

# 2010 PV Module Guide



by Justine Sanchez

Photo [www.topherdonahue.com](http://www.topherdonahue.com)

These are exciting times for the PV module market—due to political and economic forces at work, the PV industry is on the move and changing at a rapid clip, and new products are being added regularly.

Our previous buyer's guides have focused on module specifications, and have given detailed information on how to apply the data to the design process. This guide focuses on the criteria used to select the modules included in the table, along with residential PV price trends, specifications definitions, and general advice to PV module shoppers.

## PV Module Criteria

Only crystalline modules 100 watts or larger and 60 watts and larger for thin-film are included in this guide. They also meet the following criteria:

- Listed on the California Energy Commission's (CEC) SB1 guidelines-compliant module list, as of October 1, 2009
- Manufacturers must have U.S.-based sales offices
- Available to the residential and small commercial market; in stock and ready to ship

**CEC SB1 guidelines-compliant module list**—As of July 1, 2009, the CEC provides incentives only for modules that have been independently tested and are listed on the SB1 guidelines-compliant module list hosted by the Go Solar California Web site (see Access). Prior lists of modules eligible for incentives in California only had to be in compliance with Underwriters Laboratories (UL) 1703—a safety standard that doesn't reflect module performance.

Under the CEC guidelines, incentive-eligible modules must report the following performance parameters, as verified by an independent testing agency:

- Maximum power
- Temperature coefficients
- Nominal operating cell temperature (NOCT)
- Performance at STC and NOCT
- Performance at low irradiance (200 W/m<sup>2</sup>).

## PTC Ratings

Based on a higher cell temperature (about 25 to 30°C higher) than STC (standard test conditions), PTC (PVUSA test conditions) testing provides a more realistic module output value than STC. The higher cell temperature (which is based on NOCT) is used with the maximum power temperature coefficient to calculate the PTC rating.

Before July 1, 2009, NOCT and maximum power temperature coefficients were simply unverified values supplied by PV module manufacturers. Now, independent testing agencies verify these values—a big improvement to the PV industry and better yardstick for predicting actual performance. Another testament to the need for third-party verification? About 65% of the initial 475 modules relisted on the CEC-eligible module list were found to have up to 6.3% overrated PTC ratings prior to testing under the new requirement.

The test laboratory must be affiliated with the International Laboratory Accreditation Cooperation (ILAC), which includes CSA, Intertek (ETL), TUV Rhineland of North America, and UL, but also includes other testing facilities around the world. Once these parameters are tested and reported, module PTC ratings (see “PTC Ratings” sidebar) can be calculated and used to determine California’s incentive amount.

Independent testing has been required in Europe for many years, but before July 2009, no U.S. incentive programs required this testing. As a result, the likelihood of underperforming PV modules entering the U.S. was high. Now that the CEC requires testing for its PV incentive programs, it is expected that other programs in the United States will follow suit.

Modules that have been independently verified are thought to carry a vote of confidence from their manufacturer, since they’ve spent the extra time and money for the verification process. More PV modules are added to this list regularly. For an up-to-date list, visit the Go Solar California Web site.

**U.S.-based sales offices.** An increasing number of international companies are supplying the U.S. PV market, and some of their modules appear on the CEC list. However, not all of these companies have offices located stateside. End users and installers should have ready access to customer support, so we have included only those PV manufacturers that have offices in the United States.

#### Product in stock and available to the residential PV market.

To be included in the guide, module suppliers have stated that they will have these products in stock and ready to ship by the magazine’s issue date (December 2009).

And, since *Home Power* is focused on home-scale subjects, our final criterion is that modules are available to the residential and small-commercial market.

## The Specs

All module specifications in the table were provided by the manufacturers.

### Cell type

The type of silicon cell, based on the cell manufacturing process. Amorphous silicon (a-Si) arrays require nearly twice as much area to produce an equal amount of power as crystalline modules. On the flip side, amorphous modules can offer better high-temperature performance (see the “Maximum Power Temperature Coefficient” specification).

### Rated power at STC (W)

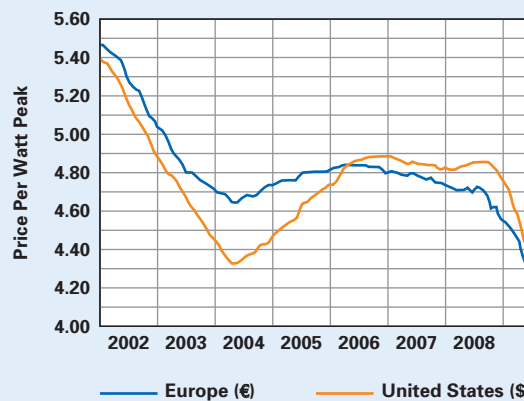
The module power rating at standard test conditions (STC)—1,000 watts per square meter solar irradiance, 25°C (77°F) cell temperature. Because module output is dependent on environmental conditions, modules are tested at STC so they can be compared and rated on a level playing field. Actual power output in the field will vary as available sunlight and module temperature fluctuate.

## Dropping Module Prices

PV market growth and module-supply limitations of previous years sparked a huge module production ramp up in 2008. However, this increase in module supply then collided with the economic downturn—which means less money available and lower PV sales. The result was lower price per watt as manufacturers try to unload surplus stock.

Module prices are not listed in the table, since that price varies depending on distributor and quantity. However, we have included information from Solarbuzz’s online retail price per watt survey, which shows the average retail module price dropping from \$5.40 per watt in 2001 to the current average retail price of \$4.40 (September 2009). While this graph shows the *average* retail values from the survey, a quick Internet search revealed that modules can be easily found for lower prices. (The lowest price we found was about \$3 per watt for unblemished, listed modules.) This price drop, along with local, state, and federal incentive programs for PV systems, means that it’s an excellent time to buy. (For more information, see the solar incentives article in this issue.) Also remember that price is only one criterion of concern to module shoppers—also consider warranty terms, customer service, and company longevity and reputation.

### PV Module Retail Price Index



Data courtesy www.solarbuzz.com

### Rated power at PTC (W)

The module power rating at PVUSA test conditions (PTC)—1,000 watts per square meter solar irradiance, 20°C (68°F) ambient temperature, and wind speed of 1 meter per second at 10 meters above ground level. This rating translates into a much higher—and more realistic—module operating temperature and is used in some incentive programs to calculate incentive amounts (see “PTC Ratings” sidebar).

