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New products on display in Milan

Preview of Europe's annual PV conference and exhibition

Silicon slices from Oregon

Sparsely populated state evolving into largest US wafer hub

PV in Europe series: Sweden & Turkey

Strong module manufacturing base in the north, but limited PV activities in the south

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Good or bad connection?

PHOTON Lab puts module connectors to the test

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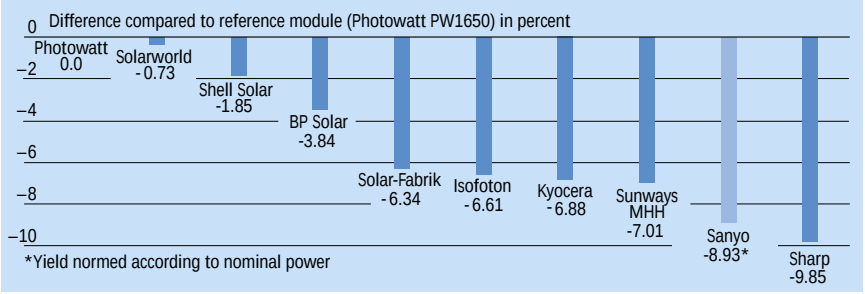
Not up to snuff

In PHOTON Lab's module test, one module in particular – Sanyo's – lags far behind

For an entire year now, 10 different module types have sat on PHOTON Lab's test bench in Germany. The test results are surprising: of all things, one of Sanyo's HIP modules performed second to last. But not necessarily for technological reasons. It has more to do with this particular test module's dubious origin. Nevertheless, the results are quite interesting, even for other manufacturers, as they reveal a great deal about the state of the German PV market.

Comparing results



High yield: Photowatt PW1650 modules have the highest standardized yield; the other candidates are measured against it. SolarWorld and Shell modules followed in second and third place, respectively.

Last September, the first four solar modules mounted at PHOTON Lab's outdoor test site in western Germany completed their first 12 months under the sun (see PI 10/2006, p. 8). Now this club of four has become 10: BP Solar, Sharp, Solar-Fabrik, and Sunways panels are joined by modules from Isofoton, Kyocera, Photowatt, Sanyo, Shell, and SolarWorld.

They belong to the very small number of solar modules subjected to independent, ongoing public testing. The tests are »public« in the sense that the results obtained by manufacturers from institutions like TÜV or other research institutes are usually for the client's eyes only, and are hardly ever made public. Whoever seeks an answer to the fundamental question of how much electricity yield a certain solar module is good for will have a hard time finding it there.

This information is now available – well, at least for 10 modules. But as always, there's a little bad news with the good: without consideration of a few details the results from PHOTON Lab's test are not comparable. These factors aren't a result of any technical inadequacy in the test – the elaborate measurement procedure covers everything (see box, p. 22). The data obtained is substantiated, and the measured yields of each solar module are standardized according to its output under standard testing conditions (STC) – in other words, the module's power as measured by a solar simulator in the manufacturer's production facility. Of course, one could argue that some module brands use a more precise solar simulator than others – but when all goes according to plan, the devices are still aligned with a calibrated reference module, and therefore results should lie within a uniform tolerance range. Simulator data is unequivocally better for comparisons than the nominal power (Pnom) listed on the specification plate. It allows different module types to be compared with one another. Second, solar simulator data has narrower tolerances than the power values on the specification plate, which often show significant deviations.

For this reason, what appears at first glance to be a sensationally poor performance on the part of Sanyo's HIP-J54BE2 should be taken with a grain of salt. The three test specimens were purchased from a distributor that sold us »samples.« Unfortunately, we only discovered this later. That doesn't necessarily mean that they should be cheap products, or somehow »low-yield sub-standard goods« – although that's what Sanyo claims. When we requested data from their tests, Sanyo said that the devices were produced for demonstration purposes only, and therefore were not measured with a solar simulator at the factory.

