module frames using stainless steel hardware. John Wiles, program manager for the Institute for the Energy and the Environment, advocates bolting this lay-in lug in place using a lock nut, and most manufacturers include this detail in their literature. The concern is that even if a thread-forming screw has a high enough thread count to engage two threads in the module frame, there is no way to ensure that this connection will remain intact for the life of the PV system. In addition, due to the softness of the materials involved, thread-forming screws cannot be screwed and unscrewed without compromising the mechanical and electrical connection to the frame.



Grounding clips
The UGC-1 (universal grounding clip) from Unirac bonds typical c-Si PV module frames to the SolarMount rail. Rail-to-rail grounding is achieved using WEEBLug hardware and an appropriately sized equipment-grounding conductor.

Courtesy unirac.com

The third method described in installation manuals allows for the use of module grounding clips, like the WEEB products from Wiley Electronics. This is again best exemplified by Evergreen Solar in the installation instructions for the ES-A Series modules, which state, "Evergreen panels can also be grounded using third party grounding washers or clip devices provided the devices are listed and identified for grounding the metallic frames of PV panels and the devices are installed in accordance with the manufacturers specified instructions." REC Solar includes a similar allowance, slightly more generic, but no less useful to installers who want to use grounding clips.

Like thread-forming screws in an aluminum frame, module grounding clips are single-use devices. They are intended to be wedged in place at specific torque values and to remain in place. "The WEEB, like other grounding methods," notes Gleason, "is not foolproof and requires careful installation to be effective. For example, it is very easy to slide modules along a rail and inadvertently bend the WEEB nubs out of the way."

Wiles' concern about the use of grounding clips is slightly different. "Few module manufacturers," CONTINUED ON PAGE 72

2009 c-Si PV Module Specifications

Manufacturer	Model	Cell type	Rated power @ STC (W)	Rated power @ PTC (W)	Rated power tolerance (%)	Rated power per sq. ft. (W)	Module efficiency (%)	Cell efficiency (%)	Max. power voltage (Vmp)	Max. power current (Imp)	Open-circuit voltage (Voc)	Short-circuit current (Isc)
BP	BP 3115 J	poly	115	DNR	+/-3	10.5	11.3	DNR	17.1	6.70	21.8	7.50
BP	BP 312 5J	poly	125	DNR	+/-3	11.4	12.3	DNR	17.4	7.20	22.0	8.10
BP	SX 3140 J	poly	140	DNR	+/-9	12.8	13.8	DNR	17.5	8.00	22.0	8.20
BP	SX 3165 B	poly	165	146.1	+/-9	12.2	13.1	DNR	35.2	4.70	44.2	5.10
BP	SX 3170 I	poly	170	150.6	+/-9	12.0	13.1	DNR	35.4	4.80	44.2	5.27
BP	BP 170 I	poly	170	DNR	+/-5	12.0	13.1	DNR	35.4	4.80	43.6	5.27
BP	BP 170 B	poly	170	DNR	+/-5	12.6	13.5	DNR	35.4	4.80	43.6	5.27
BP	SX 3175 B	poly	175	155.2	+/-9	12.9	13.9	DNR	36.1	4.90	44.2	5.30
BP	BP 175 B	poly	175	155.2	+/-5	12.9	13.9	DNR	36.1	4.90	43.6	5.30
BP	BP 175 I	poly	175	155.2	+/-5	12.4	13.9	DNR	36.1	4.90	43.6	5.30
BP	BP 4175 B	mono	175	155.2	+/-5	12.9	13.9	DNR	35.4	4.94	43.6	5.45
BP	BP 4175 I	mono	175	155.2	+/-5	12.4	13.9	DNR	35.4	4.94	43.6	5.45
BP	BP 180 B	poly	180	DNR	+/-5	13.3	14.4	DNR	36.1	4.90	43.6	5.40
BP	BP 4180 B	mono	180	159.8	+/-5	13.3	14.3	DNR	35.5	5.10	43.6	5.60
BP	BP 4180 I	mono	180	159.7	+/-5	12.7	14.3	DNR	35.5	5.10	43.6	5.60
BP	SX 3190 B	poly	190	168.4	+/-9	12.6	13.5	DNR	24.3	7.82	30.6	8.50
BP	SX 3190 W	poly	190	168.4	+/-9	12.6	13.5	DNR	24.3	7.82	30.6	8.50
BP	SX 3195 N	poly	195	DNR	+/-9	12.9	13.9	DNR	24.4	7.96	30.7	8.60
BP	SX 3195 B	poly	195	173.0	+/-9	12.9	13.9	DNR	24.4	7.96	30.7	8.60
BP	SX 3200 B	poly	200	177.5	+/-9	13.2	14.2	DNR	24.5	8.16	30.8	8.70
BP	BP 3230 N	poly	230	DNR	+/-3	12.8	13.8	DNR	29.2	7.90	36.4	8.70
Canadian	CS6C-100	poly/mono	100	88.2	+/-2.5	9.4	10.1	11.6	17.3	5.79	21.5	6.46
Canadian	CS6C-105	poly/mono	105	92.7	+/-2.5	9.9	10.6	12.2	17.3	6.08	21.5	6.74
Canadian	CS6C-110	poly/mono	110	97.3	+/-2.5	10.3	11.1	12.8	17.3	6.36	21.6	7.01
Canadian	CS6C-115	poly/mono	115	101.8	+/-2.5	10.8	11.6	13.4	17.3	6.64	21.6	7.28
Canadian	CS6C-120	poly/mono	120	106.3	+/-2.5	11.3	12.1	14.0	17.3	6.92	21.7	7.52
Canadian	CS6A-120	poly	120	105.5	+/-2.5	8.6	9.2	10.5	22.9	5.24	28.5	5.89
Canadian	CS6C-125	poly/mono	125	110.9	+/-2.5	11.7	12.6	14.6	17.4	7.20	21.8	7.75
Canadian	CS6A-125	poly	125	110.4	+/-2.5	8.9	9.6	10.9	22.9	5.45	28.6	6.10
Canadian	CS5A-130	poly/mono	130	114.6	+/-2.5	9.5	10.2	12.4	34.6	3.75	42.9	4.21
Canadian	CS6C-130	poly/mono	130	115.4	+/-2.5	12.2	13.1	15.1	17.5	7.43	22.0	7.96
Canadian	CS6A-130	poly	130	114.5	+/-2.5	9.3	10.0	11.4	23.0	5.66	28.6	6.31
Canadian	CS5A-135	poly/mono	135	119.4	+/-2.5	9.8	10.6	12.9	34.7	3.89	42.9	4.35
Canadian	CS6A-135	poly	135	119.4	+/-2.5	9.6	10.4	11.8	23.0	5.87	28.7	6.52
Canadian	CS5A-140	poly/mono	140	123.6	+/-2.5	10.2	11.0	13.3	34.7	4.03	42.9	4.49
Canadian	CS6A-140	poly	140	123.5	+/-2.5	10.0	10.8	12.2	23.0	6.08	28.7	6.72
Canadian	CS5A-145	poly/mono	145	128.4	+/-2.5	10.5	11.3	13.8	34.7	4.17	43.0	4.63
Canadian	CS6A-145	poly	145	128.4	+/-2.5	10.4	11.2	12.7	23.0	6.29	28.8	6.92
Canadian	CS5A-150	poly/mono	150	132.6	+/-2.5	10.9	11.7	14.3	34.8	4.31	43.2	4.74
Canadian	CS6A-150	poly	150	132.5	+/-2.5	10.7	11.5	13.1	23.1	6.50	28.8	7.12
Canadian	CS6P-150	poly	150	132.3	+/-2.5	8.7	9.3	10.5	28.6	5.25	35.6	5.90
Canadian	CS5A-155	poly/mono	155	137.5	+/-2.5	11.3	12.1	14.8	34.8	4.45	43.4	4.86
Canadian	CS6A-155	poly	155	137.5	+/-2.5	11.1	11.9	13.5	23.1	6.71	28.8	7.32
Canadian	CS6P-155	poly	155	136.8	+/-2.5	9.0	9.6	10.8	28.6	5.42	35.6	6.08
Canadian	CS5A-160	poly/mono	160	141.7	+/-2.5	11.6	12.5	15.3	34.9	4.58	43.6	4.97
Canadian	CS6A-160	poly	160	141.6	+/-2.5	11.4	12.3	14.0	23.1	6.92	28.9	7.51
Canadian	CS6P-160	poly	160	141.3	+/-2.5	9.2	9.9	11.2	28.6	5.59	35.7	6.26
Canadian	CS5A-165	poly/mono	165	146.2	+/-2.5	12.0	12.9	15.7	35.2	4.69	43.8	5.08
Canadian	CS6A-165	poly	165	146.1	+/-2.5	11.8	12.7	14.4	23.1	7.13	29.0	7.69
Canadian	CS6P-165	poly	165	145.8	+/-2.5	9.5	10.3	11.5	28.7	5.76	35.7	6.45
Canadian	CS5A-170	poly/mono	170	150.8	+/-2.5	12.4	13.3	16.2	35.5	4.79	44.1	5.19
Canadian	CS6A-170	poly	170	150.7	+/-2.5	12.1	13.1	14.8	23.2	7.33	29.2	7.85
Canadian	CS6P-170	poly	170	150.4	+/-2.5	9.8	10.6	11.9	28.7	5.93	35.8	6.62