(continued on page 60)

Manufacturer	Model	Cell Type	Power @ STC (W)	Power @ PTC (W)	Power Tolerance (%)	Power Per Sq. Ft. (W)	Module Efficiency (%)	Max. Power Voltage (Vmp)	Max. Power Current (Imp)
<b>Aleo Solar</b> www.aleo-solar.com	S_16 165	Poly	165	146.1	+/-3	11.1	12.0	23.2	7.11
	S_16 170		170	150.6		11.5	12.3	23.4	7.26
	S_16 175		175	155.2		11.8	12.7	23.6	7.41
	S_16 180		180	159.7		12.1	13.1	23.8	7.55
	S_16 185		185	164.3		12.5	13.4	24.0	7.70
	S_18 210		210	186.2		11.9	12.8	28.4	7.41
	S_18 215		215	190.8		12.2	13.1	28.6	7.53
	S_18 220		220	195.3		12.4	13.4	28.7	7.65
	S_18 225		225	199.9		12.7	13.7	28.9	7.78
	S_18 230		230	204.5		13.0	14.0	29.1	7.90

<b>BP Solar</b> www.bpsolar.us	BP 4175T	Mono	175	157.2	+5/-3	13.0	14.0	35.4	4.94
	BP 175B	Poly	175	157.3	+/-5	12.9	13.9	35.8	4.90
	BP 175I		175	157.3		12.4	13.3	35.8	4.90
	BP 4180T	Mono	180	161.8	+5/-3	13.3	14.4	35.8	5.03
	BP 3180T	Poly	180	161.8		13.3	14.4	35.6	5.00
	BP3220T		220	193.1		12.3	13.2	28.9	7.60
	BP3220B		220	193.1		12.3	13.2	28.9	7.60
	BP3225T		225	197.7		12.5	13.5	29.1	7.70
BP3230T	230		202.2	12.8		13.8	29.1	7.90	

<b>Canadian Solar</b> www.csisolar.com	CS6A-150PE	Poly	150	132.6	+/-3.3	10.7	DNR (Did Not Report)	23.1	6.50
	CS5A-160M	Mono	160	145.4	+/-3.1	11.6		34.9	4.58
	CS6A-160P	Poly	160	139.6		11.4		23.1	6.92
	CS6A-160PE		160	141.7		11.4		23.1	6.92
	CS5A-170M	Mono	170	154.7	+/-2.9	12.4		35.5	4.79
	CS6A-170P	Poly	170	148.6		12.1		23.2	7.33
	CS6P-170PE		170	150.0	9.8	28.7		5.93	
	CS5A-180M	Mono	180	164.0	+/-2.8	13.1		36.1	4.99
	CS6A-180P	Poly	180	157.6		12.9		23.6	7.62
	CS6P-180PE		180	159.0		10.4		28.7	6.26
	CS6P-190PE		190	168.1	+/-2.6	11.0		28.8	6.60
	CS6P-200P		200	172.8	+/-2.5	11.6		28.9	6.93
	CS6P-200PE		200	177.1		11.6		28.9	6.93
	CS6P-210P		210	181.7	+/-2.4	12.1		28.9	7.26
	CS5P-220M	Mono	220	201.5	+/-2.3	12.0		46.9	4.69
	CS6P-220P	Poly	220	190.7		12.7		29.3	7.52
	CS5P-230M	Mono	230	210.9	+/-2.2	12.6		47.5	4.84
CS6P-230P	Poly	230	199.6	13.3		29.8	7.71		
CS5P-240M	Mono	240	220.4	+/-2.1	13.1	48.1	4.99		

<b>Day4 Energy</b> www.day4energy.com	Day4 48MC 160	Poly	160	143.3	+/-3.5	11.5	12.4	22.6	7.08
	Day4 48MC 165		165	147.9		11.8	12.7	23.0	7.19
	Day4 48MC 170		170	152.5		12.2	13.1	23.0	7.38
	Day4 48MC 175		175	157.1		12.6	13.5	23.4	7.48
	Day4 48MC 180		180	161.7		12.9	13.9	23.7	7.60
	Day4 48MC 185		185	166.3		13.3	14.3	23.8	7.77
	Day4 48MC 190		190	170.9		13.6	14.7	24.0	7.92

<b>ET Solar</b> www.etsolar.com	ET-M572165	Mono	165	146.5	+3/-1	12.0	12.9	35.8	4.60
	ET-M572170		170	151.1		12.4	13.3	36.1	4.71
	ET-M572175		175	155.7		12.7	13.7	36.2	4.83
	ET-M572180	+/-3	180	157.7	13.1	14.1	36.3	4.95	
	ET-M572185		185	162.2	13.5	14.5	36.3	5.09	
	ET-P654190		190	167.9	12.0	12.9	26.8	7.10	
	ET-P654195	Poly	195	172.4	+3/-1	12.3	13.3	27.0	7.22
	ET-P654200		200	176.9		12.6	13.6	27.2	7.36
	ET-P654205		205	181.5		13.0	13.9	27.3	7.50
	ET-P654210		210	186.1	+/-3	13.3	14.3	27.5	7.63
	ET-P672255		255	226.6	+3/-1	12.2	12.1	35.2	7.23
	ET-P672260		260	231.2		12.4	13.4	36.0	7.23
	ET-P672265	265	235.8	12.7		13.7	36.4	7.28	
	ET-P672270	270	237.2	12.9		13.9	36.4	7.42	
	ET-P672275	275	241.7	13.2		14.2	36.7	7.49	
ET-P672280	280	246.3	+/-3	13.4		14.4	36.7	7.63	

Open-Circuit Voltage (Voc)	Short-Circuit Current (Isc)	Pmp Temp. Coeff. (%/°C)	Voc Temp. Coeff. (%/°C)	Isc Temp. Coeff. (%/°C)	Nominal Operating Cell Temp. (°C)	Series Fuse Rating (A)	Connector Type	Frame Color	Back-Sheet Color	Length (In.)	Width (In.)	Depth (In.)	Weight (Lbs.)	Materials Warranty (Yrs.)	Power Warranty (Yrs.) 90%/80%
29.6	7.69	-0.48	-0.34	0.04	48	15	Tyco	Silver	White	65.35	32.68	1.97	37.50	10	10/25
29.8	7.82														
30.0	7.95														
30.2	8.07														
30.4	8.20														
35.9	8.03	-0.46	-0.34	0.04	48	15	Tyco	Silver	White	65.35	38.98	1.97	46.30	10	10/25
36.1	8.13														
36.3	8.24														
36.4	8.34														
36.6	8.44														