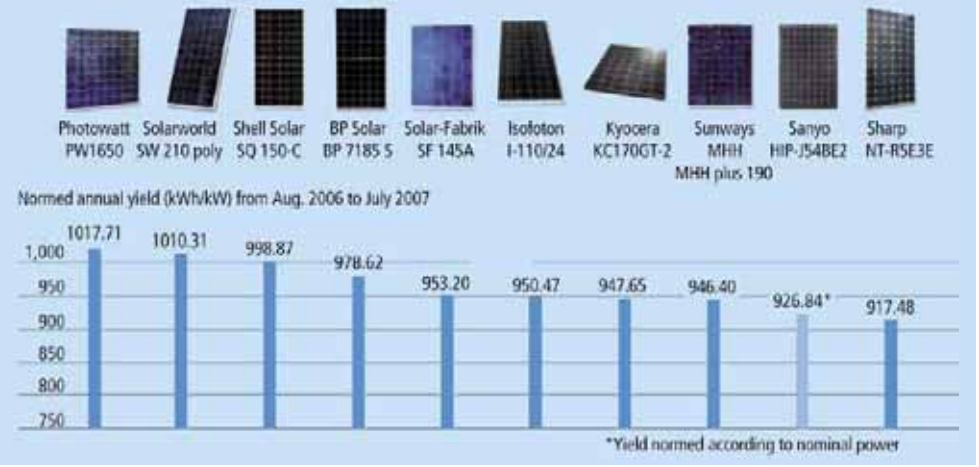
Nevertheless, we felt it was worthwhile to include the three Sanyo HIP modules in the test, seeing as Sanyo has repeatedly touted their module's particularly strong yields, and since they were available – for whatever reason – at reasonable prices. And the results are interesting: if HIP modules delivered to stores via conventional distribution channels really do produce above-average high yields – which is still to be tested – then the actual power of the three specimens

Results of module tests after one year*

Module type	Pnom (W)	PSTC (W)	Yield (kWh)	Normed yield (kWh/kW)	Average of normed yield (kWh/kW)	Performance ratio (%)	Average of PR (%)
Photowatt – PW1650	175	172.64	177.45	1,027.89	1,017.71	92.26	91.34
	175	170.32	167.79	985.14		88.42	
	175	171.43	178.30	1,040.10		93.35	
Solarworld – SW 210 poly	210	213.21	214.28	1,005.02	1,010.31	90.21	90.68
	210	212.37	217.43	1,023.82		91.89	
	210	212.2	212.64	1,002.08		89.94	
Shell – SQ 150-C	150	153.2	160.12	1,045.18	998.87	93.81	89.65
	150	156.5	150.67	962.74		86.41	
	150	155.8	154.04	988.68		88.74	
BP 7185 S	185	186.1	181.91	977.73	978.62	87.76	87.84
	185	185.1	181.24	979.32		87.90	
	185	187.6	183.60	978.81		87.85	
Solar-Fabrik SF 145A	145	145.80	135.76	931.16	953.20	83.58	85.55
	145	145.46	141.86	975.24		87.53	
Isofoton – I-110/24	110	102.498	96.90	945.38	950.47	84.85	85.31
	110	100.317	97.54	972.29		87.27	
	110	100.464	93.81	933.75		83.81	
Kyocera – KC170GT-2	170	178.4	169.96	952.69	947.65	85.51	85.06
	170	176.8	165.69	937.18		84.12	
	170	177.2	168.89	953.08		85.54	
Sunways / MHH plus 190	190	199.5	187.05	937.82	946.40	84.17	84.94
	190	199.6	190.64	954.98		85.71	
Sanyo – HIP-J54BE2	180	–	166.24	923.57	926.84	82.90	83.19
	180	–	159.89	888.29		79.73	
	180	–	174.36	968.66		86.94	
Sharp NT-R5E3E	175	187.9	169.94	904.54	917.48	81.19	82.35
	175	188.0	173.21	921.39		82.70	
	175	187.9	174.12	926.53		83.16	

* Aug. 2006 to July 2007; Irradation at module level: 1,114 kWh/m²

Normed annual yield (kWh/kW) from Aug. 2006 to July 2007



A significant deviation: PHOTON's recent module tests measured 10 modules. The module with the highest yield (Photowatt) and the module with the weakest yield (Sharp) are separated by almost exactly 100 kWh per kW.

purchased by our staff is substantially below nominal power. In other words: it looks like we bought second quality stock at the full price. In that case, it's less a dilemma for Sanyo's engineers than it is a problem for the company's sales team – or even the legal department.