DNR = Did Not Report

Pmp temp. coefficientt (%/°C)	Voc temp. coefficient (%/°C)	Isc temp. coefficient (%/ºC)	Nominal operating cell temp. (°C)	Series fuse rating (A)	Connector type	# of J-boxes	Frame color	Backsheet color	Length (in.)	Width (in.)	Depth (in.)	Weight (lbs.)	Materials warranty (yrs.)	Power warranty (yrs.) 90%/80%
-0.47	-0.37	0.07	47.0	15	terminal	1	silver	DNR	59.45	26.54	1.97	26.64	5	12/25
-0.47	-0.36	0.07	47.0	15	terminal	1	silver	DNR	59.45	26.54	1.97	26.64	5	12/25
-0.47	-0.36	0.07	47.0	15	terminal	1	silver	DNR	59.45	26.54	1.97	26.64	5	12/25
-0.47	DNR	0.07	47.0	15	MC3	1	DNR	DNR	62.72	31.10	1.97	33.88	5	12/25
-0.47	DNR	0.07	47.0	15	MC3	1	DNR	DNR	62.48	32.61	1.97	33.88	5	12/25
-0.47	DNR	0.07	47.0	15	MC3	1	bronze	white	62.48	32.61	1.97	33.88	5	12/25
-0.47	DNR	0.07	47.0	15	MC3	1	bronze	black	62.72	31.10	1.97	33.88	5	12/25
-0.47	DNR	0.07	47.0	15	MC3	1	DNR	DNR	62.72	31.10	1.97	33.88	5	12/25
-0.47	-0.37	0.07	47.0	15	MC3	1	bronze	black	62.72	31.10	1.97	33.06	5	12/25
-0.47	-0.37	0.07	47.0	15	MC3	1	bronze	white	62.48	32.61	1.97	33.88	5	12/25
-0.47	DNR	0.07	47.0	15	MC3	1	bronze	black	62.72	31.10	1.97	33.88	5	12/25
-0.47	DNR	0.07	47.0	15	MC3	1	bronze	black	62.48	32.61	1.97	33.88	5	12/25
-0.47	DNR	0.07	47.0	15	MC3	1	DNR	DNR	62.48	31.10	1.97	33.88	5	12/25
-0.47	DNR	0.07	47.0	15	MC3	1	DNR	DNR	62.72	31.10	1.97	33.88	5	12/25
-0.47	DNR	0.07	47.0	15	MC3	1	DNR	DNR	62.48	32.61	1.97	33.88	5	12/25
-0.47	-0.36	0.07	47.0	15	MC3	1	bronze	black	66.14	32.95	1.97	37.84	5	12/25
-0.47	-0.36	0.07	47.0	15	MC3	1	bronze	white	66.14	32.95	1.97	37.84	5	12/25
-0.47	-0.36	0.07	47.0	15	MC3	1	silver	white	66.14	32.95	1.97	37.84	5	12/25
-0.47	-0.36	0.07	47.0	15	MC3	1	bronze	white	66.14	32.95	1.97	37.84	5	12/25
-0.47	-0.36	0.07	47.0	15	MC3	1	bronze	black	66.14	32.95	1.97	37.84	5	12/25
-0.47	DNR	0.07	47.0	20	MC3	1	DNR	DNR	65.63	39.37	1.97	42.68	5	12/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	58.46	26.22	1.57	26.46	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	58.46	26.22	1.57	26.46	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	58.46	26.22	1.57	26.46	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	58.46	26.22	1.57	26.46	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	58.46	26.22	1.57	26.46	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	52.13	38.66	1.57	35.27	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	58.46	26.22	1.57	26.46	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	52.13	38.66	1.57	35.27	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	62.80	31.54	1.57	34.17	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	58.46	26.22	1.57	26.46	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	52.13	38.66	1.57	35.27	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	62.80	31.54	1.57	34.17	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	52.13	38.66	1.57	35.27	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	62.80	31.54	1.57	34.17	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	52.13	38.66	1.57	35.27	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	62.80	31.54	1.57	34.17	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	52.13	38.66	1.57	35.27	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	62.80	31.54	1.57	34.17	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	52.13	38.66	1.57	35.27	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	62.80	31.54	1.57	34.17	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	52.13	38.66	1.57	35.27	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	62.80	31.54	1.57	34.17	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	52.13	38.66	1.57	35.27	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	62.80	31.54	1.57	34.17	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	52.13	38.66	1.57	35.27	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	62.80	31.54	1.57	34.17	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	52.13	38.66	1.57	35.27	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25

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2009 c-Si PV Module Specifications

Manufacturer	Model	Cell type	Rated power @ STC (W)	Rated power @ PTC (W)	Rated power tolerance (%)	Rated power per sq. ft. (W)	Module efficiency (%)	Cell efficiency (%)	Max. power voltage (Vmp)	Max. power current (Imp)	Open-circuit voltage (Voc)	Short-circuit current (Isc)
Canadian	CS5A-175	poly/mono	175	155.3	+/-2.5	12.7	13.7	16.7	35.8	4.89	44.3	5.29
Canadian	CS6A-175	poly	175	155.2	+/-2.5	12.5	13.5	15.3	23.4	7.49	29.3	8.03
Canadian	CS6P-175	poly	175	154.9	+/-2.5	10.1	10.9	12.2	28.7	6.10	35.9	6.80
Canadian	CS5A-180	poly/mono	180	159.9	+/-2.5	13.1	14.1	17.2	36.1	4.99	44.5	5.40
Canadian	CS6A-180	poly	180	159.8	+/-2.5	12.9	13.8	15.7	23.6	7.62	29.4	8.20
Canadian	CS6P-180	poly	180	159.4	+/-2.5	10.4	11.2	12.6	28.7	6.26	35.9	6.98
Canadian	CS5A-185	poly/mono	185	164.8	+/-2.5	13.4	14.5	17.6	36.4	5.09	44.7	5.50
Canadian	CS6A-185	poly	185	164.4	+/-2.5	13.2	14.2	16.2	24.0	7.71	29.5	8.37
Canadian	CS6P-185	poly	185	163.9	+/-2.5	10.7	11.5	12.9	28.8	6.43	36.0	7.16
Canadian	CS5A-190	poly/mono	190	169.0	+/-2.5	13.8	14.9	18.1	36.6	5.18	44.9	5.60
Canadian	CS6A-190	poly	190	168.9	+/-2.5	13.6	14.6	16.6	24.2	7.84	29.6	8.54
Canadian	CS6P-190	poly	190	168.5	+/-2.5	11.0	11.8	13.3	28.8	6.60	36.0	7.33
Canadian	CS6P-195	poly	195	173.0	+/-2.5	11.3	12.1	13.6	28.8	6.76	36.1	7.51
Canadian	CS5P-200	poly	200	176.8	+/-2.5	10.9	11.8	14.3	46.4	4.31	57.4	4.78
Canadian	CS6P-200	poly	200	177.0	+/-2.5	11.6	12.4	14.0	28.9	6.93	36.2	7.68
Canadian	CS5P-205	poly	205	181.3	+/-2.5	11.2	12.1	14.7	46.5	4.41	57.6	4.86
Canadian	CS6P-205	poly	205	181.6	+/-2.5	11.8	12.7	14.3	28.9	7.10	36.2	7.80
Canadian	CS5P-210	poly	210	185.9	+/-2.5	11.5	12.4	15.0	46.6	4.51	57.9	4.94
Canadian	CS6P-210	poly	210	186.1	+/-2.5	12.1	13.1	14.7	28.9	7.26	36.4	7.91
Canadian	CS5P-215	poly	215	190.4	+/-2.5	11.8	12.6	15.4	46.7	4.61	58.1	5.02
Canadian	CS6P-215	poly	215	190.7	+/-2.5	12.4	13.4	15.0	29.0	7.43	36.5	8.01
Canadian	CS5P-220	poly	220	194.9	+/-2.5	12.0	12.9	15.7	46.9	4.69	58.4	5.10
Canadian	CS6P-220	poly	220	195.2	+/-2.5	12.7	13.7	15.4	29.3	7.52	36.6	8.09
Canadian	CS5P-225	poly	225	199.5	+/-2.5	12.3	13.2	16.1	47.2	4.76	58.6	5.18
Canadian	CS6P-225	poly	225	199.8	+/-2.5	13.0	14.0	15.7	29.5	7.63	36.7	8.19
Canadian	CS5P-230	poly	230	204.0	+/-2.5	12.6	13.5	16.4	47.5	4.84	58.8	5.25
Canadian	CS6P-230	poly	230	204.4	+/-2.5	13.3	14.3	16.1	29.8	7.71	36.8	8.34
Canadian	CS5P-235	poly	235	208.6	+/-2.5	12.8	13.8	16.8	47.8	4.92	59.1	5.33
Canadian	CS5P-240	poly	240	213.2	+/-2.5	13.1	14.1	17.2	48.1	4.99	59.3	5.40
Day4Energy	Day4 48MC	poly	160	143.5	+/-3.5	11.5	12.4	DNR	22.6	7.08	28.3	7.70
Day4Energy	Day4 48MC	poly	165	148.1	+/-3.5	11.8	12.7	DNR	23.0	7.19	28.6	7.80
Day4Energy	Day4 48MC	poly	170	152.7	+/-3.5	12.2	13.1	DNR	23.0	7.38	28.8	7.90
Day4Energy	Day4 48MC	poly	175	157.3	+/-3.5	12.6	13.5	DNR	23.4	7.48	29.2	8.05
Day4Energy	Day4 48MC	poly	180	161.9	+/-3.5	12.9	13.9	DNR	23.7	7.60	29.4	8.10
Day4Energy	Day4 48MC	poly	185	166.5	+/-3.5	13.3	14.3	DNR	23.8	7.77	29.5	8.20
Day4Energy	Day4 48MC	poly	190	171.1	+/-3.5	13.6	14.7	DNR	24.0	7.92	29.7	8.30
ET	ET-P636115	poly	115	DNR	+/-3	10.7	11.5	DNR	17.2	6.68	21.8	7.55
ET	ET-P636120	poly	120	DNR	+/-3	11.1	12.0	DNR	17.4	6.89	21.8	7.63
ET	ET-P636125	poly	125	DNR	+/-3	11.6	12.5	DNR	17.4	7.18	21.8	7.80
ET	ET-P636130	poly	130	DNR	+/-3	12.1	13.0	DNR	17.4	7.47	21.8	8.10
ET	ET-P636135	poly	135	DNR	+/-3	12.5	13.5	DNR	17.6	7.67	22.0	8.41
ET	ET-P636140	poly	140	DNR	+/-3	13.0	14.0	DNR	17.6	7.95	22.0	8.41
ET	ET-P636145	poly	145	DNR	+/-3	13.5	14.5	DNR	17.8	8.15	22.0	8.50
ET	ET-M572155	mono	155	136.8	+/-3	11.3	12.1	DNR	35.2	4.40	43.3	4.98
ET	ET-P648155	poly	155	DNR	+/-3	11.0	11.8	DNR	23.0	6.73	29.0	7.60
ET	ET-M572160	mono	160	141.3	+/-3	11.6	12.5	DNR	35.6	4.49	43.9	5.07
ET	ET-P648160	poly	160	DNR	+/-3	11.3	12.2	DNR	23.0	6.95	29.0	7.80
ET	ET-M572165	mono	165	145.9	+/-3	12.0	12.9	DNR	35.8	4.60	44.1	5.19
ET	ET-P648165	poly	165	DNR	+/-3	11.7	12.6	DNR	23.0	7.17	29.0	7.90
ET	ET-M572170	mono	170	150.4	+/-3	12.4	13.3	DNR	36.1	4.71	44.2	5.30
ET	ET-P648170	poly	170	DNR	+/-3	12.0	12.9	DNR	23.0	7.39	29.0	8.10
ET	ET-M572175	mono	175	155.0	+/-3	12.7	13.7	DNR	36.2	4.83	44.3	5.50
ET	ET-P648175	poly	175	DNR	+/-3	12.4	13.3	DNR	23.2	7.54	29.0	8.10
ET	ET-M572180	mono	180	159.5	+/-3	13.1	14.1	DNR	36.3	4.95	44.6	5.61