43.6	5.45	-0.50	-0.36	0.07	47	20	MC4	Silver	White	62.48	31.10	1.97	33.95	5	12/25
43.6	5.47					15	MC3	Black	Grey	62.72	31.10				
43.6	5.47								Grey	62.48	32.61				
43.6	5.58									62.48	31.10				
43.6	5.40									62.48	31.10				
36.6	8.20														
36.6	8.20														
36.6	8.30														
36.6	8.30														
36.7	8.40														

28.8	7.12	-0.42	-0.35	0.08	45	15	MC4	Silver	White	52.13	38.66	1.57	35.27	6	10/25									
43.6	4.97	-0.45														0.06	10	62.80	31.54	34.17				
28.9	7.51	-0.42														0.08	15	52.13	38.66	35.27				
28.9	7.51	-0.42														0.08	10	52.13	38.66	35.27				
44.1	5.19	-0.45														0.06	10	62.80	31.54	34.17				
29.2	7.85	-0.45														0.06	15	52.13	38.66	35.27				
35.8	6.62	-0.42														0.08	15	64.49	38.66	44.09				
44.5	5.40	-0.45														0.06	10	62.80	31.54	34.17				
29.4	8.20	-0.45														0.06	15	52.13	38.66	35.27				
35.9	6.98	-0.42														0.08	15	64.49	38.66	1.57	44.09			
36.0	7.33	-0.42														0.08								
36.2	7.68	-0.45														0.06								
36.2	7.68	-0.42														0.08								
36.4	7.91	-0.45														0.06						10	63.07	41.77
58.4	5.10																					15	64.49	38.66
36.6	8.09																					10	63.07	41.77
58.8	5.25																					15	64.49	38.66
36.8	8.34																					10	63.07	41.77
59.3	5.40																							

28.3	7.70	-0.44	-0.33	0.03	47	15	Tyco	Silver	White	51.46	39.01	1.38	38.28	5	10/25
28.6	7.80														
28.8	7.90														
29.2	8.05														
29.4	8.10														
29.5	8.20														
29.7	8.30														

44.1	5.19	-0.47	-0.40	0.06	44	10				62.20	31.81	1.97	34.20		
44.2	5.30														
44.3	5.50														
44.6	5.61														
44.6	5.80	-0.46	-0.35	0.07	45	12	MC4	Silver	White	58.35	39.06	1.97	39.30	5	12/25
32.5	7.72														
32.8	7.98														
32.7	7.86														
32.8	8.10														
32.8	8.30														
43.9	7.85														
43.5	7.79														
43.6	7.90														
43.6	7.90														
43.8	7.96														
43.8	7.98														



Manufacturer	Model	Cell Type	Power @ STC (W)	Power @ PTC (W)	Power Tolerance (%)	Power Per Sq. Ft. (W)	Module Efficiency (%)	Max. Power Voltage (Vmp)	Max. Power Current (Imp)
<b>Evergreen Solar</b> www.evergreensolar.com	ES-C-110-fa2	Ribbon	110	99.1	+5/-5	9.9	10.6	16.8	6.57
	ES-C-115-fa4		115	103.7		10.3	11.1	17.9	6.42
	ES-C-120-fa2		120	108.3		10.8	11.6	17.3	6.95
	ES-C-125-fa4		125	112.9		11.2	12.1	18.4	6.81
	ES-B-180-fa1/fb1		180	154.6	+3.4/-2	11.2	12.0	17.1	10.53
	ES-B-190-fa1/fb1		190	163.4	+2.6/-2	11.8	12.7	17.4	10.92
	ES-B-195-fa1/fb1		195	167.9	+2.6/-0	12.1	13.1	17.6	11.08
	ES-A-200-fa3		200	180.7	+2.5/-0	11.8	12.7	18.1	11.05
	ES-A-205-fa3		205	185.4	+2.4/-0	12.1	13.1	18.2	11.27
	ES-A-210-fa3		210	190.0		12.4	13.4	18.3	11.48
<b>GE Energy</b> www.gepower.com	GEPVp-200-M	Poly	200	173.1	+/-5	12.8	13.9	26.3	7.60
	GEPVp-205-M		205	177.6		13.1	14.2	27.2	7.60
<b>Kaneka</b> www.pv.kaneka.co.jp	G-SA060	a-Si	60	57	+10/-5	5.9	6.3	67	0.9
<b>Kyocera</b> www.kyocerasolar.com	KD130GX-LP	Poly	130	114.8	+/-3.8	12.0	12.9	17.7	7.39
	KD135GX-LP		135	119.4	+/-3.7	12.5	13.4	17.7	7.63
	KD135GX-LPU		135	119.4		14.0	13.4	17.7	7.63
	KD185GX-LPU		185	162.5	+/-2.7	11.6	13.9	23.6	7.84
	KD205GX-LPU		205	180.0	+2.4/-0	12.8	13.8	26.6	7.71
	KD210GX-LPU		210	184.6	+2.3/-0	13.1	14.1	26.6	7.90
	KD215GX-LPU		215	189.1		13.4	14.4	26.6	8.09
<b>Lumos</b> www.lumosolar.com	LS 185	Mono	185	165.6	+/- 3	13.5	14.5	37.1	5.01
<b>Mitsubishi</b> www.mitsubishielectricsolar.com	PV-EE120MF5N	Poly	120	108.7	+10/-5	11.1	11.9	17.2	6.99
	PV-EE125MF5N		125	112.4		11.5	12.4	17.3	7.23
	PV-EE130MF5N		130	117.0		12.0	12.9	17.4	7.47
	PV-UD175MF5		175	157.0	+/-3	11.8	12.7	23.9	7.32
	PV-UD180MF5		180	161.6		12.1	13.0	24.2	7.45
	PV-UD185MF5		185	166.2		12.4	13.4	24.4	7.58
	PV-UD190MF5		190	169.8		12.8	13.7	24.7	7.71
<b>NingBo Solar</b> www.nbsolar.com	TDB125x125-72-P 150W	Mono	150	133.2	+/-5	10.9	11.8	35.2	4.26
	TDB125x125-72-P 155W		155	137.7		11.3	12.2	35.4	4.38
	TDB125x125-72-P 160W		160	142.3		11.7	12.5	35.6	4.50
	TDB125x125-72-P 165W		165	146.8		12.0	12.9	35.8	4.61
	TDB125x125-72-P 170W		170	151.4		12.4	13.3	36.0	4.72
	TDB125x125-72-P 175W		175	155.9		12.7	13.7	36.2	4.84
	TDB125x125-72-P 180W		180	160.5		13.1	14.1	36.4	4.95
<b>Pevafera</b> www.pevafera-america.com	IP-VA 180	Mono	180	159.2	+3/-2	13.03	14.1	35.3	4.83
	IP-VAP210	Poly	210	183.7		12.02	13.0	27.47	7.58
	IP-VAP230		230	201.0		13.17	14.2	27.66	7.72
<b>REC</b> www.recgroup.com	REC205AE-US	Poly	205	178.2	+/-3	11.5	12.4	27.2	7.60
	REC210AE-US		210	182.7		11.8	12.7	27.6	7.60
	REC215AE-US		215	187.2		12.1	13.0	28.0	7.70
	REC220AE-US		220	191.7		12.4	13.3	28.4	7.80
	REC225AE-US		225	196.2		12.7	13.6	28.8	7.80
	REC230AE-US		230	200.7		12.9	13.9	29.1	7.90
<b>Sanyo</b> www.sanyo.com/solar	HIT-190BA19	Mono, a-Si	190	171.2	+10/-0	15.2	16.4	54.8	3.47
	HIT-186DA3 <sup>1</sup>		186	172.6		14.2 <sup>2</sup> /18.2 <sup>3</sup>	15.3 <sup>2</sup> /19.6 <sup>3</sup>	54.8 <sup>2</sup> /55.1 <sup>3</sup>	3.40 <sup>2</sup> /4.32 <sup>3</sup>
	HIT-190DA3 <sup>1</sup>		190	176.8		14.6 <sup>2</sup> /18.6 <sup>3</sup>	15.7 <sup>2</sup> /20.0 <sup>3</sup>	55.3 <sup>2</sup> /55.6 <sup>3</sup>	3.44 <sup>2</sup> /4.37 <sup>3</sup>
	HIT-195DA3 <sup>1</sup>		195	181.1		14.9 <sup>2</sup> /19.1 <sup>3</sup>	16.1 <sup>2</sup> /20.5 <sup>3</sup>	55.8 <sup>2</sup> /56.1 <sup>3</sup>	3.50 <sup>2</sup> /4.45 <sup>3</sup>
	HIT-195BA19		195	179.8		15.6	16.8	55.3	3.53
	HIT-200BA19		200	184.5		16.0	17.2	55.8	3.59
	HIT-205BA19		205	185.1		16.4	17.7	56.7	3.62
	HIT-205NKHA1		205	190.2		15.1	16.3	40.7	5.05
	HIT-210NKHA1		210	194.9		15.5	16.7	41.3	5.09
	HIT-215NKHA1		215	199.6		15.9	17.1	42.0	5.13

