



October 15, 2009

**SolarWorld Photovoltaic Modules
Sunmodule SW230mono**

This certification applies to SolarWorld Sunmodule SW230mono that has been manufactured in the United States.

It is hereby certified that the SW230mono modules:

1. Qualify as photovoltaic devices which use solar energy to generate electricity and qualify as solar electric property.
2. Meet or exceed the Federal Trade Commission (FTC) requirements to apply the “**Made in USA**” label to the product and all advertising materials.
3. Meet or exceed the provisions of the **Buy American Act**.
4. Meet or exceed the provisions of the **American Recovery and Reinvestment Act**.
5. Have been manufactured in a SolarWorld ISO 9001:2000 certified factory.
6. Meet or exceed the UL 1703 requirements and are listed with the Underwriters Laboratories.
7. Have been certified to the “Crystalline silicon terrestrial photovoltaic (PV) modules-Design qualification and type approval”, IEC 61215 2005-04.
8. SolarWorld will accept these modules for recycling at their end of life.

It should be noted that these modules meet the above requirements, not by virtue of having been made in countries with favorable trade agreements with the United States of America, but by the fact that they were actually manufactured in the United States. Our modules not only meet the letter of the law in this regard, but the intent of the law.

Raju Yenamandra
VP Sales and Marketing



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Manufacturer's Certification

SolarWorld Photovoltaic Modules Sunmodule SW175 – SW240

September 9, 2009

This certification applies to SolarWorld Sunmodules, SW165/175/220/230 mono, that have been manufactured in the United States.

It is hereby certified that the referenced modules:

1. Qualify as photovoltaic devices which use solar energy to generate electricity and qualify as solar electric property.
2. Meet or exceed the Federal Trade Commission (FTC) requirements to apply the "**Made in USA**" label to all advertising materials.
3. Meet or exceed the provisions of the **Buy American Act**.
4. Meet or exceed the provisions of the **American Recovery and Reinvestment Act**.
5. Have been manufactured in a SolarWorld ISO 9001:2000 certified factory.
6. Meet or exceed the UL 1703 requirements and are listed with the Underwriters Laboratories.
7. Have been certified to the "Crystalline silicon terrestrial photovoltaic (PV) modules-Design qualification and type approval", IEC 61215 2005-04.
8. SolarWorld will accept these modules for recycling at their end of life.

Under penalties of perjury, I declare that I have examined this certification statement, and to the best of my knowledge and belief, the facts presented are true, correct and complete.

Paul Norum

Quality Manager
SolarWorld Industries USA

The best PV modules are made in the USA

What does it really mean to be made in America?

For SolarWorld, being made in America means more than simply assembling foreign components in the USA, which does little to benefit the economy. By carrying out the entire value chain in the USA, we are creating American manufacturing jobs not only at our factories but at our suppliers' factories as well.

American components and materials

- Raw silicon
- Tempered glass
- Aluminum module frames
- Back sheets and embedding
- Other direct and indirect materials

American manufacturing

- Silicon reprocessing in Vancouver, WA
- Crystal growing and wafering in Hillsboro, OR
- Cell manufacturing in Hillsboro, OR
- Module assembly, sales & customer service in Camarillo, CA

Why made in America is important to our customers

- Highest quality products
- Reliable delivery schedules
- Local warranty and product support
- Real energy independence vs importing
- Meets and exceeds Buy America requirements
- Avoids environmental costs of overseas shipping
- Money spent stimulates the US economy and creates US jobs
- Processes meet stringent US labor and environmental policies

SolarWorld is investing over \$500 million to expand US-based manufacturing, which generates hundreds of millions of dollars each year for American workers, goods and services.

SolarWorld California
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service@solarworld-usa.com



www.solarworld-usa.com

We've been leading the industry for over 30 years

SolarWorld is the largest PV manufacturer in the USA since 1977

- Vertically integrated from raw silicon to modules, kits and systems
- Financially stable with over \$1.2 billion in revenues
- Over 30 years of PV manufacturing experience

SolarWorld Sunmodules produce the most kWh

- Proven in independent real-world testing by Photon International
- Up to 10% more kWh/kW than other major brand modules
- Superior low-light performance through cell texturing
- Tight $\pm 3\%$ power tolerance

