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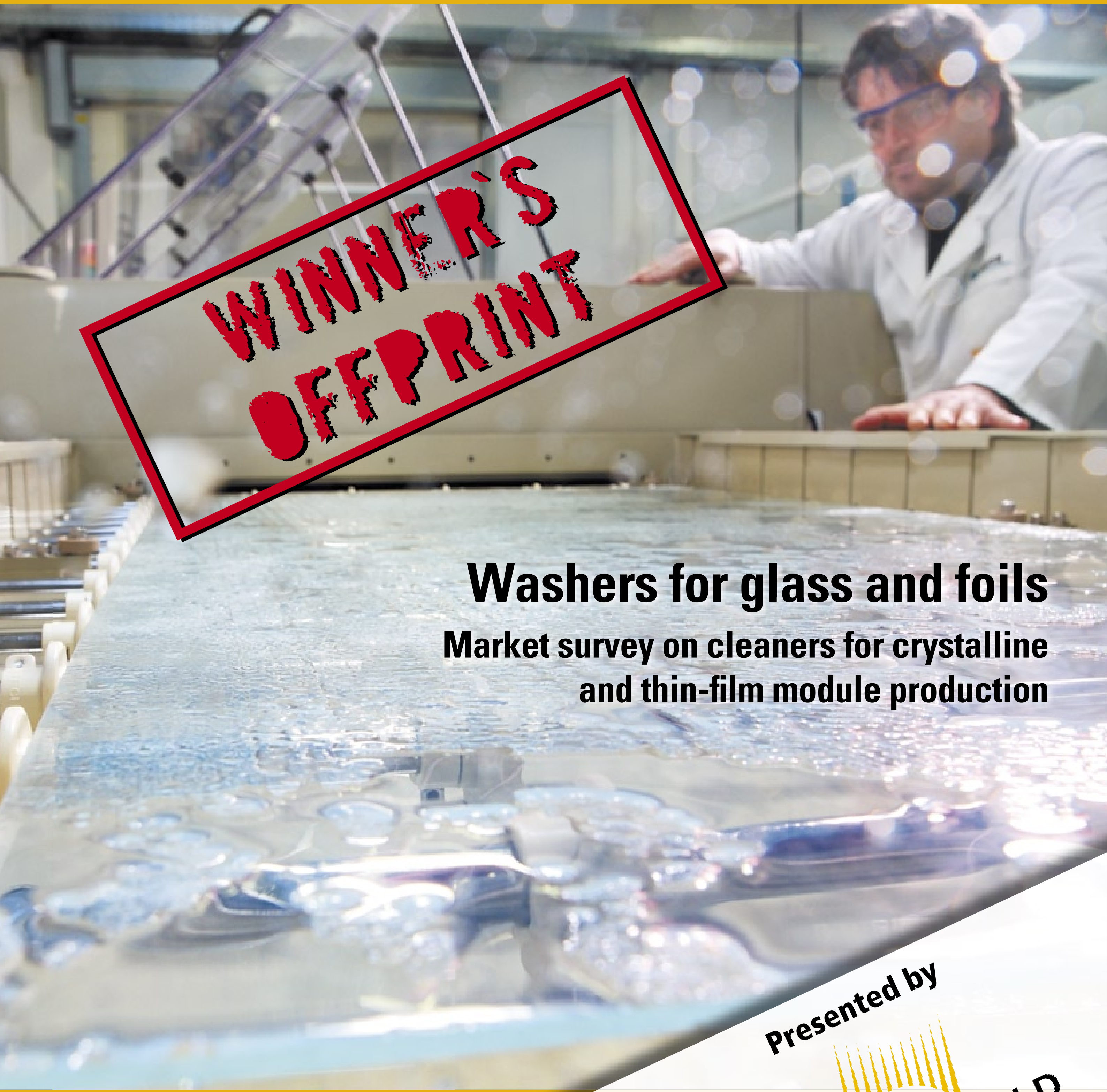


WINNER'S OFFPRINT

Washers for glass and foils

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

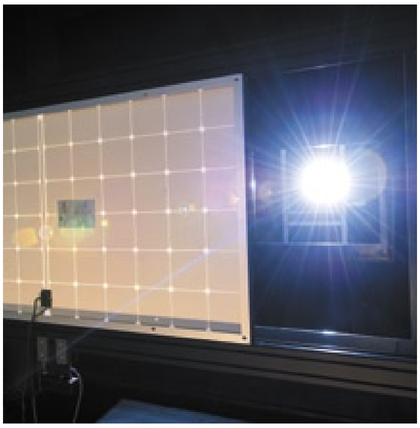
Presented by SOLARWORLD THE SUNPOWERED COMPANY®

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

PHOTON Photovoltaic Technology Show
Latest production equipment on display in Munich in March


Norbert Michalke / 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.