<sup>1</sup> Bifacial module <sup>2</sup> At STC <sup>3</sup> At up to 30% backside irradiance contribution

Open-Circuit Voltage (Voc)	Short-Circuit Current (Isc)	Pmp Temp. Coeff. (%/°C)	Voc Temp. Coeff. (%/°C)	Isc Temp. Coeff. (%/°C)	Nominal Operating Cell Temp. (°C)	Series Fuse Rating (A)	Connector Type	Frame Color	Back-Sheet Color	Length (In.)	Width (In.)	Depth (In.)	Weight (Lbs.)	Materials Warranty (Yrs.)	Power Warranty (Yrs.) 90%/80%
20.9	7.33	-0.43	-0.31	0.05	45	15	J-Box	Silver	White	62.40	25.67	1.60	27.00	5	10/25
22.3	7.15														
21.3	7.62														
22.6	7.37														
21.3	11.64	-0.49	-0.34	0.06	46	20	MC4	Black	White	61.80	37.50	40.10	5	10/25	
21.5	11.95														
21.7	12.11														
22.6	11.80														
22.7	11.93	-0.43	-0.31	0.05	45					65.00	1.80	41.00	5	10/25	
22.8	12.11														
32.9	8.10	-0.50	-0.36	0.07	50	15	Tyco	Silver	White	58.50	38.60	1.40	39.00	5	10/20
33.0	8.20														
91.8	1.19	-0.26	-0.31	DNR	45	7	MC	Black	N/A	37.79	38.97	1.57	30.2	5	25
22.1	8.06	-0.48			47	15	MC4	Black	White	59.10	26.30	1.40	28.70	5	10/20
22.1	8.37														
22.1	8.37														
29.5	8.58	-0.49	-0.36	0.05	48	15	MC4	Black	White	59.10	39.00	1.81	36.30	5	10/20
33.2	8.36														
33.2	8.58														
33.2	8.78														
45.4	5.27	-0.47	-0.38	0.10	45	10	MC4	Black / Silver	White	62.20	31.80	1.40	34.10	5	10/25
21.6	7.75	-0.45	-0.34	0.05	48	15	MC4	Black	White	58.90	26.50	1.81	29.80	5	10/25
21.8	7.90														
21.9	8.05														
30.2	7.93														
30.4	8.03														
30.6	8.13														
30.8	8.23														
43.4	4.92	-0.40	-0.35	0.03	47	10	MC4	Silver	White	62.20	31.80	1.80	35.27	5	10/25
43.6	4.98														
43.8	5.04														
44.0	5.10														
44.2	5.16														
44.4	5.22														
44.6	5.28														
44.9	5.19	-0.50	-0.37	0.106	47	10	Tyco	Silver, others avail.	White, others avail.	62.72	31.61	1.81	41.14	5	12/25
36.9	8.10			0.135	48					64.60	38.94	1.91	51.70		
36.8	8.32			-0.36	49										
36.0	8.30	-0.50	-0.37	0.11	49	15	MC4	Silver / Black	White	65.55	39.02	1.69	48.50	5	10/25
36.1															
36.3															
36.4															
36.6															
36.8															
67.5	3.75	-0.30			45	15	MC4	Black	White	51.90	34.60	1.80	33.07	5	10/20
67.5 <sup>2</sup> /68.2 <sup>3</sup>	3.68 <sup>2</sup> /4.78 <sup>3</sup>				47		MC3	Silver	None	53.20	35.35	2.36	50.70	2	
68.1 <sup>2</sup> /68.8 <sup>3</sup>	3.70 <sup>2</sup> /4.81 <sup>3</sup>				-0.29		-0.25	0.02	45	MC4	Black	White	51.90	34.60	
68.7 <sup>2</sup> /69.5 <sup>3</sup>	3.73 <sup>2</sup> /4.85 <sup>3</sup>	-0.30													
68.1	3.79	-0.29			45	15	MC4	Black	White	51.90	34.60	1.80	33.07	5	10/20
68.7	3.83														
68.8	3.84	-0.34	-0.28	0.04	46					62.20	31.40	1.80	35.30	5	10/20
50.3	5.54														
50.9	5.57														
51.6	5.61														
		-0.27	0.03												