SolarWorld is an industry leader

- First to offer a 25 year warranty for PV modules
- First to manufacture UL listed PV modules
- First to fully recycle crystalline PV modules
- First to build 1 MW+ solar PV projects
- First to offer grid tied PV kits

SolarWorld products are the highest quality available

- Tested to 112 psf for IEC 61215 heavy load compliance
- NEC 2008 compliant module and connections
- Unsurpassed 25 year warranty

SolarWorld is a sustainable, socially responsible manufacturer

- Environmental impacts reported along side financial results
- Local manufacturing under strict environmental regulations
- Solar2World initiative supplies projects in developing nations
- Broken or obsolete modules are recycled



Silicon reprocessing - Vancouver, WA



Crystal growing, wafering and cell production - Hillsboro, OR



Module assembly and sales center for the Americas - Camarillo, CA





Sunmodule[®] SW 220/230 mono



The Sunmodule from SolarWorld represents one of the best values in the PV industry. The Sunmodule's tight power tolerance of +/-3% ensures the highest system efficiency without the need for on-site module sorting. The fully automated manufacturing process at SolarWorld's ISO 9001-2000 factories produces modules with consistently high quality. Choosing the Sunmodule[®] will ensure high kWh yields for the long term.

To guarantee long term yields, Sunmodules are built to last. SolarWorld bonds the tempered glass laminate deep into the aluminum frame with a continuous bead of silicone adhesive. This method guarantees exceptional rigidity for the entire module and prevents the frame from loosening or pulling away from the glass in cases such as the sliding of heavy snow or handling. Tests carried out in accordance with IEC 61215, which applies loads of up to 113 lb/sf (5.4 kN/m²) demonstrate that the module can withstand high loads such as heavy accumulations of snow and ice.

The Sunmodule[®] features a patented, low profile junction box with integrated 25A Schottkey bypass diodes that is completely sealed against corrosion. The ability to rapidly dissipate excess heat allows the diodes and junction box to operate at lower temperatures. The junction box is reliably connected by a solid, welded bond to guarantee lasting functionality and is factory-equipped with high-quality, robust cables and locking connectors. All Sunmodules carry a 25-year performance warranty and can be returned to SolarWorld at their end of life for recycling



Sunmodule®

SW 220/230 mono

Performance under standard test conditions

		SW 220	SW 230
Maximum power	P_{max}	220 Wp	230 Wp
Open circuit voltage	V_{oc}	36.6 V	36.9 V
Maximum power point voltage	V_{mpp}	29.3 V	29.6 V
Short circuit current	I_{sc}	8.18 A	8.42 A
Maximum power point current	I_{mpp}	7.51 A	7.76 A

Performance at 800 W/m², NOCT, AM 1.5

		SW 220	SW 230
Maximum power	P_{max}	157 Wp	164 Wp
Open circuit voltage	V_{oc}	33.1 V	33.4 V
Maximum power point voltage	V_{mpp}	26.3 V	26.6 V
Short circuit current	I_{sc}	6.76 A	6.96 A
Maximum power point current	I_{mpp}	5.98 A	6.18 A

Minor reduction in efficiency under partial load conditions at 25°C: at 220 W/m², 95% (+/- 3%) of the STC efficiency (1000 W/m²) is achieved.

Component materials

Cells per module	60
Cell type	monocrystalline silicon
Cell dimensions	6.14 x 6.14 in ² (156 x 156 mm ²)