DNR = Did Not Report

Pmp temp. coefficientt (%/°C)	Voc temp. coefficient (%/°C)	Isc temp. coefficient (%/ºC)	Nominal operating cell temp. (°C)	Series fuse rating (A)	Connector type	# of J-boxes	Frame color	Backsheet color	Length (in.)	Width (in.)	Depth (in.)	Weight (lbs.)	Materials warranty (yrs.)	Power warranty (yrs.) 90%/80%
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	62.80	31.54	1.57	34.17	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	52.13	38.66	1.57	35.27	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	62.80	31.54	1.57	34.17	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	52.13	38.66	1.57	35.27	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	62.80	31.54	1.57	34.17	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	52.13	38.66	1.57	35.27	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	62.80	31.54	1.57	34.17	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	52.13	38.66	1.57	35.27	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	63.07	41.77	1.57	44.09	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	63.07	41.77	1.57	44.09	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	63.07	41.77	1.57	44.09	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	63.07	41.77	1.57	44.09	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	63.07	41.77	1.57	44.09	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	63.07	41.77	1.57	44.09	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	63.07	41.77	1.57	44.09	2	10/25
-0.45	-0.35	0.06	45.0	15	MC4	1	silver	white	64.49	38.66	1.57	40.79	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	63.07	41.77	1.57	44.09	2	10/25
-0.45	-0.35	0.06	45.0	10	MC4	1	silver	white	63.07	41.77	1.57	44.09	2	10/25
-0.44	-0.33	0.03	46.9	15	SolarLok	1	silver	white	51.46	39.01	1.38	38.28	5	10/25
-0.44	-0.33	0.03	46.9	15	SolarLok	1	silver	white	51.46	39.01	1.38	38.28	5	10/25
-0.44	-0.33	0.03	46.9	15	SolarLok	1	silver	white	51.46	39.01	1.38	38.28	5	10/25
-0.44	-0.33	0.03	46.9	15	SolarLok	1	silver	white	51.46	39.01	1.38	38.28	5	10/25
-0.44	-0.33	0.03	46.9	15	SolarLok	1	silver	white	51.46	39.01	1.38	38.28	5	10/25
-0.44	-0.33	0.03	46.9	15	SolarLok	1	silver	white	51.46	39.01	1.38	38.28	5	10/25
-0.44	-0.33	0.03	46.9	15	SolarLok	1	silver	white	51.46	39.01	1.38	38.28	5	10/25
-0.49	-0.36	0.07	45.3	12	MC4	1	silver	white	58.30	26.60	1.30	26.50	5	12/25
-0.49	-0.36	0.07	45.3	12	MC4	1	silver	white	58.30	26.60	1.30	26.50	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	58.30	26.60	1.30	26.50	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	58.30	26.60	1.30	26.50	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	58.30	26.60	1.30	26.50	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	58.30	26.60	1.30	26.50	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	58.30	26.60	1.30	26.50	5	12/25
-0.55	-0.40	0.06	44.4	10	MC4	1	silver	white	62.20	31.81	1.97	34.20	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	52.13	39.06	1.97	34.45	5	12/25
-0.55	-0.40	0.06	44.4	10	MC4	1	silver	white	62.20	31.81	1.97	34.20	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	52.13	39.06	1.97	34.45	5	12/25
-0.55	-0.40	0.06	44.4	10	MC4	1	silver	white	62.20	31.81	1.97	34.20	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	52.13	39.06	1.97	34.45	5	12/25
-0.55	-0.40	0.06	44.4	10	MC4	1	silver	white	62.20	31.81	1.97	34.20	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	52.13	39.06	1.97	34.45	5	12/25
-0.55	-0.40	0.06	44.4	10	MC4	1	silver	white	62.20	31.81	1.97	34.20	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	52.13	39.06	1.97	34.45	5	12/25
-0.55	-0.40	0.06	44.4	10	MC4	1	silver	white	62.20	31.81	1.97	34.20	5	12/25

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2009 c-Si PV Module Specifications

Manufacturer	Model	Cell type	Rated power @ STC (W)	Rated power @ PTC (W)	Rated power tolerance (%)	Rated power per sq. ft. (W)	Module efficiency (%)	Cell efficiency (%)	Max. power voltage (Vmp)	Max. power current (Imp)	Open-circuit voltage (Voc)	Short-circuit current (Isc)
ET	ET-P648180	poly	180	DNR	+/-3	12.7	13.7	DNR	23.5	7.66	29.0	8.10
ET	ET-M572185	mono	185	164.1	+/-3	13.5	14.5	DNR	36.3	5.09	44.6	5.80
ET	ET-P648185	poly	185	DNR	+/-3	13.1	14.1	DNR	23.5	7.87	29.0	8.41
ET	ET-P648190	poly	190	DNR	+/-3	13.4	14.5	DNR	23.5	8.08	29.2	8.41
ET	ET-P648195	poly	195	DNR	+/-3	13.8	14.8	DNR	23.5	8.29	29.2	8.50
ET	ET-P660200	poly	200	DNR	+/-3	11.4	12.3	DNR	28.8	6.95	36.0	7.71
ET	ET-P660205	poly	205	DNR	+/-3	11.7	12.6	DNR	28.8	7.13	36.0	7.80
ET	ET-P654205	poly	205	183.3	+/-3	13.0	13.9	DNR	27.3	7.50	32.8	8.10
ET	ET-P660210	poly	210	DNR	+/-3	12.0	12.9	DNR	28.8	7.30	36.0	7.99
ET	ET-P654210	poly	210	187.9	+/-3	13.3	14.3	DNR	27.5	7.63	32.8	8.30
ET	ET-P660215	poly	215	DNR	+/-3	12.3	13.2	DNR	29.0	7.41	36.0	8.10
ET	ET-P654215	poly	215	192.5	+/-3	13.6	14.6	DNR	27.5	7.81	33.2	8.50
ET	ET-P660220	poly	220	DNR	+/-3	12.6	13.5	DNR	29.0	7.58	36.3	8.10
ET	ET-P660225	poly	225	DNR	+/-3	12.8	13.8	DNR	29.0	7.75	36.3	8.10
ET	ET-P660230	poly	230	DNR	+/-3	13.1	14.1	DNR	29.4	7.82	36.5	8.30
ET	ET-P660235	poly	235	DNR	+/-3	13.4	14.4	DNR	29.4	7.99	36.5	8.30
ET	ET-P660240	poly	240	DNR	+/-3	13.7	14.7	DNR	29.4	8.16	36.5	8.50
ET	ET-P672240	poly	240	213.9	+/-3	11.5	12.4	DNR	35.0	6.88	43.9	7.63
ET	ET-P672245	poly	245	218.5	+/-3	11.7	12.6	DNR	35.0	7.01	43.9	7.70
ET	ET-P672250	poly	250	223.0	+/-3	12.0	12.9	DNR	35.2	7.12	43.9	7.81
ET	ET-P672255	poly	255	227.6	+/-3	12.2	13.1	DNR	35.2	7.23	43.9	7.85
ET	ET-P672260	poly	260	232.2	+/-3	12.4	13.4	DNR	36.0	7.23	43.5	7.79
ET	ET-P672265	poly	265	236.8	+/-3	12.7	13.7	DNR	36.4	7.28	43.6	7.90
ET	ET-P672270	poly	270	241.4	+/-3	12.9	13.9	DNR	36.4	7.42	43.6	7.90
ET	ET-P672275	poly	275	245.9	+/-3	13.2	14.2	DNR	36.7	7.49	43.8	7.96
ET	ET-P672280	poly	280	250.5	+/-3	13.4	14.4	DNR	36.7	7.63	43.8	7.98
Evergreen	ES-B-180	ribbon	180	159.7	+3.4/-2	11.2	12.0	DNR	17.1	10.53	21.3	11.64
Evergreen	ES-B-190	ribbon	190	168.8	+2.6/-2	11.8	12.7	DNR	17.4	10.92	21.5	11.95
Evergreen	ES-B-195	ribbon	195	173.3	+2.6/-0	12.1	13.1	DNR	17.6	11.08	21.7	12.11
Evergreen	ES-A-200	ribbon	200	180.6	+2.5/-0	11.8	12.7	DNR	18.1	11.05	22.6	11.80
Evergreen	ES-A-205	ribbon	205	185.2	+2.4/-0	12.1	13.1	DNR	18.2	11.27	22.7	11.93
Evergreen	ES-A-210	ribbon	210	189.8	+2.4/-0	12.4	13.4	DNR	18.3	11.48	22.8	12.11
GE	GEPVp-200-M	poly	200	173.2	+/-5	12.8	13.9	DNR	26.3	7.60	32.9	8.10
GE	GEPVp-205-M	poly	205	177.7	+/-5	13.1	14.2	DNR	27.2	7.60	33.0	8.20
Kyocera	KD130SX	poly	130	114.8	+/-5	12.0	13.0	14.8	17.7	7.35	22.1	8.06
Kyocera	KD135SX	poly	135	119.4	+/-5	12.5	13.5	15.4	17.7	7.63	22.1	8.37
Kyocera	KD130GX	poly	130	114.8	+/-5	12.0	13.0	14.8	17.7	7.35	22.1	8.06
Kyocera	KD135GX	poly	135	119.4	+/-5	12.5	13.5	15.4	17.7	7.63	22.1	8.37
Kyocera	KD180GX	poly	180	156.0	+/-5	12.6	13.6	15.4	23.6	7.63	29.5	8.35
Kyocera	KD205GX	poly	205	180.0	+/-5	12.8	13.8	15.6	26.6	7.71	33.2	8.36
Kyocera	KD210GX	poly	210	184.6	+/-5	13.1	14.2	16.0	26.6	7.90	33.2	8.58
Mitsubishi	PV-UE115MF5N	poly	115	102.0	+10/-5	10.6	11.4	13.1	17.1	6.75	21.5	7.60
Mitsubishi	PV-UE120MF5N	poly	120	106.5	+10/-5	11.1	11.9	13.7	17.2	6.99	21.6	7.75
Mitsubishi	PV-UE125MF5N	poly	125	111.1	+10/-5	11.5	12.4	14.3	17.3	7.23	21.8	7.90
Mitsubishi	PV-UE130MF5N	poly	130	115.6	+10/-5	12.0	12.9	14.8	17.4	7.47	21.9	8.05
Mitsubishi	PV-UD175MF5	poly	175	155.6	+/-3	11.8	12.7	14.4	23.9	7.32	30.2	7.93
Mitsubishi	PV-UD180MF5	poly	180	160.1	+/-3	12.1	13.0	14.8	24.2	7.45	30.4	8.03
Mitsubishi	PV-UD185MF5	poly	185	164.7	+/-3	12.4	13.4	15.2	24.4	7.58	30.6	8.13
Mitsubishi	PV-UD190MF5	poly	190	169.3	+/-3	12.8	13.7	15.6	24.7	7.71	30.8	8.23
NingBo	TDB125_125-72-P	mono	150	131.7	+/-5	10.9	11.8	14.1	35.2	4.26	43.4	4.92
NingBo	TDB125_125-72-P	mono	155	136.2	+/-5	11.3	12.2	14.6	35.4	4.38	43.6	4.98
NingBo	TDB125_125-72-P	mono	160	140.8	+/-5	11.7	12.5	15.1	35.6	4.50	43.8	5.04
NingBo	TDB125_125-72-P	mono	165	145.3	+/-5	12.0	12.9	15.5	35.8	4.61	44.0	5.10