Manufacturer	Model	Cell Type	Power @ STC (W)	Power @ PTC (W)	Power Tolerance (%)	Power Per Sq. Ft. (W)	Module Efficiency (%)	Max. Power Voltage (Vmp)	Max. Power Current (Imp)
<b>Schott Solar</b> www.us.schottsolar.com	SAPC-170	Mono	170	149.1	+10/-5	12.1	13.1	34.8	4.90
	SAPC-175		175	151.8		12.5	13.5	35.4	4.95
	POLY 202	Poly	202	177.6	+/-4	11.2	12.1	28.9	6.99
	POLY 210		210	184.8		11.7	12.6	29.3	7.16
	POLY 217		217	191.2		12.0	13.0	29.6	7.33
	POLY 220		220	193.9		12.2	13.1	29.7	7.41
	POLY 225		225	198.4		12.5	13.4	29.8	7.55
	ASE 250	Ribbon	250	221.6	+/-2	9.6	10.3	48.5	5.15
	ASE 260		260	230.6		10.0	10.7	48.7	5.50
	ASE 270		270	239.7		10.3	11.1	49.1	5.50
	ASE 280		280	248.8		10.7	11.5	49.6	5.65
	ASE 290		290	257.9		11.1	11.9	50.1	5.80
	ASE 300		300	267.0		11.5	12.4	50.6	5.90
	ASE 310		310	276.2		11.9	12.8	51.1	6.10

<b>Schüco</b> www.schuco-usa.com	165 SPU-4	Poly	165	146.4	+/-5	11.1	11.9	23.4	7.06
	170 SPU-4		170	150.9		11.4	12.3	23.7	7.19
	175 SPU-4		175	157.0		11.8	12.7	23.9	7.32
	180 SPU-4		180	161.6		12.1	13.0	24.2	7.45
	200 SMAU-1	Mono	200	178.1	+/-3	12.7	14.2	25.4	7.89
	210 SMAU-1		210	187.3		13.3	14.9	26.3	7.98

<b>SET-Solar</b> www.set-solar.com	SDM-170/(165)-72M	Mono	165	145.3	+/-3	12.0	DNR	35.6	4.65
	SDM-170/(170)-72M		170	149.8		12.4		35.8	4.76
	SDM-170/(175)-72M		175	154.3		12.7		36.2	4.85
	SDM-170/(180)-72M		180	158.9		13.1		36.8	4.90
	SDM-170/(185)-72M		185	163.4		13.5		37.5	4.95

<b>Sharp</b> www.solar.sharppusa.com	ND-72ERUC <sup>4</sup>	Poly	72	63.2	+10/-5	5.8	12.5	10.0	7.18
	ND-72ELUC <sup>4</sup>		72	63.2		5.8	12.4	10.0	7.18
	ND-123UJF		123	108.2		11.5	12.4	17.2	7.15
	ND-130UJF		130	113.8		12.2	13.1	17.4	7.50
	ND-N2ECUF		142	124.1		11.4	12.3	19.9	7.13
	ND-N2ECUC		142	124.1		11.4	12.3	19.9	7.13
	NE-165U1		165	144.6		11.8	12.7	34.6	4.77
	NE-165UC1		165	144.6		11.8	12.7	34.6	4.77
	ND-167UC1		167	147.3		11.8	12.7	23.0	7.27
	NE-170U1		170	149.1		12.1	13.1	34.8	4.90
	NE-170UC1		170	149.1		12.1	13.1	34.8	4.90
	NT-170UC1		170	147.3		12.1	13.1	34.8	4.90
	NT-175U1	Mono	175	151.8		12.5	13.5	35.4	4.95
	NT-175UC1		175	151.8		12.5	13.5	35.4	4.95
	ND-176U1Y	Poly	176	152.4		12.4	13.3	23.4	7.52
	ND-176UC1		176	152.4		12.4	13.3	23.4	7.52
	NT-180U1	Mono	180	156.3		12.9	13.8	35.9	5.02
	ND-187UC1	Poly	187	164.7		13.2	14.2	25.8	7.25
	ND-198U1F		198	170.5		12.4	13.4	26.3	7.52
	ND-198UC1		198	170.5		12.4	13.4	26.3	7.52
	ND-200U1F		200	173.0		11.4	12.3	28.4	7.04
	ND-200UC1		200	173.0		11.4	12.3	28.4	7.04
	ND-208U1F		208	180.1		11.9	12.8	28.7	7.25
	ND-208UC1		208	180.1		11.9	12.8	28.7	7.25
	ND-216U1F		216	185.0		12.3	13.3	28.9	7.48
	ND-216UC1		216	185.0		12.3	13.3	28.9	7.48
	ND-U216C1		216	185.0		12.3	13.3	30.2	7.16
	ND-216U2		216	187.3		12.3	13.3	28.7	7.53
	ND-220U1F		220	188.5		12.5	13.5	29.2	7.54
	ND-220UC1	220	188.5	12.5		13.5	29.2	7.54	
	ND-224U1F	224	192.6	12.8		13.7	29.3	7.66	
	ND-224UC1	224	192.6	12.8		13.7	29.3	7.66	
	ND-U224C1	224	192.6	12.8		13.7	30.2	7.42	
	ND-V230A1	230	198.0	13.1		14.1	30.3	7.60	
ND-U230C1	230	198.0	13.1	14.1	30.3	7.60			
NU-U230F3	Mono	230	207.1	13.1	14.1	30.0	7.67		
NU-U235F1		235	211.7	13.4	14.4	30.0	7.84		