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

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

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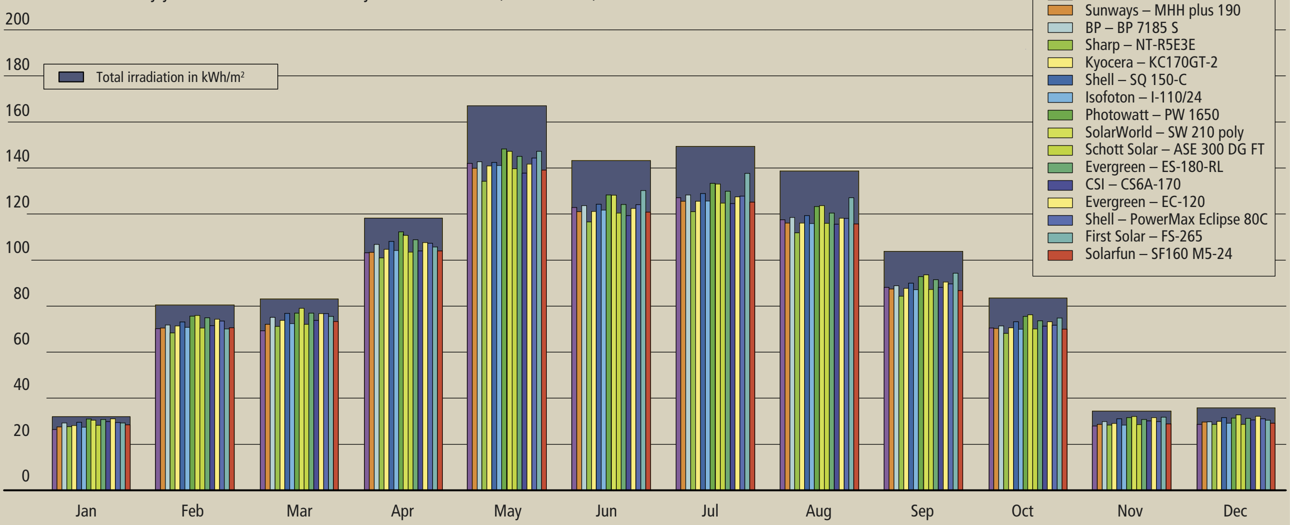
▲ A big black box: PHOTON Lab's solar simulator is installed in a dark chamber.

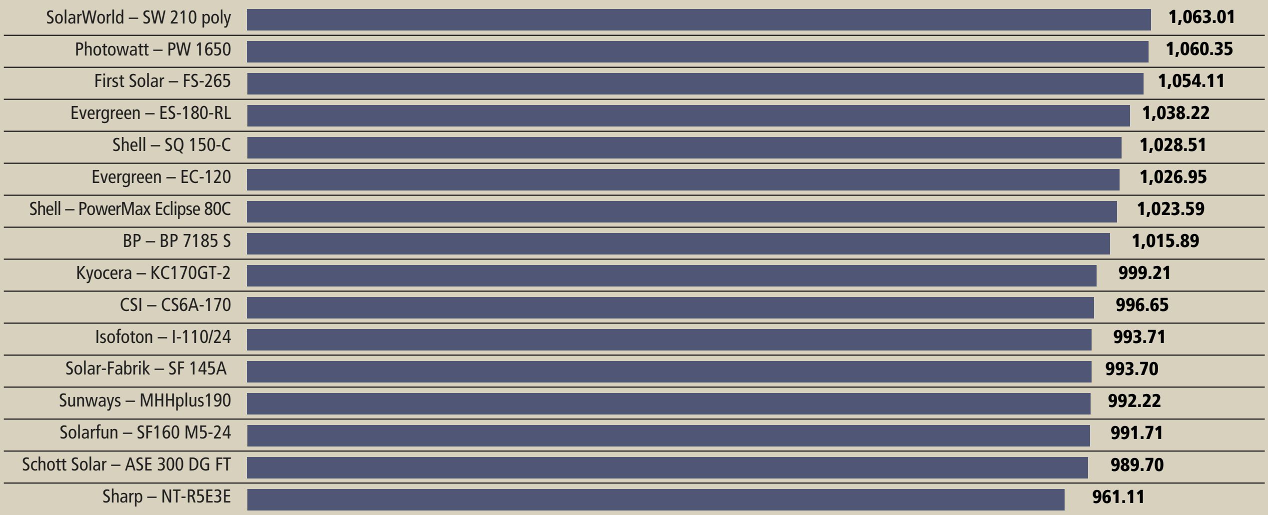
PHOTON Lab's module test 2008

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 kW 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

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TEST WINNER

PHOTON MODULE TEST 2008

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