Photon
LABORATORY

Solar Module Yield Measurement 2011/2012

In a comparative measurement, the yield of more than 80 module types is measured on PHOTON's outdoor test field

Facts

- Detection of each module`s yield (second-by-second) using sophisticated measurement devices
- Evaluation of the module`s yield independent of other system components
- Performance measurement under real outdoor conditions for a period of 12-months
- Standardization of the monthly and annual yield to the STC power measured at PHOTON Lab
- Collection of the solar irradiation and weather data for in-depth analysis

Check the monthly test results in:

- PHOTON Profi (German)
- PHOTON – Das Solarstrom-Magazin (German)
- PHOTON – Le Magazine du Photovoltaïque (French)
- PHOTON – Il mensile del fotovoltaico (Italian)
- PHOTON – La Revista de Photovoltaica (Spanish)
- PHOTON – International (English)
- PHOTON – International (Chinese)
- PHOTON – The Photovoltaic Magazine (English)

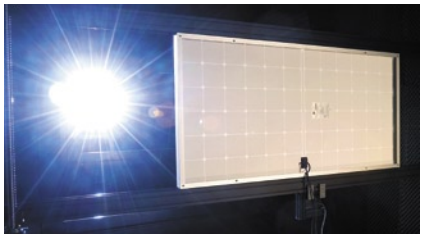
www.photon-laboratory.com

How PHOTON conducts its test

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 Lab intends to answer with its module field tests. Over the course of 2010, a total of 26 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.



Norbert Michalke / photon-pictures.com

PHOTON Lab is using a Pasan Class AAA Sun Simulator to detect the maximum power of solar modules under STC.

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 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. This is exactly the point where PHOTON Lab 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. Since then, PHOTON Lab has conducted its own power measurements for each module being tested under standard testing conditions (STC).

René Düpont, Jochen Siemer

SOLAR MODULES: RESULTS OF PHOTON YIELD MEASUREMENTS IN 2010

In test since	Ranking	Manufacturer	Model	Cell type	Origin	Yield in kWh/kW	Below 2010 best by
2009	1	**Siliken SL**	SLK60P6L 230Wp	poly	Spain	1,044	**best of 2010**
	2	**Kioto Photovoltaics GmbH**	KPV 210 PE*	poly	Austria	1,022	**2.1 %**
	3	**Win Win Precision Technology Co. Ltd.**	Winaico WSP-230P6	poly	Taiwan	1,021	**2.3 %**
	4	**Trina Solar Energy Co. Ltd.**	TSM-180DC01	mono	China	1,020	**2.3 %**
	5	**Frankfurt CS Solar GmbH**	FS215W-Poly	poly	China	1,020	**2.3 %**
	6	**Mage Solar GmbH**	Mage Powertec Plus 225/6PJ	poly	China	1,019	**2.4 %**
	7	**S-Energy Co. Ltd.**	SM-220PA8	poly	South Korea	1,018	**2.6 %**
	8	**PV Power Technologies Pvt. Ltd.**	PVQ3 220	poly	India	1,016	**2.7 %**
	9	**Sunrise Solartech Co. Ltd.**	SRM-180D-72	mono	China	1,003	**3.9 %**
	10	**Isofoton SA**	IS-170/24	mono	Spain	950	**9.1 %**
2007	1	**First Solar LLC**	FS-265	CdTe	USA	1,013	**2.9 %**
	2	**Shell Solar GmbH**	Powermax Eclipse 80-C*	CIS	USA	987	**5.5 %**
	3	**Solarfun Co. Ltd.**	SF160 M5-24 (175 W)	mono	China	959	**8.1 %**
	4	**Canadian Solar Inc.**	CS6A-170P	poly	China	957	**8.4 %**
	5	**Evergreen Solar Inc.**	ES-180-RL*	ribbon	Germany	955	**8.5 %**
	6	**Schott Solar GmbH**	ASE-300-DG-FT (300 W)*	ribbon	USA	935	**10.4 %**
2006	1	**Solarworld AG**	Sunmodule Plus SW 210 poly*	poly	Germany	1,005	**3.7 %**
	2	**Photowatt International SAS**	PW 1650-175W	poly	France	999	**4.3 %**
	3	**Shell Solar GmbH (jetzt Solarworld)**	SQ 150-C*	mono	Portugal	994	**4.8 %**
	4	**Evergreen Solar Inc.**	EC-120*	ribbon	USA	986	**5.6 %**
	5	**Isofoton SA**	I-110/24*	mono	Spain	944	**9.6 %**
	6	**Kyocera Corp.**	KC170GT-2*	poly	Japan	941	**9.8 %**
2005	1	**BP Solar International Inc.**	BP 7185 S*	mono	Spain, India	944	**9.6 %**
	2	**Solar-Fabrik AG**	SF 145A*	ribbon	Germany	934	**10.5 %**
	3	**Sunways AG**	MHH plus 190 (190 Wp)*	poly	Germany	931	**10.8 %**
	4	**Sharp Corp.**	NT-R5E3E*	mono	Japan	914	**12.5 %**

Irradiance at module plane*: 1,193.1 kWh per m² per year**
Global irradiance (horizontal)*: 1,031.2 kWh per m² per year**
Please note: Yield data for each module are normalized to yield under standard test conditions (STC) – more precisely, to the average yield of the test candidates of each module type, as measured at PHOTON Laboratory. *no longer manufactured **previous model designation: SW 210 ***measured with thermopile pyranometer CM21 from Kipp & Zonen BV

A note on the 2010 yield measurements

PHOTON first published annual yield results in February 2011 for modules that had been on PHOTON Lab's test field for the full year in 2010. Modules that were installed beginning in January 2010 therefore couldn't be included in the annual results. This corresponds to modules from four manufacturers: REC Solar, Bisol, Trina Solar and Solarfun.