System integration parameters

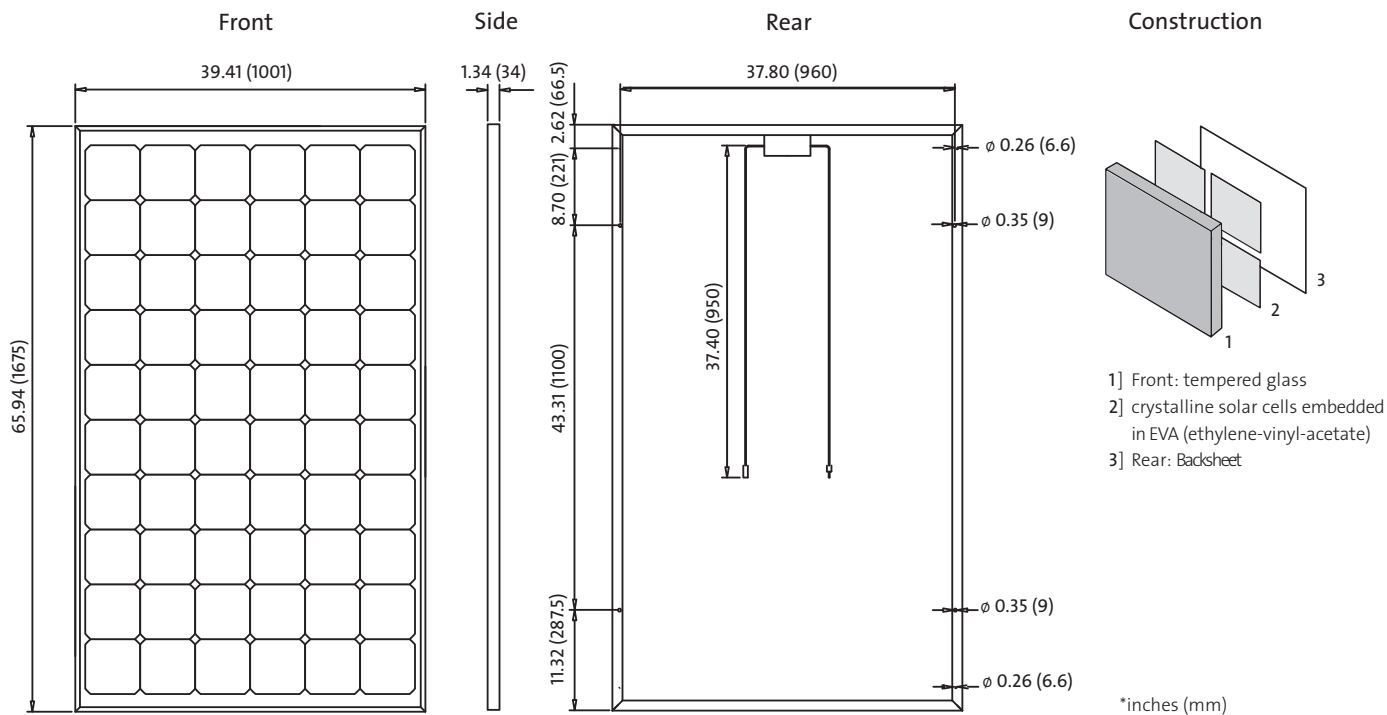
Maximum system voltage SC II	1,000 V _{DC}
Maximum system voltage USA NEC	600 V _{DC}
Maximum series fuse rating	15 A
Maximum reverse current	Do not apply external voltages larger than V_{oc} to the module

Thermal characteristics

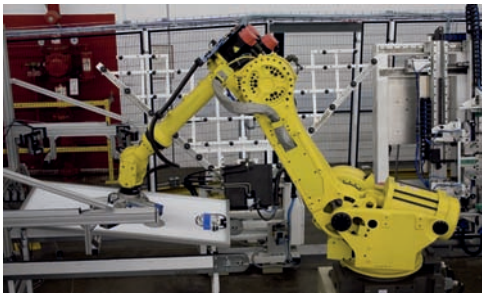
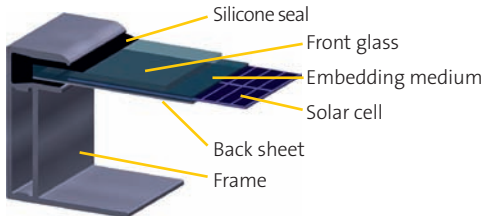
NOCT	46°C
TC I_{sc}	0.042 %/K
TC V_{oc}	-0.33 %/K
TC P_{max}	-0.45 %/K

Additional data

Power tolerance	+/- 3 %
Junction box	IP 65
Connector	MC type 4



What makes the SolarWorld Sunmodule® the best in the industry.