DNR = Did Not Report [1] Black frame option

Pmp temp. coefficientt (%/°C)	Voc temp. coefficient (%/°C)	Isc temp. coefficient (%/ºC)	Nominal operating cell temp. (°C)	Series fuse rating (A)	Connector type	# of J-boxes	Frame color	Backsheet color	Length (in.)	Width (in.)	Depth (in.)	Weight (lbs.)	Materials warranty (yrs.)	Power warranty (yrs.) 90%/80%
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	52.13	39.06	1.97	34.45	5	12/25
-0.55	-0.40	0.06	44.4	10	MC4	1	silver	white	62.20	31.81	1.97	34.20	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	52.13	39.06	1.97	34.45	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	52.13	39.06	1.97	34.45	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	52.13	39.06	1.97	34.45	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	64.57	39.06	1.97	42.61	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	64.57	39.06	1.97	42.61	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	58.30	39.10	2.00	39.30	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	64.57	39.06	1.97	42.61	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	58.30	39.10	2.00	39.30	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	64.57	39.06	1.97	42.61	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	58.30	39.10	2.00	39.30	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	64.57	39.06	1.97	42.61	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	64.57	39.06	1.97	42.61	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	64.57	39.06	1.97	42.61	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	64.57	39.06	1.97	42.61	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	64.57	39.06	1.97	42.61	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	77.00	39.10	2.00	50.70	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	77.00	39.10	2.00	50.70	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	77.00	39.10	2.00	50.70	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	77.00	39.10	2.00	50.70	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	77.00	39.10	2.00	50.70	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	77.00	39.10	2.00	50.70	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	77.00	39.10	2.00	50.70	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	77.00	39.10	2.00	50.70	5	12/25
-0.49	-0.35	0.07	45.3	12	MC4	1	silver	white	77.00	39.10	2.00	50.70	5	12/25
-0.49	-0.34	0.06	45.9	20	MC4	1	silver[1]	white	61.80	37.50	1.60	40.10	5	10/25
-0.49	-0.34	0.06	45.9	20	MC4	1	silver[1]	white	61.80	37.50	1.60	40.10	5	10/25
-0.49	-0.34	0.06	45.9	20	MC4	1	silver[1]	white	61.80	37.50	1.60	40.10	5	10/25
-0.43	-0.31	0.05	45.4	20	MC4	1	silver[1]	white	65.00	37.50	1.80	41.00	5	10/25
-0.43	-0.31	0.05	45.4	20	MC4	1	silver[1]	white	65.00	37.50	1.80	41.00	5	10/25
-0.43	-0.31	0.05	45.4	20	MC4	1	silver[1]	white	65.00	37.50	1.80	41.00	5	10/25
-0.50	-0.36	0.07	50.0	15	SolarLok	1	silver	white	58.50	38.60	1.40	39.00	5	10/20
-0.50	-0.36	0.07	50.0	15	SolarLok	1	silver	white	58.50	38.60	1.40	39.00	5	10/20
-0.46	-0.36	0.06	49.0	15	terminal	1	silver	white	59.10	26.30	1.41	28.70	1	10/20
-0.46	-0.36	0.06	49.0	15	terminal	1	silver	white	59.10	26.30	1.42	28.70	1	10/20
-0.46	-0.36	0.06	49.0	15	MC4	1	black	white	59.10	26.30	1.41	28.70	1	10/20
-0.46	-0.36	0.06	49.0	15	MC4	1	black	white	59.10	26.30	1.42	28.70	1	10/20
-0.46	-0.36	0.06	49.0	15	MC4	1	black	white	52.80	39.00	1.40	36.40	1	10/20
-0.46	-0.36	0.06	49.0	15	MC4	1	black	white	59.10	39.00	1.40	40.80	1	10/20
-0.46	-0.36	0.06	49.0	15	MC4	1	black	white	59.10	39.00	1.40	40.80	1	10/20
-0.45	-0.34	0.05	47.5	15	MC4	1	black	white	58.90	26.50	1.81	29.80	1.25	10/25
-0.45	-0.34	0.05	47.5	15	MC4	1	black	white	58.90	26.50	1.81	29.80	1.25	10/25
-0.45	-0.34	0.05	47.5	15	MC4	1	black	white	58.90	26.50	1.81	29.80	1.25	10/25
-0.45	-0.34	0.05	47.5	15	MC4	1	black	white	58.90	26.50	1.81	29.80	1.25	10/25
-0.45	-0.34	0.05	47.5	15	MC4	2	black	white	65.30	32.80	1.81	37.00	1.25	10/25
-0.45	-0.34	0.05	47.5	15	MC4	2	black	white	65.30	32.80	1.81	37.00	1.25	10/25
-0.45	-0.34	0.05	47.5	15	MC4	2	black	white	65.30	32.80	1.81	37.00	1.25	10/25
-0.45	-0.34	0.05	47.5	15	MC4	2	black	white	65.30	32.80	1.81	37.00	1.25	10/25
-0.40	-0.35	0.03	47.0	10	MC4	1	silver	white	62.20	31.80	1.80	35.27	5	10/25
-0.40	-0.35	0.03	47.0	10	MC4	1	silver	white	62.20	31.80	1.80	35.27	5	10/25
-0.40	-0.35	0.03	47.0	10	MC4	1	silver	white	62.20	31.80	1.80	35.27	5	10/25
-0.40	-0.35	0.03	47.0	10	MC4	1	silver	white	62.20	31.80	1.80	35.27	5	10/25

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2009 c-Si PV Module Specifications