Given that these modules were nevertheless up and running for just less than a full calendar year, and that January is an especially low-yield month, we created a projected yield for the missing month. To get this value, we found the ratio of the yield of the best-performing module (SLK60P6L 230 Wp from Siliken) in January 2010 to its yield in January 2011. We then applied that ratio to the January 2011 yields of the four modules in question to generate projections for January 2010.

Therefore we are able to also present yield values for the entire year 2010 for these modules, albeit with a small margin of error. The actual values could have differed from the projected values by a range of about 3 kWh, which we determined by comparing the same calculation to known yields from January 2010.

Taking into account this small margin of error, we decided nevertheless to publish a list of the latecomers. While the difference from the best module indeed carries the same margin of error, we included it because its deviation from the real measurement data is minor – in contrast to a ranking.

The results for the four latecomers show a distribution that differs very little from the results we published a month ago. The REC module is neck and neck with 2010's top-ranked module from Siliken. The Solarfun module is the worst-performing latecomer. It falls just below the model from Sunrise, which was the worst of the 2009 group – if you leave out the extreme outlier, Isofoton. *cpo*

SOLAR MODULES: LATECOMERS IN PHOTON LAB'S 2010 RESULTS

In test since	Manufacturer	Model	Cell type	Origin	STC power (W)	Yield (kWh/kW)	Below 2010 best by*
2009	**Siliken SL**	SLK60P6L 230Wp	multi	Spain	229.7	1,044	**best of 2010**
1/2010	**REC Scanmodule AB**	REC230AE	multi	Sweden	228.6	1,040	**0.4 %**
1/2010	**Bisol d.o.o.**	BMU-215-2/221	multi	Slovenia	229.1	1,019	**2.4 %**
1/2010	**Trina Solar Energy Co. Ltd.**	TSM-PC05 (225)	multi	China	233.0	1,012	**3.1 %**
1/2010	**Solarfun Co. Ltd.**	SF160-24-1M175	mono	China	183.0	1,003	**4.0 %**

*because a small portion of the results for the four modules added in January 2010 is projected, the actual difference in yield may differ slightly from that which is presented here

Photon
LABORATORY

Order

Ordering Party

Company _____

Contact Person _____

Street _____

Zip Code / City _____ _____

Country / State _____

Phone _____

Fax _____

E-Mail _____

1. Starting point

By signing this document, the ordering party commissions PHOTON Laboratory GmbH to grant the license of a set of measuring data.

The data, which is put at free disposal for the ordering party, includes the following parameters:

- Annual energy yield for the calendar year
- Annual energy yield adjusted for the nominal sun year
- Module power parameters at different irradiation levels, ambient temperatures, and angles of incidence
- Provision of data for the single and dual diode model
- Comprehensive measuring data, indicating potential improvements of the module design to achieve higher yields

Test results and evaluations (including partial and interim results) generated during the 12-month test period will be released in the publications of PHOTON Europe GmbH and PHOTON USA Corp,.

2. Prerequisite

The prerequisite of a generally accepted, conclusive and realistic test is that the three modules provided by the ordering party for the test are regarded as standard modules with serial numbers randomized from the current production. By signing this document, the ordering party confirms the compliance of the modules with this vital prerequisite.

Ordering party

Manufacturer: .....

Module type: .....

Serial number: .....

Production date: .....

3. Right of use

The ordering party shall be entitled to use the published test findings for advertising purposes. In doing so, the ordering party's advertisements shall be designed in such a way that the consumer will not get an incorrect impression of the quality and performance assessment of the advertised module type from the test findings. The ordering party shall always mention the date of evaluation or release by PHOTON.

4. Payment

€ 9,700 net, due within 14 days after date of invoice.

5. Transfer of ownership

After receipt of the measurement data package, PHOTON Laboratory GmbH shall become the owner of the three tested modules plus accessories and documents. PHOTON shall ensure that the modules received will not be disposed, nor shall they be made available gratuitously to third parties.

The signatory assures that he or she has company authorization to sign this order.

Location, date _____ Signature _____

PHOTON Laboratory GmbH • Yield Measurement • Juelicher Strasse 376 • 52070 Aachen (Germany)
Phone +49 - 241 / 40 03 - 53 00 • Fax +49 - 241 / 40 03 - 57 00 • martina.siebmanns@photon-laboratory.com