The best design

- Robust module engineered with 30 years of industry experience
- Can be mounted in any orientation without frame shading
- Capable of withstanding 1 inch hailstones at over 50 mph

The best materials

- Materials are selected for quality and environmental sustainability
- Over 98% of the materials in the Sunmodule® come from the USA
- Internal recycling at every process step minimizes waste

The best cells

- Designed and manufactured for maximum energy production
- Textured to capture more sun - even in low-light conditions
- Fully automated US-based production ensures high quality
- Wafers cut from a single crystal of pure silicon
- Proven long life

The strongest frames

- Deep channel provides complete sealing and reinforcement
- Tested to 112 pounds per square foot vs. industry standard 50
- Stands up to high winds as well as sliding snow and ice

The toughest junction box

- Integrated connections are NEC 690.35D ungrounded system compliant
- Integrated connections meet UL and TUV safety class 2 requirements
- Integrated heat sinks keep bypass diodes cool in hot weather
- Integrated quick connectors audibly lock to seal out moisture

The best assembly techniques

- California-based operations provide flexible delivery schedules
- Tight $\pm 3\%$ power tolerance ensures high performance
- Fully automated assembly ensures high quality

The lightest packaging

- Flexible pallet packaging reduces shipping costs and job site waste
- All packaging materials are fully recyclable

The best warranty

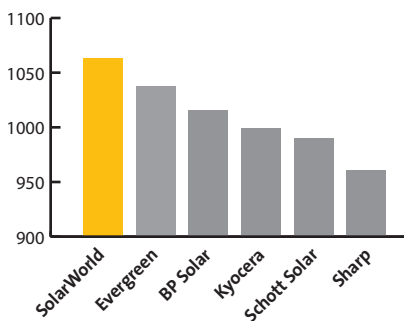
- SolarWorld was first in the industry with a 25 year power warranty
- SolarWorld's warranty exceeds industry standards
- Backed by the largest PV manufacturer in the USA since 1977



SolarWorld outshines the competition

Independent real-world testing confirms what our customers have been telling us for over 30 years; the SolarWorld Sunmodule® produces more energy year over year than competing products.

The SolarWorld Sunmodule® generates more kWh per kW than other major brands.



Normalized annual output (kWh/kW), according to multi-year testing performed by Photon magazine

PV modules are sold based on their labeled capacity. However, it's their actual energy production which provides cost savings and avoids CO₂ emissions.

That's why we design our modules for maximum energy production year-round and apply tight $\pm 3\%$ power tolerances when labelling capacity.

Get more out of your PV installation by installing SolarWorld Sunmodules, proudly made in the USA.



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SolarWorld. And EveryDay is a SunDay.

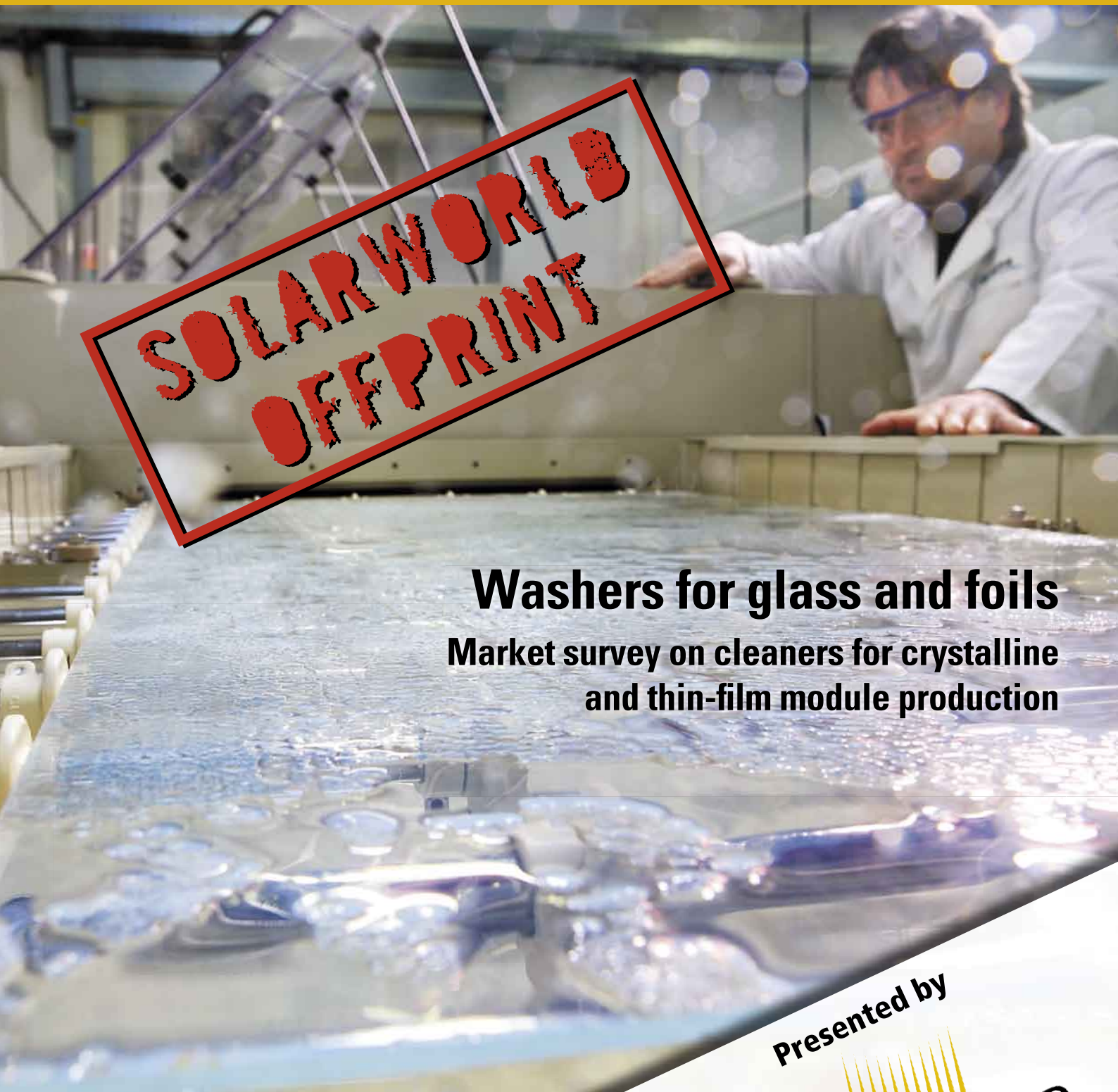
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**SOLARWORLD
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Washers for glass and foils