Manufacturer	Model	Cell type	Rated power @ STC (W)	Rated power @ PTC (W)	Rated power tolerance (%)	Rated power per sq. ft. (W)	Module efficiency (%)	Cell efficiency (%)	Max. power voltage (Vmp)	Max. power current (Imp)	Open-circuit voltage (Voc)	Short-circuit current (Isc)
NingBo	TDB125_125-72-P	mono	170	149.8	+/-5	12.4	13.3	16.0	36.0	4.72	44.2	5.16
NingBo	TDB125_125-72-P	mono	175	154.3	+/-5	12.7	13.7	16.5	36.2	4.84	44.4	5.22
NingBo	TDB125_125-72-P	mono	180	159.8	+/-5	13.1	14.1	16.9	36.4	4.95	44.6	5.28
REC	REC205AE-USA	poly	205	182.2	+/-3	11.5	12.4	14.0	28.1	7.30	36.1	7.90
REC	REC210AE-USA	poly	210	186.7	+/-3	11.8	12.7	14.4	28.2	7.50	36.1	8.10
REC	REC215AE-USA	poly	215	191.3	+/-3	12.1	13.0	14.7	28.3	7.60	36.3	8.10
REC	REC220AE-USA	poly	220	195.9	+/-3	12.4	13.3	15.1	28.7	7.70	36.6	8.20
REC	REC225AE-USA	poly	225	200.4	+/-3	12.7	13.6	15.4	29.1	7.70	36.8	8.20
REC	REC230AE-USA	poly	230	205.0	+/-3	13.0	13.9	15.8	29.4	7.80	37.1	8.30
Sanyo	HIT Power 190	mono, a-Si	190	177.2	+10/-0	15.2	16.4	18.8	54.8	3.47	67.5	3.75
Sanyo	HIT Power 195	mono, a-Si	195	181.9	+10/-0	15.6	16.8	19.3	55.3	3.53	68.1	3.79
Sanyo	HIT Power 200	mono, a-Si	200	187.1	+10/-0	16.0	17.2	19.7	55.8	3.59	68.7	3.83
Sanyo	HIT Power 205	mono, a-Si	205	191.9	+10/-0	16.4	17.7	20.2	56.7	3.62	68.8	3.84
Sanyo	HIT Double 186[1]	mono, a-Si	186	173.4	+10/-0	14.2[2]/ 18.2[3]	15.3[2] / 19.6 [3]	18.4	54.8[2] / 55.1[3]	3.40[2] / 4.32[3]	67.5[2] / 68.2[3]	3.68[2] / 4.78[3]
Sanyo	HIT Double 190 [1]	mono, a-Si	190	177.2	+10/-0	14.6[2] / 18.6[3]	15.7[2] / 20.0[3]	18.8	55.3[2] / 55.6[3]	3.44[2] / 4.37[3]	68.1[2] / 68.8[3]	3.70[2] / 4.81[3]
Sanyo	HIT Double 195 [1]	mono, a-Si	195	182.4	+10/-0	14.9[2] / 19.1[3]	16.1[2] / 20.5[3]	19.3	55.8[2] / 56.1[3]	3.50[2] / 4.45[3]	68.7[2] / 69.5[3]	3.73[2] / 4.85[3]
Sanyo	HIT Power 205N	mono, a-Si	205	190.1	+10/-0	15.1	16.3	18.4	40.7	5.05	50.3	5.54
Sanyo	HIT Power 210N	mono, a-Si	210	194.8	+10/-0	15.5	16.7	18.9	41.3	5.09	50.9	5.57
Sanyo	HIT Power 215N	mono, a-Si	215	199.6	+10/-0	15.9	17.1	19.3	42.0	5.13	51.6	5.61
Schott	SAPC-170	mono	170	149.9	+10/-5	12.1	13.1	DNR	34.8	4.90	43.2	5.47
Schott	SAPC-175	mono	175	154.4	+10/-5	12.5	13.5	DNR	35.4	4.95	44.4	5.40
Schott	POLY 202	poly	202	DNR	+/-4	11.2	12.1	DNR	28.9	6.99	35.8	7.79
Schott	POLY 210	poly	210	DNR	+/-4	11.6	12.6	DNR	29.3	7.16	36.1	7.95
Schott	POLY 217	poly	217	DNR	+/-4	12.0	13.0	DNR	29.6	7.33	36.4	8.10
Schott	POLY 225	poly	225	DNR	+/-4	12.5	13.5	DNR	29.8	7.50	36.7	8.24
Schott	ASE 250	ribbon	250	223.6	+/-2	9.6	10.3	DNR	48.5	5.15	60.0	5.90
Schott	ASE 260	ribbon	260	232.7	+/-2	10.0	10.7	DNR	48.7	5.50	60.0	5.90
Schott	ASE 270	ribbon	270	241.8	+/-2	10.3	11.1	DNR	49.1	5.50	60.0	6.05
Schott	ASE 280	ribbon	280	251.0	+/-2	10.7	11.5	DNR	49.6	5.65	61.9	6.20
Schott	ASE 290	ribbon	290	260.2	+/-2	11.1	11.9	DNR	50.1	5.80	62.5	6.40
Schott	ASE 300	ribbon	300	269.3	+/-2	11.5	12.4	DNR	50.6	5.90	63.2	6.50
Schott	ASE 310	ribbon	310	278.5	+/-2	11.9	12.8	DNR	51.1	6.10	63.8	6.50
Schüco	165 SPU-4	poly	165	147.5	+/-5	11.1	11.9	14.4	23.4	7.06	29.7	7.73
Schüco	170 SPU-4	poly	170	152.1	+/-5	11.4	12.3	14.8	23.7	7.19	29.9	7.83
Schüco	175 SPU-4	poly	175	156.6	+/-5	11.8	12.7	15.2	23.9	7.32	30.2	7.93
Schüco	180 SPU-4	poly	180	161.2	+/-5	12.1	13.0	15.5	24.2	7.45	30.4	8.03
Schüco	200 SMAU-1	mono	200	180.7	+/-3	12.7	14.2	16.3	25.4	7.89	33.5	8.24
Schüco	210 SMAU-1	mono	210	189.9	+/-3	13.3	14.9	17.0	26.3	7.98	33.7	8.35
Schüco	MPE 310 MP02	mono	310	283.2	+/-3	10.7	11.5	15.3	72.3	4.30	88.1	4.65
Schüco	MPE 320 MP02	mono	320	292.5	+/-3	11.0	11.9	15.7	72.3	4.40	88.1	4.75
Schüco	MPE 330 MP02	mono	330	301.8	+/-3	11.4	12.2	16.0	72.4	4.50	88.6	4.80
Sharp	ND-72ERUC	poly	72	63.0	+10/-5	11.6	13.3	DNR	10.3	7.18	12.7	7.89
Sharp	ND-72ELUC	poly	72	63.0	+10/-5	11.6	13.3	DNR	10.3	7.18	12.7	7.89
Sharp	ND-123UJF	poly	123	107.2	+10/-5	11.5	13.1	DNR	17.2	7.15	21.8	7.99
Sharp	ND-130UJF	poly	130	114.1	+10/-5	12.2	13.1	DNR	17.4	7.50	21.9	8.20
Sharp	ND-N2ECUC	poly	142	125.0	+10/-5	11.4	12.3	DNR	19.9	7.13	25.2	7.84
Sharp	NE-170UC1	poly	170	149.9	+10/-5	12.1	13.1	DNR	34.8	4.90	43.2	5.47
Sharp	NT-175UC1	mono	175	154.4	+10/-5	12.5	13.5	DNR	35.4	4.95	44.4	5.40
Sharp	ND-176UC1	poly	176	155.3	+10/-5	12.4	13.4	DNR	23.4	7.52	29.3	8.22
Sharp	ND-198UC1	poly	198	174.7	+10/-5	12.4	13.4	DNR	26.3	7.52	32.9	8.23
Sharp	ND-200UC1	poly	200	176.1	+10/-5	11.4	13.3	DNR	28.9	7.48	36.5	8.10
Sharp	ND-208UC1	poly	208	183.3	+10/-5	11.9	13.3	DNR	28.7	7.53	36.3	8.35
Sharp	ND-216UC1	poly	216	190.5	+10/-5	12.3	13.3	DNR	28.9	7.48	36.5	8.10

[1] Bifacial module [2] @ STC [3] @ up to 30% backside irradiance contribution DNR = Did Not Report