<sup>4</sup> Triangular module, generally installed in pairs making > 100 W

Open-Circuit Voltage (Voc)	Short-Circuit Current (Isc)	Pmp Temp. Coeff. (%/°C)	Voc Temp. Coeff. (%/°C)	Isc Temp. Coeff. (%/°C)	Nominal Operating Cell Temp. (°C)	Series Fuse Rating (A)	Connector Type	Frame Color	Back-Sheet Color	Length (In.)	Width (In.)	Depth (In.)	Weight (Lbs.)	Materials Warranty (Yrs.)	Power Warranty (Yrs.) 90%/80%	
43.2	5.47	-0.49	-0.36	0.05	48	10	MC3	Silver	White	62.01	32.52	1.81	35.30	1	10/25	
44.4	5.40									66.34	39.09	0.19	50.70	2		
35.8	7.79	-0.45	-0.33	0.03	47	15	Tyco	Silver	White	66.34	39.09	0.19	50.70	2		10/25
36.1	7.95															
36.4	8.10															
36.5	8.15															
36.7	8.24															
60.0	5.90	-0.47	-0.35	0.05	45	10	MC3	Silver	None	74.50	50.50	2.00	107.00	1		10/25
60.0	5.90															
60.0	6.05															
61.9	6.20															
62.5	6.40															
63.2	6.50	-0.39	0.05	0.05	45	12	MC3	Silver	None	74.50	50.50	2.00	107.00	1	10/25	
63.8	6.50															

29.7	7.73	-0.45	-0.35	0.06	46	15	MC4	Black	White	65.28	32.83	1.81	37.50	5	12/25
29.9	7.83														
30.2	7.93														
30.4	8.03														
33.5	8.24														
33.7	8.35	-0.50	-0.33	0.03	43	Tyco	58.31	38.94	1.87	37.92	5	12/25			

43.2	5.20	-0.47	-0.34	0.04	DNR	DNR	MC4	Silver	DNR	62.20	31.80	1.65	35.30	5	25
43.6	5.25														
43.9	5.30														
44.2	5.35														
44.5	5.40														

12.7	7.89	-0.49	-0.36	0.05	48	15	MC	Black	Black	45.87	38.98	1.81	23.10	1	10/25						
12.7	7.89						J-Box	Silver	White	59.00	26.10	1.80	30.86								
21.8	7.99						MC	Black	Black	45.87	38.98	1.81	31.96								
21.9	8.20																				
25.2	7.84																				
25.2	7.84																				
43.1	5.46															Silver	White	62.00	32.50	1.80	37.49
43.1	5.31																				
29.0	8.02															Black	Black	52.30	39.10	2.30	36.40
43.2	5.47															Silver	White	62.00	32.50	1.80	35.30
43.2	5.47																				37.50
43.2	5.47																				35.30
44.4	5.40						MC	Black	Black	52.30	39.10	2.30	36.40								
44.4	5.40																				
29.3	8.22																				
29.3	8.22																				
44.8	5.60												Silver			White	62.00	32.50	1.80	37.50	
32.7	7.99												Black			Black	52.30	39.10	2.30	36.40	
32.9	8.23																			39.60	
32.9	8.23												MC			Silver	White	64.60	39.10	1.80	44.10
36.0	7.90																				
36.0	7.90																				
36.3	7.99																				
36.3	7.99																				
36.3	7.99																				
36.5	8.10																				
36.5	8.10																				
36.7	7.85																				
36.3	8.35																				
36.5	8.24																				
36.5	8.24																				
36.6	8.33																				
36.6	8.33																				
36.9	8.07																				
37.0	8.24																				
37.0	8.24																				
37.0	8.40																				
37.0	8.60	Black	Black	44.00																	