Market survey on cleaners for crystalline and thin-film module production

Presented by



Solar modules update 2009

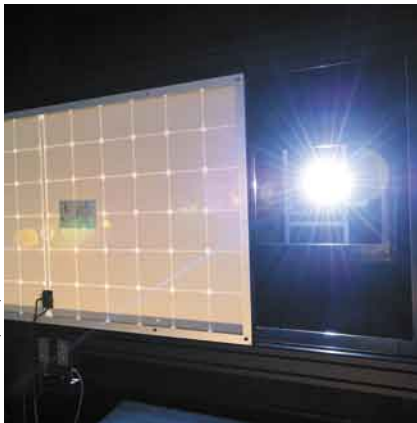
Technical specs for over 2,700 different models

Strong US market growth

Installed PV capacity increases by 70 percent in 2008

Solar loans

Many German banks still financing PV systems



Norbert Michalek / photon-pictures.com

A new best module

PHOTON Lab's module test results for 2008

▲ A module's power can be measured with the help of a solar simulator, but only long-term outdoor tests can determine module yield – PHOTON Lab has been conducting such tests since 2006.

A module's nominal power is interesting, as is its efficiency – and, depending on the customer's expertise, so are a few other pieces of technical module data. But the single most important factor for PV system operators is yield: how many kilowatt-hours per kW of installed power flow from the PV system to the inverter? This is exactly the question PHOTON Laboratory intends to answer with its module field tests. Over the course of 2008, a total of 16 different module types installed on a piece of property – free of shadowing – were monitored constantly using an elaborate measurement system.

Three units of each module type are represented in the test to prevent potential faulty products or modules with below average results from distorting the results for the entire series. The modules are installed in Germany, facing south at a 28° angle and are mounted about 2.5 m above the ground, which means they have complete rear ventilation. PHOTON Lab has developed its own electronics to perform fully automated measurements at each module's output. This eliminates the possibility of errors due to false inverter adjustment or small cable cross-sections. The test set-up's measurement tolerance is currently +/- 1.85 percent.

Every second, each module is measured to capture an IV curve with a nominal 14 bit resolution composed of 2,000 measurement points and the maximum power point (MPP). This measurement process takes about 10 milliseconds, which means almost 99 percent of the test module's yield can be fed into the grid via a DC-DC converter, a DC bus and an inverter. This is important as it allows the test system to operate under real-world conditions

and prevents modules from overheating due to permanent open-circuit operation.

In addition to data from the solar modules, the test field employs several highly accurate pyranometers to measure solar irradiation horizontally and at the module level every second, as well as other climate data such as ambient temperature, wind speed, precipitation and barometric pressure. Module and weather data is stored in synchronized databases to ensure precise correlation.