Pmp temp. coefficient (%/°C)	Voc temp. coefficient (%/°C)	Isc temp. coefficient (%/ºC)	Nominal operating cell temp. (°C)	Series fuse rating (A)	Connector type	# of J-boxes	Frame color	Backsheet color	Length (in.)	Width (in.)	Depth (in.)	Weight (lbs.)	Materials warranty (yrs.)	Power warranty (yrs.) 90%/80%
-0.40	-0.35	0.03	47.0	10	MC4	1	silver	white	62.20	31.80	1.80	35.27	5	10/25
-0.40	-0.35	0.03	47.0	10	MC4	1	silver	white	62.20	31.80	1.80	35.27	5	10/25
-0.40	-0.35	0.03	47.0	10	MC4	1	silver	white	62.20	31.80	1.80	35.27	5	10/25
-0.45	-0.34	0.07	47.5	15	MC4	1	silver	white	65.55	39.02	1.69	48.50	5	10/25
-0.45	-0.34	0.07	47.5	15	MC4	1	silver	white	65.55	39.02	1.69	48.50	5	10/25
-0.45	-0.34	0.07	47.5	15	MC4	1	silver	white	65.55	39.02	1.69	48.50	5	10/25
-0.45	-0.34	0.07	47.5	15	MC4	1	silver	white	65.55	39.02	1.69	48.50	5	10/25
-0.45	-0.34	0.07	47.5	15	MC4	1	silver	white	65.55	39.02	1.69	48.50	5	10/25
-0.45	-0.34	0.07	47.5	15	MC4	1	silver	white	65.55	39.02	1.69	48.50	5	10/25
-0.30	-0.25	0.02	46.9	15	MC4	1	black	white	51.90	34.60	1.80	33.07	5	10/20
-0.30	-0.25	0.02	46.9	15	MC4	1	black	white	51.90	34.60	1.80	33.07	5	10/20
-0.29	-0.25	0.02	46.9	15	MC4	1	black	white	51.90	34.60	1.80	33.07	5	10/20
-0.29	-0.25	0.02	46.9	15	MC4	1	black	white	51.90	34.60	1.80	33.07	5	10/20
-0.30	-0.25	0.02	46.6	15	MC3	1	silver	glass	53.20	35.35	2.36	50.70	2	10/20
-0.30	-0.25	0.02	46.6	15	MC3	1	silver	glass	53.20	35.35	2.36	50.70	2	10/20
-0.29	-0.25	0.02	46.6	15	MC3	1	silver	glass	53.20	35.35	2.36	50.70	2	10/20
-0.34	-0.28	0.04	46.0	15	MC4	1	black	white	62.20	31.40	1.80	35.30	5	10/20
-0.34	-0.28	0.04	46.0	15	MC4	1	black	white	62.20	31.40	1.80	35.30	5	10/20
-0.34	-0.27	0.03	46.0	15	MC4	1	black	white	62.20	31.40	1.80	35.30	5	10/20
-0.49	-0.36	0.05	47.5	10	MC3	1	silver	white	62.01	32.52	1.81	35.30	1	10/25
-0.49	-0.36	0.05	47.5	10	MC3	1	silver	white	62.01	32.52	1.81	35.30	1	10/25
-0.47	-0.38	0.10	DNR	15	SolarLok	1	silver	white	66.39	39.12	2.00	42.25	1	10/20
-0.47	-0.38	0.10	DNR	15	SolarLok	1	silver	white	66.39	39.12	2.00	42.25	1	10/20
-0.47	-0.38	0.10	48.1	15	SolarLok	1	silver	white	66.39	39.12	2.00	42.25	1	10/20
-0.47	-0.38	0.10	47.1	15	SolarLok	1	silver	white	66.39	39.12	2.00	42.25	1	10/20
-0.47	-0.33	0.03	45.0	10	MC3	1	silver	glass	74.50	50.50	2.00	107.00	1	10/20
-0.47	-0.35	0.03	45.0	10	MC3	1	silver	glass	74.50	50.50	2.00	107.00	1	10/20
-0.47	-0.41	0.03	45.0	10	MC3	1	silver	glass	74.50	50.50	2.00	107.00	1	10/20
-0.47	-0.46	0.03	45.0	12	MC3	1	silver	glass	74.50	50.50	2.00	107.00	1	10/20
-0.47	-0.42	0.05	45.0	12	MC3	1	silver	glass	74.50	50.50	2.00	107.00	1	10/20
-0.47	-0.39	0.05	45.0	12	MC3	1	silver	glass	74.50	50.50	2.00	107.00	1	10/20
-0.47	-0.39	0.05	45.0	12	MC3	1	silver	glass	74.50	50.50	2.00	107.00	1	10/20
-0.45	-0.35	0.06	46.2	15	MC4	2	black	white	65.28	32.83	1.81	37.50	5	12/25
-0.45	-0.35	0.06	46.3	15	MC4	2	black	white	65.28	32.83	1.81	37.50	5	12/25
-0.45	-0.35	0.06	46.3	15	MC4	2	black	white	65.28	32.83	1.81	37.50	5	12/25
-0.45	-0.35	0.06	46.3	15	MC4	2	black	white	65.28	32.83	1.81	37.50	5	12/25
-0.50	-0.33	0.03	43.0	15	SolarLok	1	black	white	58.31	38.94	1.87	37.92	5	12/25
-0.50	-0.33	0.03	43.0	15	SolarLok	1	black	white	58.31	38.94	1.87	37.92	5	12/25
-0.37	-0.34	0.09	46.0	10	MC4	2	bronze	gray	84.72	49.29	3.66	108.03	5	12/25
-0.37	-0.34	0.09	46.0	10	MC4	2	bronze	gray	84.72	49.29	3.66	108.03	5	12/25
-0.37	-0.34	0.09	46.0	10	MC4	2	bronze	gray	84.72	49.29	3.66	108.03	5	12/25
-0.49	-0.36	0.05	47.5	15	MC4	1	black	black	45.87	38.98	1.81	23.10	1	10/25
-0.49	-0.36	0.05	47.5	15	MC4	1	black	black	45.87	38.98	1.81	23.10	1	10/25
-0.49	-0.36	0.05	47.5	15	terminal	1	silver	white	59.00	26.10	1.80	30.86	1	10/25
-0.49	-0.36	0.05	47.5	15	terminal	1	silver	white	59.00	26.10	1.80	30.86	1	10/25
-0.49	-0.36	0.05	47.5	15	MC4	1	black	black	45.87	38.98	1.81	31.96	1	10/25
-0.49	-0.36	0.05	47.5	10	MC4	1	silver	white	62.00	32.50	1.80	35.30	1	10/25
-0.49	-0.36	0.05	47.5	10	MC4	1	silver	white	62.00	32.50	1.80	35.30	1	10/25
-0.49	-0.36	0.05	47.5	15	MC4	1	black	white	52.30	39.10	2.30	36.40	1	10/25
-0.49	-0.36	0.05	47.5	15	MC4	1	black	white	58.70	39.10	2.30	39.60	1	10/25
-0.49	-0.36	0.05	47.5	15	MC4	1	silver	white	64.60	39.10	1.80	44.10	1	10/25
-0.49	-0.36	0.05	47.5	15	MC4	1	silver	white	64.60	39.10	1.80	44.10	1	10/25
-0.49	-0.36	0.05	47.5	15	MC4	1	silver	white	64.60	39.10	1.80	44.10	1	10/25

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2009 c-Si PV Module Specifications

Manufacturer	Model	Cell type	Rated power @ STC (W)	Rated power @ PTC (W)	Rated power tolerance (%)	Rated power per sq. ft. (W)	Module efficiency (%)	Cell efficiency (%)	Max. power voltage (Vmp)	Max. power current (Imp)	Open-circuit voltage (Voc)	Short-circuit current (Isc)
Sharp	ND-U216C1	poly	216	190.5	+10/-5	12.3	13.3	DNR	30.2	7.16	36.7	7.85
Sharp	ND-224UC1	poly	224	197.8	+10/-5	12.8	13.7	DNR	29.3	7.66	36.6	8.33
Sharp	ND-U224C1	poly	224	197.8	+10/-5	12.8	13.7	DNR	30.2	7.42	36.9	8.07
Sharp	ND-U230C1	poly	230	203.2	+10/-5	13.1	14.1	DNR	30.3	7.60	37.0	8.24
Siliken	SLK60P6L 205	poly	205	183.8	+/-5	11.7	12.6	14.0	28.7	7.15	36.4	7.90
Siliken	SLK60P6L 210	poly	210	188.4	+/-5	12.0	12.9	14.4	28.9	7.30	36.5	8.00
Siliken	SLK60P6L 215	poly	215	193.0	+/-5	12.3	13.2	14.7	29.0	7.41	36.6	8.02
Siliken	SLK60P6L 220	poly	220	197.6	+/-5	12.6	13.6	15.1	29.2	7.54	36.7	8.10
Siliken	SLK60P6L 225	poly	225	202.2	+/-5	12.9	13.9	15.4	29.3	7.68	36.8	8.20
Siliken	SLK60P6L 230	poly	230	206.8	+/-5	13.1	14.2	15.8	29.5	7.79	36.9	8.32
Siliken	SLK60P6L 235	poly	235	211.4	+/-5	13.4	14.5	16.1	29.5	7.97	36.9	8.35
Siliken	SLK60P6L 240	poly	240	216.1	+/-5	13.7	14.8	16.4	29.6	8.12	37.0	8.40
Solarfun [4]	160-24-M165	mono	165	145.2	+/-5	12.0	12.9	15.5	35.8	4.61	44.0	5.10
Solarfun	160-24-M165	mono	165	145.2	+/-5	12.0	12.9	15.5	35.8	4.61	44.0	5.10
Solarfun	160-24-M170	mono	170	149.8	+/-5	12.4	13.3	16.1	35.9	4.74	44.5	5.12
Solarfun	160-24-M170	mono	170	149.8	+/-5	12.4	13.3	16.1	35.9	4.74	44.5	5.12
Solarfun	190-27-M170	mono	170	149.1	+/-5	10.6	11.4	13.1	26.1	6.51	32.4	7.49
Solarfun	190-27-M170	mono	170	149.1	+/-5	10.6	11.4	13.1	26.1	6.51	32.4	7.49
Solarfun	160-24-M175	mono	175	154.3	+/-5	12.7	13.7	16.6	36.0	4.86	44.8	5.17
Solarfun	160-24-M175	mono	175	154.3	+/-5	12.7	13.7	16.6	36.0	4.86	44.8	5.17
Solarfun	190-27-M175	mono	175	153.6	+/-5	10.9	11.7	13.5	26.2	6.68	32.5	7.69
Solarfun	190-27-M175	mono	175	153.6	+/-5	10.9	11.7	13.5	26.2	6.68	32.5	7.69
Solarfun	160-24-M180	mono	180	158.9	+/-5	13.1	14.1	17.2	36.0	5.00	45.0	5.20
Solarfun	160-24-M180	mono	180	158.9	+/-5	13.1	14.1	17.2	36.0	5.00	45.0	5.20
Solarfun	190-27-M180	mono	180	158.2	+/-5	11.2	12.1	13.9	26.3	6.84	32.6	7.78
Solarfun	190-27-M180	mono	180	158.2	+/-5	11.2	12.1	13.9	26.3	6.84	32.6	7.78
Solarfun	190-27-M200	mono	200	176.2	+/-5	12.4	13.4	15.5	26.7	7.49	33.0	8.19
Solarfun	190-27-M200	mono	200	176.2	+/-5	12.4	13.4	15.5	26.7	7.49	33.0	8.19
Solarfun	190-27-P200	poly	200	178.8	+/-5	12.4	13.4	15.4	26.9	7.44	32.8	8.24
Solarfun	190-27-P200	poly	200	178.8	+/-5	12.4	13.4	15.4	26.9	7.44	32.8	8.24
Solarfun	190-27-M205	mono	205	180.8	+/-5	12.8	13.7	15.9	26.8	7.65	33.1	8.26
Solarfun	190-27-M205	mono	205	180.8	+/-5	12.8	13.7	15.9	26.8	7.65	33.1	8.26
Solarfun	190-27-P205	poly	205	183.3	+/-5	12.8	13.7	15.8	27.0	7.60	32.9	8.35
Solarfun	190-27-P205	poly	205	183.3	+/-5	12.8	13.7	15.8	27.0	7.60	32.9	8.35
Solarfun	190-27-M210	mono	210	185.3	+/-5	13.1	14.1	16.3	26.9	7.81	33.2	8.32
Solarfun	190-27-M210	mono	210	185.3	+/-5	13.1	14.1	16.3	26.9	7.81	33.2	8.32
Solarfun	190-27-P210	poly	210	187.9	+/-5	13.1	14.0	16.2	27.1	7.75	33.0	8.48
Solarfun	190-27-P210	poly	210	187.9	+/-5	13.1	14.0	16.2	27.1	7.75	33.0	8.48
SolarWorld	SW 155	mono	155	138.2	+/-3	11.0	11.9	DNR	34.8	4.46	43.6	4.90
SolarWorld	SW 165	mono	165	147.3	+/-3	11.8	12.7	DNR	35.3	4.68	44.0	5.10
SolarWorld	SW 175	mono	175	156.6	+/-3	12.5	13.4	DNR	35.8	4.89	44.4	5.30
SunPower	SPR-210-BLK	mono	210	193.7	+/-5	15.7	16.9	21.0	40.0	5.25	47.7	5.75
SunPower	SPR-215-WHT	mono	215	198.5	+/-5	16.1	17.3	21.0	39.8	5.40	48.3	5.80
SunPower	SPR-225-BLK	mono	225	207.1	+/-5	16.8	18.1	22.4	41.0	5.49	48.5	5.87
SunPower	SPR-230-WHT	mono	230	213.5	+/-5	17.2	18.5	22.4	41.0	5.61	48.7	5.99
SunPower	SPR-305-WHT	mono	305	282.1	+/-5	17.4	18.7	22.4	54.7	5.58	64.2	5.96
Suntech	STP170S-24/Ab-1	mono	170	150.0	+/-3	12.4	13.3	15.9	35.2	4.83	43.8	5.14
Suntech	STP175S-24/Ab-1	mono	175	154.5	+/-3	12.7	13.7	16.4	35.2	4.95	44.2	5.20
Suntech	STP180S-24/Ab-1	mono	180	159.1	+/-3	13.1	14.1	16.8	35.6	5.05	44.4	5.40
Suntech	STP190-18/Ub-1	poly	190	170.6	+/-3	12.0	12.9	14.5	26.0	7.31	33.0	7.89
Suntech	STP200-18/Ub-1	poly	200	179.8	+/-3	12.6	13.6	15.2	26.2	7.63	33.4	8.12
Suntech	STP210-18/Ub-1	poly	210	189.0	+/-3	13.3	14.3	16.0	26.4	7.95	33.6	8.33
Suntech	STP260-24/Vb-1	poly	260	233.6	+/-3	12.4	13.4	15.1	34.8	7.47	44.0	8.09