Other oddities emerged from testing as well. Although not second quality stock, the test specimens from Isofoton apparently aren't particularly well suited for use in grid-connected PV systems. At least that was the explanation given for the rather meek performance of the I110/24 module when we contacted the company. This device is exclusively designed for use in off-grid systems, it said, and distributors only sell the modules for that purpose. But not this time. Perhaps the dealers in question asked what technical difference it makes on the module side whether the energy feeds into the grid or into a battery – in the latter configuration there isn't a meter, so the customer can't check whether his installation is actually delivering the expected yield.

Sharp's solar modules deliver far beyond expectations – that is, at least in the area of wattage. All three of this manufacturer's candidates had actual powers significantly above the nominal power. There is no question that the results are impressive, but these results, too, should be taken with a grain of salt. It's impossible, regardless of how hard we try, to obtain a small sample of three of the same module type on the open market. So, PHOTON had to order test specimens directly from the manufacturer. Nevertheless, we didn't just allow the manufacturer to choose the modules itself, but rather selected the test specimens randomly from a list of serial numbers.

And even if the manufacturer in question specifically sought out particularly high-yield specimens to supply PHOTON's test laboratory, that wouldn't have helped them in the final analysis. The yield in kWh per kW power is standardized to the power from the flasher test, which means, for all practical purposes, the nominal power is actually irrelevant.

The impressive ratio between these two values didn't prevent Sharp's module from coming in last in the rankings when it came to total comparison of annual yields. The total yield is calculated from adding measurements gathered between the start of Aug. 2006 and the end of July 2007, one per second from electronic measuring equipment – that's about 31.5 million data points per module. The test candidates' average yield was nearly 965 kWh per kW with an irradiation sum at the module level of 1,114 kWh per m^2.

The choice to purchase three specimens of every module type proved to be a wise precaution, not only as a means for filtering out faulty products, but also in the event that irregularities surfaced during the test. For instance, one of the Sunways modules delivered significantly weaker performance than the two other Sunways specimens. Naturally, that could have been a defect in the measuring device attached to this module, but an examination of the device eliminated that possibility. We are still trying to locate the cause of this aberrant behavior, which is why the yield measurement analysis didn't include this module. The same goes for one of Solar-Fabrik's modules – it, too, was eliminated from the yield analysis on account of abnormal behavior. On the other hand, one of the three BP modules, eliminated last year on account of a manufacturing flaw in the measuring device, is back in the race, at least for the immediate term.

In total, we tested 28 specimens from 10 different module types that delivered an average annual yield of 965 kWh per kW. The mean standardized annual yield for each model ranged from 1,017 to 917 kWh per kW. The module with the highest yield (Photowatt) and the module with the weakest yield (Sharp) are separated by almost exactly 100 kWh per kW. In this test series, Photowatt's PW1650 had a performance ratio – i.e. the relationship between irradiation and yield – of 91.34 percent, and serves as the reference point with which all other candidates must be compared. The modules from SolarWorld and Shell deviated at most 1.85 percent from the reference point, which is still within the measuring tolerance (see graph, p. 20). The Shell module now also comes from the house of SolarWorld, which purchased the oil giant's monocrystalline solar business. So, presumably, SolarWorld will be as pleased with the final results as Photowatt.

René Düpont, Jochen Siemer

Test configuration

Three modules of each type are represented in order to filter out any potential lemons, and in case any damages are incurred during testing on the side of the module or the test equipment. The panels are ground-mounted in a field in western Germany at a height of about 2.5 m and oriented to the south at an angle of 28 degrees – that is, elevated and rear-ventilated.

A self-developed electronic measuring device collects the measured data automatically directly at the point of departure from each module, eliminating yield reductions stemming from faulty cabling and inverter installation. Each second, from each module, the instrument records a complete current-voltage curve with 2,000 data points and a nominal resolution of 14 bits and delivers the Maximum Power Point (MPP). The measurement error tolerance is currently at 1.85 percent. In addition, irradiation data and climate data is provided up to the second by a high-precision pyranometer. *rd*

The following panels are currently undergoing outdoor testing at the PHOTON Lab:
- Schott Solar ASE-300-DG-FT
- Evergreen Solar ES-180-SL
- CSI CS6A-170
- Evergreen Solar EC-120

In preparation:
- Solarfun SF1600M5-24
- Shell PowerMax Eclipse 80-C
- Sanyo HIP-210NHE1
- SunPower SPR-220
- First Solar FS-265

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