Real power is the decisive factor

The measured yields of the individual modules are standardized according to their power under standard test conditions (STC), which is determined by the manufacturer during production. PHOTON Lab retrieved this data based on the module serial number, if the solar simulator test results were not included with the module.

For technical reasons, the solar modules in a certain series do not all have identical powers. That's why nominal power is always listed with a certain tolerance range, which manufacturers determine using very different methodologies. For instance, a few manufacturers list a module's nominal power at 100 W when the actual power of the module in question actually achieves this value. Other manufacturers, by contrast, list a 100 W nominal power for a series with a true power of between 95 and 105 W. Moreover, there are some manufacturers that list module power at 100 W when their products achieve 100 W at maximum but likely display lower nominal powers.

Of course, in a certain sense, standardization of yield according to STC power can

Highlights

- Over the last three years, PHOTON Lab has monitored the yields of 16 different module types for a period of at least one year
- The top three results were achieved by modules from SolarWorld, Photowatt and First Solar
- The module from Sharp performed worst
- The tested modules rank differently when observed on a monthly basis, with First Solar showing the highest yield from April to July

Expansion of PHOTON Laboratory

Yield measurements from PHOTON's module test field only make sense if the measurement results can be standardized based on module power. The decisive factor isn't yield alone – the sum of produced kWh – but rather the yield in relation to power. And, to repeat, calculations must be based on actual power if the goal is to compare the modules being tested (see article). This is exactly the point where PHOTON Laboratory noticed a critical gap in its testing process: in order to obtain each test module's power measured using a solar simulator, PHOTON Lab had to contact the manufacturer and submit the module's serial number. Naturally, no test lab likes to rely on figures provided by the manufacturer. It prefers to rely on its own measurements. But, unfortunately, a good solar simulator is rather expensive.

As of November 2008, PHOTON Lab solved this problem by purchasing a Pasan Sun Simulator IIIb device. From now on, PHOTON Lab can conduct its own power measurements for each module being tested under standard testing conditions (STC). Furthermore, other newly bought equipment will enable PHOTON Lab to produce thermographic images of modules during operation, as well as capture electroluminescent images.

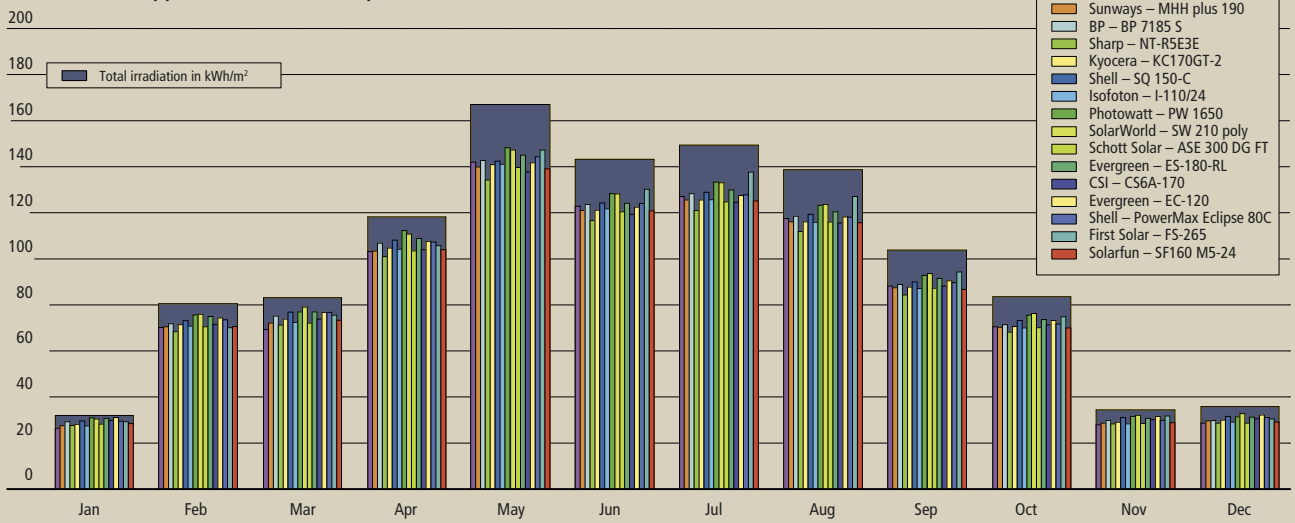
Of course, PHOTON Lab didn't buy this equipment just to take yield measurements. The lab can now conduct a variety of independent tests and, therefore, can be contracted for various tasks – for example, to examine a PV system on behalf of an operator or to test modules for installers.