Manufacturer	Model	Cell Type	Power @ STC (W)	Power @ PTC (W)	Power Tolerance (%)	Power Per Sq. Ft. (W)	Module Efficiency (%)	Max. Power Voltage (Vmp)	Max. Power Current (Imp)
<b>Siliken</b> www.siliken.com	SLK60P6L 215	Poly	215	192.4	+3/-0	12.3	13.2	29.0	7.41
	SLK60P6L 220		220	197.0		12.6	13.6	29.2	7.54
	SLK60P6L 225		225	201.5		12.9	13.9	29.3	7.68
	SLK60P6L 230		230	206.1		13.1	14.2	29.5	7.79
	SLK60P6L 235		235	210.7		13.4	14.5	29.5	7.97
<b>Solarfun</b> www.solarfun.com.cn	160-24-M165	Mono	165	147.2	+/-5	12.0	12.9	35.8	4.61
	160-24-M170		170	151.8		12.4	13.3	35.9	4.74
	190-27-M170		170	150.4		10.6	11.4	26.1	6.51
	160-24-M175		175	156.4		12.7	13.7	36.0	4.86
	190-27-M175		175	155.0		10.9	11.7	26.2	6.68
	160-24-M180	180	161.0	13.1		14.1	36.0	5.00	
	190-27-M180	180	159.5	11.2		12.1	26.3	6.84	
	190-27-P200	Poly	200	177.7		12.4	13.4	26.9	7.44
	190-27-P205		205	182.3		12.8	13.7	27.0	7.60
	190-27-P210		210	186.8		13.1	14.0	27.1	7.75
<b>SolarWorld</b> www.solarworld-usa.com	SW 165	Mono	165	147.4	+/-3	11.8	12.7	35.3	4.68
	SW 175		175	156.6		12.5	13.4	35.8	4.89
	SW 220		220	196.5		12.2	13.4	29.3	7.51
<b>Solon</b> www.solon.com	P220/6+/01 220Wp	Poly	220	194.3	+/- 3	12.5	13.4	28.8	7.65
	P220/6+/01 225Wp		225	198.9		12.7	13.7	28.9	7.80
	P220/6+/01 230Wp		230	203.4		13.0	14.0	29.0	7.95
	P220/6+/01 235Wp		235	208.0		13.3	14.3	29.2	8.05
<b>SunPower</b> www.sunpowercorp.com	SPR-210-BLK	Mono	210	188.9	+/-5	15.7	16.9	40.0	5.25
	SPR-215-WHT		215	195.5		16.1	17.3	39.8	5.40
	SPR-225-BLK		225	202.9		16.8	18.1	41.0	5.49
	SPR-230-WHT		230	209.5		17.2	18.5	41.0	5.61
	SPR-305-WHT		305	280.6		17.4	18.7	54.7	5.58
	SPR-310-WHT		310	285.0		17.7	19.0	54.7	5.67
	SPR-315-WHT		315	290.0		17.9	19.3	54.7	5.76
<b>Suntech</b> www.suntech-power.com	STP170S-24/Ab-1(Blk)	Mono	170	147.3	+/-3	12.4	DNR	35.2	4.83
	STP170S-24/Ab-1		170	147.5		12.4	13.3	35.2	4.83
	STP175S-24/Ab-1(Blk)		175	151.8		12.7	DNR	35.2	4.95
	STP175S-24/Ab-1		175	152.0		12.7	13.7	35.2	4.95
	STP180S-24/Ab-1(Blk)		180	156.2		13.1	DNR	35.6	5.05
	STP180S-24/Ab-1	180	156.5	13.1		14.1	35.6	5.05	
	STP190-18/Ub-1	Poly	190	162.5		12.0	12.9	26.0	7.31
	STP200-18/Ub-1		200	171.4		12.6	13.6	26.2	7.63
	STP210-18/Ub-1		210	180.3		13.3	14.3	26.4	7.95
	STP260-24/Vb-1		260	231.3		12.4	13.4	34.8	7.47
	STP270-24/Vb-1		270	236.9		12.9	13.9	35.0	7.71
	STP280-24/Vb-1		280	246.0		13.4	14.4	35.2	7.95
<b>Trina Solar</b> www.trinasolar.com	TSM-165DA01	Mono	165	146.0	+/-3	12.0	13.3	35.6	4.65
	TSM-170DA01		170	150.6		12.3	13.7	35.8	4.76
	TSM-175DA01		175	155.1		12.7	14.1	36.2	4.85
	TSM-180DA01		180	159.6		13.1	14.5	36.8	4.90
	TSM-185DA01	185	164.3	13.4		14.9	37.5	4.95	
	TSM-220PA05	Poly	220	192.9		12.5	13.9	29.8	7.39
	TSM-220DA05	Mono	220	193.6		12.5	13.9	29.8	7.39
	TSM-230PA05	Poly	230	202.0		13.1	14.6	30.0	7.66
	TSM-230DA05	Mono	230	202.7		13.1	14.6	30.0	7.66
	TSM-240PA05	Poly	240	211.0		13.6	15.2	30.6	7.84
TSM-240DA05	Mono	240	211.8	13.6	15.2	30.6	7.84		
<b>UniSolar</b> www.uni-solar.com	PVL-68	a-Si	68	61.4	+/-5	5.6	DNR	16.5	4.13
	PVL-124		124	112.0		5.8		30.0	4.13
	PVL-128		128	115.5		5.5		33.0	3.88
	PVL-136		136	122.8		5.8		33.0	4.13
	PVL-144		144	130.1		6.2		33.0	4.36
<b>Yingli</b> www.yinglisolar.com	YL175	Poly	175	148.9	+/-3	12.5	13.5	23.0	7.61
	YL 220P-29b		220	194.6		12.5	13.5	29.0	7.59
	YL 225P-29b		225	199.1		12.8	13.8	29.5	7.63
	YL 230P-29b		230	203.7		13.1	14.1	29.5	7.80
	YL 235P-29b		235	208.3		13.4	14.4	29.5	7.97

	Open-Circuit Voltage (Voc)	Short-Circuit Current (Isc)	Pmp Temp. Coeff. (%/°C)	Voc Temp. Coeff. (%/°C)	Isc Temp. Coeff. (%/°C)	Nominal Operating Cell Temp. (°C)	Series Fuse Rating (A)	Connector Type	Frame Color	Back-Sheet Color	Length (In.)	Width (In.)	Depth (In.)	Weight (Lbs.)	Materials Warranty (Yrs.)	Power Warranty (Yrs.) 90%/80%							
	36.6	8.02	-0.43	-0.36	0.04	49	15	MC4	Silver	White	64.60	39.00	1.57	41.90	5	10/25							
	36.7	8.10																					
	36.8	8.20																					
	36.9	8.32																					
	36.9	8.47																					
	44.0	5.10	-0.40	-0.38	0.04	45	8	MC4	Silver/Black	White/Black	62.20	31.80	1.77	33.00	3	10/25							
	44.5	5.12																					
	32.4	7.49																					
	44.8	5.17																					
	32.5	7.69																					
	45.0	5.20																					
	32.6	7.78																					
	32.8	8.24																					
	32.9	8.35																					
	33.0	8.48																					
	44.0	5.10	-0.47	-0.33	0.04	46	15	MC44	Silver	White	63.39	31.89	1.34	33.00	2	10/25							
	44.4	5.30																					
	36.6	8.18																					
			-0.45								65.94	39.41		48.50									
	36.4	8.30	-0.44	-0.35	0.05	DNR	15	Tyco	Silver	White	64.56	39.37	1.65	51.80	10	10/25							
	36.6	8.40																					
	36.7	8.55																					
	36.9	8.65																					
	47.7	5.75	-0.38	-0.29	0.06	46	15	MC4	Black	Black	61.39	31.42	1.81	33.10	10	12/25							
	48.3	5.80																					
	48.5	5.87																					
	48.7	5.99		-0.27		46	20			Black													
	64.2	5.96				45	15			White													
	64.2	6.05		-0.28																			
	64.2	6.14																					
	43.8	5.14	-0.48	-0.34	0.02	45	15	MC4	Black	Black	62.20	31.80	1.38	34.10	5	12/25							
	43.8	5.14																					
	44.2	5.20																					
	44.2	5.20																					
	44.4	5.40																					
	44.4	5.40																					
	33.0	7.89	-0.47	0.05	45	20	MC4	Silver	White	58.30	39.10	2.00	59.50	5	12/25								
	33.4	8.12																					
	33.6	8.33																					
	44.0	8.09																					
	44.5	8.12																					
	44.8	8.33																					
	43.2	5.20	-0.45	-0.35	0.05	47	9	Tyco	Silver/Black	White/Black	62.24	31.85	1.57	34.40	5	10/25							
	43.6	5.25																					
	43.9	5.30																					
	44.2	5.35																					
	44.5	5.40																					
	36.8	8.00				47	15				9	15	Tyco	Silver/Black			White/Black	64.96	39.05	1.81	43.00	5	10/25
	36.8	8.00																					
	37.0	8.18																					
	37.0	8.18																					
	37.5	8.38																					
	37.5	8.38																					
	23.1	5.10	-0.21	-0.38	0.10	46	8	MC	No Frame	Black	112.10	15.50	0.20	8.70	DNR	20							
	42.0	5.10																					
	47.6	4.80																					
	46.2	5.10																					
	46.2	5.30																					
	29.0	8.20	-0.45	-0.37	0.06	46	15	MC4	Silver	White	51.57	38.98	1.97	34.83	5	10/25							
	36.5	8.15																					
	36.5	8.28																					
	37.0	8.40																					
	37.0	8.54																					