[4] Solarfun modules available via Schüco DNR = Did Not Report

Pmp temp. coefficientt (%/°C)	Voc temp. coefficient (%/°C)	Isc temp. coefficient (%/ºC)	Nominal operating cell temp. (°C)	Series fuse rating (A)	Connector type	# of J-boxes	Frame color	Backsheet color	Length (in.)	Width (in.)	Depth (in.)	Weight (lbs.)	Materials warranty (yrs.)	Power warranty (yrs.) 90%/80%
-0.49	-0.36	0.05	47.5	15	MC4	1	silver	white	64.60	39.10	1.80	44.10	1	10/25
-0.49	-0.36	0.05	47.5	15	MC4	1	silver	white	64.60	39.10	1.80	44.10	1	10/25
-0.49	-0.36	0.05	47.5	15	MC4	1	silver	white	64.60	39.10	1.80	44.10	1	10/25
-0.49	-0.36	0.05	47.5	15	MC4	1	silver	white	64.60	39.10	1.80	44.00	1	10/25
-0.43	-0.35	0.04	46.0	15	MC3	1	silver	white	64.60	39.00	1.57	41.90	5	10/25
-0.43	-0.35	0.04	46.0	15	MC3	1	silver	white	64.60	39.00	1.57	41.90	5	10/25
-0.43	-0.35	0.04	46.0	15	MC3	1	silver	white	64.60	39.00	1.57	41.90	5	10/25
-0.43	-0.35	0.04	46.0	15	MC3	1	silver	white	64.60	39.00	1.57	41.90	5	10/25
-0.43	-0.35	0.04	46.0	15	MC3	1	silver	white	64.60	39.00	1.57	41.90	5	10/25
-0.43	-0.35	0.04	46.0	15	MC3	1	silver	white	64.60	39.00	1.57	41.90	5	10/25
-0.43	-0.35	0.04	46.0	15	MC3	1	silver	white	64.60	39.00	1.57	41.90	5	10/25
-0.43	-0.35	0.04	46.0	15	MC3	1	silver	white	64.60	39.00	1.57	41.90	5	10/25
-0.40	-0.38	0.04	45 +/-3	8	MC4	1	silver	white	62.20	31.80	1.77	33.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	8	MC4	1	black	black	62.20	31.80	1.80	33.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	8	MC4	1	silver	white	62.20	31.80	1.77	33.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	8	MC4	1	black	black	62.20	31.80	1.80	33.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	silver	white	58.80	39.37	1.77	39.60	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	black	black	58.80	39.37	1.77	40.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	8	MC4	1	silver	white	62.20	31.80	1.77	33.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	8	MC4	1	black	black	62.20	31.80	1.80	33.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	silver	white	58.80	39.37	1.77	39.60	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	black	black	58.80	39.37	1.77	40.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	8	MC4	1	silver	white	62.20	31.80	1.77	33.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	8	MC4	1	black	black	62.20	31.80	1.80	33.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	silver	white	58.80	39.37	1.77	39.60	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	black	black	58.80	39.37	1.77	40.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	silver	white	58.80	39.37	1.77	39.60	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	black	black	58.80	39.37	1.77	40.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	silver	white	58.80	39.37	1.77	39.60	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	black	black	58.80	39.37	1.77	40.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	silver	white	58.80	39.37	1.77	39.60	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	black	black	58.80	39.37	1.77	40.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	silver	white	58.80	39.37	1.77	39.60	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	black	black	58.80	39.37	1.77	40.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	silver	white	58.80	39.37	1.77	39.60	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	black	black	58.80	39.37	1.77	40.00	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	silver	white	58.80	39.37	1.77	39.60	3	10/25
-0.40	-0.38	0.04	45 +/-3	12	MC4	1	black	black	58.80	39.37	1.77	40.00	3	10/25
-0.47	-0.33	0.04	46.0	15	MC4	1	silver	white	63.39	31.89	1.34	33.00	2	10/25
-0.47	-0.33	0.04	46.0	15	MC4	1	silver	white	63.39	31.89	1.34	33.00	2	10/25
-0.47	-0.33	0.04	46.0	15	MC4	1	silver	white	63.39	31.89	1.34	33.00	2	10/25
-0.38	-0.29	0.06	50.5	15	MC4	1	black	black	61.39	31.42	1.81	33.10	10	12/25
-0.38	-0.28	0.06	50.5	15	MC4	1	black	white	61.39	31.42	1.81	33.10	10	12/25
-0.38	-0.27	0.06	50.5	20	MC4	1	black	black	61.39	31.42	1.81	33.10	10	12/25
-0.38	-0.27	0.06	50.5	20	MC4	1	black	white	61.39	31.42	1.81	33.10	10	12/25
-0.38	-0.28	0.06	50.5	15	MC4	1	black	white	61.39	41.18	1.81	52.80	10	12/25
-0.48	-0.34	0.04	45.0	15	MC4	1	silver	white	62.20	31.80	1.38	34.17	5	12/25
-0.48	-0.34	0.04	45.0	15	MC4	1	silver	white	62.20	31.80	1.38	34.17	5	12/25
-0.48	-0.34	0.04	45.0	15	MC4	1	silver	white	62.20	31.80	1.38	34.17	5	12/25
-0.47	-0.34	0.05	45.0	20	MC4	1	silver	white	58.30	39.10	1.38	37.04	5	12/25
-0.47	-0.34	0.05	45.0	20	MC4	1	silver	white	58.30	39.10	1.38	37.04	5	12/25
-0.47	-0.34	0.05	45.0	20	MC4	1	silver	white	58.30	39.10	1.38	37.04	5	12/25
-0.47	-0.34	0.05	45.0	20	MC4	1	silver	white	77.00	39.10	2.00	59.50	5	12/25

TABLE CONTINUED ON NEXT PAGE

2009 c-Si PV Module Specifications

Manufacturer	Model	Cell type	Rated power @ STC (W)	Rated power @ PTC (W)	Rated power tolerance (%)	Rated power per sq. ft. (W)	Module efficiency (%)	Cell efficiency (%)	Max. power voltage (Vmp)	Max. power current (Imp)	Open-circuit voltage (Voc)	Short-circuit current (Isc)
Suntech	STP270-24/Vb-1	poly	270	242.8	+/-3	12.9	13.9	15.7	35.0	7.71	44.5	8.12
Suntech	STP280-24/Vb-1	poly	280	252.0	+/-3	13.4	14.4	16.3	35.2	7.95	44.8	8.33
Sunwize	SW170	mono	170	148.9	+/-5	12.4	13.3	DNR	36.3	4.69	43.9	5.15
Sunwize	SW175	mono	175	153.4	+/-5	12.7	13.7	DNR	36.5	4.80	43.9	5.20
Sunwize	SW180	mono	180	157.9	+/-5	13.1	14.1	DNR	36.6	4.92	44.0	5.30
Trina	165-DC01	mono	165	DNR	+/-3	12.0	12.9	15.4	35.6	4.65	43.2	5.20
Trina	170-DC01	mono	170	DNR	+/-3	12.3	13.3	15.9	35.8	4.76	43.6	5.25
Trina	175-DC01	mono	175	DNR	+/-3	12.7	13.7	16.4	36.2	4.85	43.9	5.30
Trina	180-DC01	mono	180	DNR	+/-3	13.1	14.1	16.8	36.8	4.90	44.2	5.35
XC3	XC1300-130	poly	130	DNR	+/-5	12.5	13.4	DNR	17.8	7.38	22.3	7.79
XC3	XC2300-220	poly	220	DNR	+/-3	12.7	13.7	DNR	30.2	7.32	36.9	7.85
Yingli	YL175Wp	poly	175	157.2	+/-3	12.3	13.2	15.0	23.5	7.60	29.5	8.20

DNR = Did Not Report

he notes, "are going to test specialized grounding devices in a manner that will ensure safe, durable grounding for 50 years. As a result, UL has a team that is working on testing requirements that may appear in UL Standard 1703/61730. These testing requirements will allow these devices to be tested against a worst case generic module frame and then be listed as UL 1703/61730 PV module grounding devices."