▲ A big black box: PHOTON Lab's solar simulator is installed in a dark chamber.

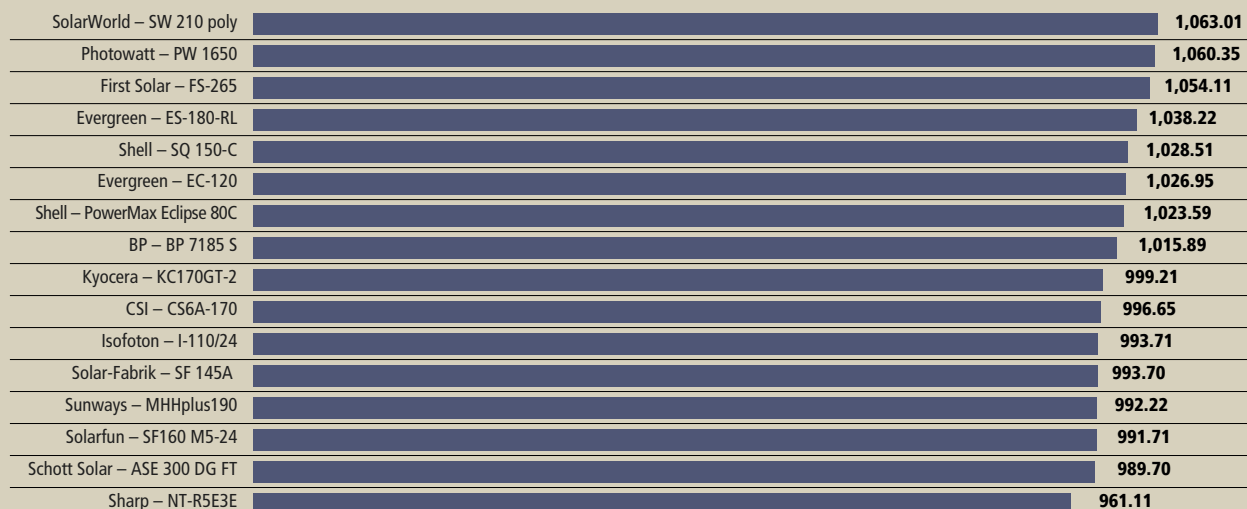
PHOTON Lab's module test 2008

Standardized monthly yield in kWh/kW and monthly irradiation totals (module level) in kWh/m²



PHOTON Lab's module tests 2008

Standardized annual yield in kWh/kW



make modules with overly optimistic nominal power specifications look better than they are: if a module with a specified nominal power of 100 W produces just 95 W under STC conditions and delivers an annual yield of 100 kWh, that's the equivalent of a yield of 1,000 kWh per kW power when standardized to nominal power. However, when standardized to STC power, that yield increases to 1,056 kWh per kW. Nevertheless, standardization according to STC power is the only way for our lab to compare all module results from its field tests. It's another reason why customers shouldn't pay for solar modules according to nominal power. It's much better to calculate module price according to STC power or a nominal power with a positive tolerance range.

Value according to yield

In 2008, the 16 candidates on PHOTON Lab's test field performed relatively well: the average yield was around 1,000 kWh per kW – not a bad result for modules tilted at an angle with a total irradiation of 1,170 kWh per m². Still, two modules failed to hold their own: one of the three Sunways MHH plus 190 units performed significantly worse than its companions. Closer examination eliminated the possibility of a problem with our measurement technology. The same problem plagued one of the three Solar-Fabrik modules. These modules were therefore excluded from final yield calculations.

Looking at the results for each individual module type (see graph, p. 133), noticeable differences can be recognized. In fact, there's a 103 kWh gap – almost 10 percent – between the modules with the highest standardized annual yields (SolarWorld SW 210 poly) and the modules with the lowest yields (Sharp NT-R5E3E).