## Web Extra

For more detailed descriptions of each specification, download "Specifications Details" at [www.homepower.com/webextras](http://www.homepower.com/webextras)



### Rated power tolerance (%)

The range within which a module will overperform or underperform its STC rated power. This is a key specification to consider—it can be extremely disappointing if under even "ideal" conditions, your 2,000 W array may only produce 1,820 W if power tolerance is +/-9%. To be assured your module has the ability to produce the amount of power it is specified for, look for a narrow (or positive only) power tolerance. Note that while the "2009 PV Buyer's Guide" listed several modules with a +/- 9% power tolerance, the largest range listed in this guide is +/- 5%—a testament to improving PV module standards.

### Rated power per square foot (W)

Also known as "power density," this value reflects power output at STC per square foot of module (not cell) area. This specification is also known as "power density." The higher the power density, the less space you need to produce a certain amount of power—if mounting space is limited, look for modules with a higher rated power density.

### Module efficiency (%)

Output power divided by input power, or how efficiently a PV module uses the photons in sunlight to generate DC electricity. Like power density (above), the higher this efficiency, the more electricity you can generate in a given space.

### Maximum power voltage (Vmp)

The voltage at which a module will put out the most power under STC. Temperature has a direct effect on module voltage, with higher temperatures resulting in lower voltage and lower temperatures resulting in higher voltage. String-sizing programs for grid-tied inverters take your site's high and low temperatures into consideration for optimizing the number of modules to be wired in series.

### Maximum power current (Imp)

The maximum amperage produced by a module or array (under STC) when exposed to sunlight and connected to a load. This value is often used when performing voltage-drop calculations for wire runs from the PV array (see *Back Page Basics* in HP133).

### Open-circuit voltage (Voc)

The maximum voltage generated by a PV module or array when exposed to sunlight, with no load connected. PV system components (modules, wiring, inverters, charge controllers,

etc.) are each rated for a specific voltage, so maximum system voltage must be calculated using this value, as well as the number of modules in series in conjunction with the open-circuit voltage temperature coefficient (discussed below) and lowest expected temperature.

### Short-circuit current (Isc)

The amperage generated by a PV module or series string when exposed to sunlight, with output terminals shorted together. This value is used to determine the wire and overcurrent protection sizes needed.

### Maximum power temperature coefficient (% per °C)

The change in module output power at temperatures other than STC (25°C). This specification is used to calculate how much module power is lost or gained due to temperature variations. A-Si modules have lower values, not losing as much power as crystalline modules when hot.

### Open-circuit voltage temperature coefficient (% per °C)

The change in module open-circuit voltage at temperatures other than STC (25°C). If given, this specification is used in conjunction with open-circuit voltage to calculate maximum system voltage for system design and labeling purposes (per *National Electrical Code* Article 690.7).

### Short-circuit current temperature coefficient (% per °C)

The change in module short-circuit current at temperatures other than STC (25°C). These coefficients are much lower than temperature coefficients for voltage, and do not greatly impact most PV system designs.

### Nominal operating cell temperature (NOCT)

The temperature of each module at an irradiance of 800 W per square meter and an ambient air temperature of 20°C. This specification is used together with the maximum power temperature coefficient to estimate power loss due to temperature increase.

### Series fuse rating (A)

The amperage value of a series fuse used to protect a module from overcurrent, under certain conditions. Because PV modules are current-limited, there are some cases where series fusing may not be needed. Series fuses (if required) are placed in a combiner box or, in some cases, inside a batteryless inverter.

### Connector type

The module output terminal or cable/connector configuration. Most modules come with plug-in weather-tight connectors (MC4, MC3, or Tyco), which makes installation easier. But some modules are returning to the J-box, since they allow the use of conduit between modules, a safety requirement for arrays installed in readily accessible locations.

### Materials warranty (years)

A limited warranty on module materials and workmanship under normal application, installation, use, and service conditions. For the modules listed in this guide, warranties usually range from one to 10 years. This warranty usually guarantees full replacement or free servicing of a defective module(s) by the manufacturer.

### Power warranty (years)

A limited warranty for module power output based on the minimum peak power rating (STC rating minus power tolerance percentage) of a given module. This warranty is usually separated into two time frames. Most manufacturers warrant for 10 or 12 years that their modules will operate within 90% of their minimum power rating, and for 20 to 25 years that the modules will operate within 80% of their minimum power rating. Longer warranty periods mean longer protection, but it is important to consider the potential longevity of the company offering the warranty.

## Last Notes

While the PV module table continues to grow each year, in-the-field choices are often limited to models carried by your retailer or local installer. Before you buy, consider who will help you with warranty issues should you need support. If you purchase your modules online, you will likely have more difficulty with the warranty because you may have to deal with the manufacturer directly. Additionally, you will be responsible for removing the modules from the system, shipping them to either the retailer or manufacturer, and then reinstalling new modules. Installing dealers often can provide direct help with warranty claims, but ask your installer for details. “Free servicing and support” is often limited to a certain number of years after the original installation.

## Access

Justine Sanchez ([justine.sanchez@homepower.com](mailto:justine.sanchez@homepower.com)) is a NABCEP-certified PV installer, *Home Power* technical editor, and Solar Energy International instructor.

Go Solar California • [www.gosolarcalifornia.org](http://www.gosolarcalifornia.org) • PV module and other equipment listings