This process is good news for PV installers. As UL standards for grounding modules are clarified and expanded, more equipment that is specifically identified and listed for this use will enter the market. As these products become available, module manufacturers will no doubt revise their installation manuals to reflect these approved grounding methods. Many of these methods hold the promise of significant time and material savings in the field, while still ensuring a long lasting equipment grounding connection.

AVOIDING COMMON MISTAKES

While module instructions are short on some details, they do provide insight into the most common installation errors. Every module manufacturers' instructions mention, for example, that PV modules are not to be stored face down. Yet I observed this situation when touring a PV system being installed at a college in New Jersey by union electricians. Uncrated modules were spread across the flat roof, stacked in short piles on the fringes of the array area. Unfortunately, these modules were stacked face down. Rain had pooled inside the module frames, and this condition was allowed to persist. Many modules suffered water infiltration and had to be replaced as a result.

When a module is damaged due to improper handling during installation, the only recourse is to learn from the mistake and take steps to see that it does not happen again. But an even better approach is to learn from the mistakes of others and avoid making them yourself. Attending trainings is one way to do this; reading is another. Installation instructions from Sharp, for example, provide tips on avoiding hot spots on modules, the result of localized, persistent shading. This condition can permanently damage modules by causing solder joints to peel off.

New installers in areas of the country that see significant snow accumulation will appreciate an item found in the

Warranty claim? It is hard to imagine a power generation technology with better reliability than c-Si PV modules, but manufacturing defects do happen. In order for manufacturers to honor their product warranties, integrators need to ensure that their installation practices do not violate, or appear to violate, installation instructions.

Courtesy nmsu.edu/~tdi/

Pmp temp. coefficientt (%/°C)	Voc temp. coefficient (%/°C)	Isc temp. coefficient (%/°C)	Nominal operating cell temp. (°C)	Series fuse rating (A)	Connector type	# of J-boxes	Frame color	Backsheet color	Length (in.)	Width (in.)	Depth (in.)	Weight (lbs.)	Materials warranty (yrs.)	Power warranty (yrs.) 90%/80%
-0.47	-0.34	0.05	45.0	20	MC4	1	silver	white	77.00	39.10	2.00	59.50	5	12/25
-0.47	-0.34	0.05	45.0	20	MC4	1	silver	white	77.00	39.10	2.00	59.50	5	12/25
-0.34	-0.37	0.09	49.0	12	MC3	1	silver	white	62.20	31.81	1.65	37.50	2	10/25
-0.34	-0.37	0.09	49.0	12	MC3	1	silver	white	62.20	31.81	1.65	37.50	2	10/25
-0.34	-0.37	0.09	49.0	12	MC3	1	silver	white	62.20	31.81	1.65	37.50	2	10/25
-0.45	-0.35	0.05	47.0	7	MC4	1	silver	white	62.24	31.85	1.57	34.39	5	10/25
-0.45	-0.35	0.05	47.0	7	MC4	1	silver	white	62.24	31.85	1.57	34.39	5	10/25
-0.45	-0.35	0.05	47.0	7	MC4	1	silver	white	62.24	31.85	1.57	34.39	5	10/25
-0.45	-0.35	0.05	47.0	7	MC4	1	silver	white	62.24	31.85	1.57	34.39	5	10/25
-0.51	DNR	DNR	50.6	10	terminal	1	silver	DNR	57.80	26.00	1.50	26.00	5	25
-0.51	DNR	DNR	50.6	10	MC3	1	silver	DNR	64.00	39.00	1.50	53.60	5	25
-0.45	-0.37	0.06	46.0	15	MC3	1	silver	white	52.56	38.98	1.97	34.60	2	10/25

Photovoltaic Module Installation Instructions from GE Energy. The problem addressed is that module frame failures occur at higher rates in those parts of the country where snowfall is greatest. As snow sloughs off the roof, it can separate the bottom edge of the module frame from the glass. In some cases, failure is catastrophic. It is also easily avoided. In order to resist the drag forces exerted by the slowly sliding snow, simply run rails parallel with the roof slope and install the modules in landscape orientation. When the modules are clamped in place, the bottom of the frame is supported in a manner that resists the snow's drag forces.

The most common PV module failures are undoubtedly those resulting from shipping and handling mishaps. Collapsed pallets, torn boxes and forklift prints are all red flags, often signaling bent, twisted frames or broken glass. While some shipping damage is readily apparent, it can also be hidden, even invisible to the naked eye. Certain out-of-the-box failures are traceable to shipping damage, especially problems involving the bottom module on a pallet. When damage occurs during shipping, your distribution or manufacturing partner should replace the product at no charge.

It is problematic when hidden shipping damage is discovered months later, outside the time limit within which the trucking company will accept damage claims. Though a module may appear physically intact, its electrical characteristics may tell another story. The best practice for installers, when feasible, is to test each module's Voc and Isc as it comes out of the box. Record these measurements and look for obvious outliers. Measurements will vary according to ambient conditions, but it is possible to detect a failed module before it is installed.

Careful handling and good installation practices will also limit product loss on projects. Never lean modules in a position where the wind can topple them over, for example. Never cut factory installed wire whips. Use common sense and good judgment to protect your investment.

MODULE RELIABILITY

When c-Si PV modules are properly manufactured and used, failures are exceedingly rare, in part because the technology is so well understood. Paul Wormser, senior director of product development for Sharp Solar, is confident in the technology: "The reliability issues that the industry faced in the early days of terrestrial photovoltaics have largely been eliminated by the experienced producers. In addition to the test protocols that are shared across the industry, we conduct a highly rigorous quality assurance and quality control program, including extensive product and materials testing."

While module failures are uncommon, they do happen. Failures may include delamination, burnt bypass diodes, frame sealant failure and wire whips without continuity. "The purpose of IEC qualification testing," explains Brooks, "is to identify weaknesses in product design by applying a series of tests that stress specific failure modes. Modules that do not receive these qualification tests should be expected to experience a variety of solder joint and busbar failures, and cell and glass breakage, just to name a few."

Precisely because c-Si PV modules are expected to last for decades, maintaining product warranties in the field is critical. It is sometimes difficult to distinguish a manufacturing or material failure from an installation error or the effects of an "act of God." For this reason, PV system installations need to be beyond reproach. The last thing that a growing installation company needs is to find itself at the wrong end of a warranty dispute with a major module manufacturer,

especially on a high profile or very large project.

"Keep in mind that every major manufacturer who has a decade or more of manufacturing experience has had module manufacturing defects," Brooks warns. "We will experience major product malfunctions over the next few years. Some of these problems will be covered by the manufacturers, while others will take the manufacturers and those integrators who gambled on the products into bankruptcy."

Courtesy multi-contact-usa.com

Evolving safety standards Next generation, locking PV output circuit connectors, like the MC4 connectors pictured here, were used in Europe for years before *Code* changes made them commonplace in North America.

PRODUCT EVOLUTION

While the c-Si PV modules available today resemble the products that were available 30 years ago in substantial ways, they are also vastly improved. The forces driving these improvements include end-user expectations, the needs of installers, performance requirements, competitive market conditions and evolving safety standards.

***Code* driven changes.** Listed PV Wire output conductors for modules and locking module connectors are a couple of recent product changes resulting from revisions to the *National Electrical Code*. Other *Code* changes, while not altering products per se, have affected the way that PV systems are designed and installed.

Looking forward to the 2011 *NEC,* UL is currently reviewing dc arc-fault protection for PV systems. This is in response to module failures noted in Europe. As modules age, internal faults and open circuits occur. Wiles notes, "A small crack in the foil conductor is an easy place for an arc to start when driven by open-circuit voltages approaching 600 Vdc." The concern, of course, is that arcing faults can cause fires.

Arc-fault circuit interrupter (AFCI) protection is already required for certain circuits in dwellings, according to *NEC* Article 210.12(B). But these AFCI devices are designed for 120 Vac circuits, and incorporating arc-fault protection in PV systems will require a new class of dc arc-fault equipment. According to Wiles, "UL and others are getting a handle on dc series arc-fault signature. If and when this signature can be defined and modeled, it will be used to design a recognition circuit. This could be used to open a faulted circuit or shut down the inverter. No load current, no series arc fault."

This may prove a daunting task to complete in time for the next *Code* cycle. As Brooks observes, "Although having these new devices will improve system safety, it is currently unclear whether significant enough progress can be made on the technology side to justify adding the requirement in the 2011 *NEC*. But clearly arc-fault detection is coming down the road, so our industry needs to work on low cost solutions that can provide this improved safety feature."

One *Code* change that Brooks does expect to see in 2011 is better temperature information for designing PV arrays and sizing system conductors. This includes defining the lowest expected ambient temperature as the ASHRAE mean extreme minimum annual drybulb temperature. "Tables of these values will be available shortly," according to Brooks, "at the Solar America Board for Codes and Standards Web site."

Market driven changes. Expect demand for c-Si PV products to remain highest in rooftop applications. Product trends already underway are likely to continue. Look for more all-black modules for aesthetically sensitive residential applications. The trend toward higher capacity and larger format modules will undoubtedly continue. Designers and installers can also look forward to more module manufacturers releasing proprietary racking systems that feature integrated grounding. Many of these systems currently allow for rail-to-rail grounding, and single-point grounding may be a reality in the future. "We may even see more frameless or plastic frame modules," Gleason hypothesizes, "especially if grounding requirements become too onerous." Perhaps one day installers in North America will even have access to modules that are UL listed for 1,000 Vdc, effectively lowering installed costs while increasing system performance. ⏚

Thanks to all the interviewees for their time and expertise, and to Doug Puffer and Joe Schwartz for compiling table specifications..

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