One module type was completely removed from the 2009 results: Sanyo's HIP-J548E2. These modules were obtained in fall 2005 from a vendor in Berlin as exhibition models, although they were purchased at the normal price. Later, we discovered that these three units were not exhibition models, but rather »sample modules« that never underwent normal quality control tests or power measurements. Since Sanyo couldn't provide an STC power, the module yield was standardized according to nominal power during the test cycle from Aug. 1, 2006 to July 31, 2007 (see PI 9/2007, p. 20) – and with poor results, the modules

landed in last-but-one place. In October 2007, PHOTON Lab sent the three modules to the Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg, Germany, for a retroactive flasher test, and then standardized the resulting yield with the new STC power. On the one hand, results very much improved (fourth place for the same testing period). But on the other, the tests revealed that the modules, which had a specified nominal power of 180 W, actually had a true power of between 161 and 172 W.

It would seem that Sanyo's sample modules differ significantly from normal serially produced modules – until now, we haven't heard of any other modules underperforming nominal power so dramatically. On top of everything, ISE cleaned the three test modules before the examination, which we have never done for the other modules on the test field for practical reasons. Therefore, we won't be able to explore the question of how sample modules perform in long-term testing, so that this set of Sanyo modules will no longer be included in our module field test results.

Small errors with the CIS modules

Thin-film modules, particularly Shell Solar's PowerMax Eclipse 80-C modules, pose a unique challenge from the perspective of measurement technology. These modules' thin-film cells based on copper, indium and diselenide (CIS) display parasitic effects. If the module short-circuits for a fraction of second when measuring the IV curve, the measurement period must be adjusted within a few milliseconds to ensure the results aren't distorted in one direction or the other. For instance, if measurements are taken along the IV curve, starting from the short-circuit, the results are too low, but if the module is measured from the open-circuit voltage, the results are too high. The ideal point for measurements is where the power is identical in both directions. However, as the IV curve is measured with increasing voltage when starting at the short circuit and the measuring period drops below 10 milliseconds at higher irradiation, the results are still affected. Once PHOTON Lab received its own solar simulator in December 2008 (see box, p. 133) and was able to examine Shell's modules independently, errors on the outdoor test were limited to an average of -0.5 percent.

First Solar among the frontrunners

When compared with other test modules, CIS modules take seventh place. Another representative of the thin-film species, namely First Solar's FS-265 with solar cells made of cadmium telluride (CdTe), performs much better and came in at third place. All in all, the test field can be divided into several groups.

The first three – SolarWorld, Photowatt and First Solar – are neck and neck within a measuring accuracy range of +/- 1.85 percent. Just behind those three are the ES-180-RL modules from Evergreen, with their string-ribbon cells, followed closely by Shell's SQ 150-C, Evergreen's EC-120 and Shell's PowerMax Eclipse 80-C. This group of three hardly differs in terms of yield, with BP Solar's BP 7185 S lagging behind them ever so slightly. Ninth to 15th place are held by modules from Kyocera, CSI, Isofoton, Solar-Fabrik, Sunways/MHH, Solarfun and Schott Solar's ASE-300-DG-FT, which contain the company's EFG solar cells that are produced with a string-ribbon technology similar to Evergreen product. This group of seven has a standardized annual yield range of just 0.89 percent, so they are practically identical. And finally, lagging considerably behind this group in last place, just like in the 2007 testing cycle, come Sharp's modules – with a performance around 9.5 percent lower than the top module.

Naturally, standardized yields can also be assessed on a monthly basis. Indeed, this reveals considerable variation among the modules. SolarWorld's modules, the top modules when it comes to annual yield, held first place on a monthly basis during just 5 months of the year (February, March, August, October, November, December). Evergreen's EC-120 module, which ranked seventh place in annual yield measurements, actually delivered the highest yield in January 2008. Moreover, First Solar's modules delivered the highest yield in September and Photowatt's modules performed best between April and July. Performance was much more consistent when it came to the modules in last place, consistently held by Sharp, with the exception of the months of January, March, November and December, when they shared last place with Solar-Fabrik's modules. ●

Text René Düpont, Jochen Siemer

Further information Contacts page 233



Welcome to the land of opportunity

With more US-based PV production than anyone, SolarWorld is powering the American dream for independent solar contractors throughout the nation.

Choosing the SolarWorld Sunmodule® not only ensures superior reliability and performance, it also secures manufacturing jobs for Americans because Sunmodules are made entirely in the USA from American components and materials. Call us at 1-800-947-6527 for a SolarWorld distributor in your area.

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