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Photon

THE SOLAR POWER MAGAZINE

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Solar modules 2010

Making the right decision

TEST WINNER
REPRINT

Thin-film or crystalline silicon?

Which manufacturer?

What price?

Are there any test results?

China-modules, or made in Germany?

California

An increasing number of residents uses the power of the sun to produce electric energy

Solar Farms

Why ground mounting systems make sense on farmland

EEG-No

1.500 whole sa

What really matters: performance, efficiency, yield

The PHOTON lab started five years ago with the first module tests. Since then, the lab has been and is still being expanded with equipment for optical inspection (infrared and electroluminescence cameras) and most importantly a power analyzer (Flasher). The next planned step is the commissioning of a climate chamber.

The focus still is the measurement of the modules themselves. Thereby, the final yield of each system is determined. How many kilowatt hours of power does a module generate during one year?

The question sounds trivial but to answer it accurately requires a major effort. The modules – three of one brand – are installed in an open area, so there are no shadows, no differences in temperature and no influences caused by reflections. They are permanently on load, feeding power into the grid. This is not to collect the feed-in tariff but because the modules would heat up excessively while idle. This in turn affects the efficiency (it decreases with increasing temperature) and thus the performance.

Nevertheless, the measurement of the yield is to happen upstream and not downstream of the inverter. Otherwise, the inverter would distort the result with its own possible weaknesses and also because not every module works equally well with a given inverter, thus discriminating against individual test candidates. At the PHOTON test facility, the modules are connected to the inverter via a DC-DC converter and a DC bus (DC: direct current).

During the actual measuring process, the modules are disconnected from the grid for a split second. A current-voltage characteristic (I / V characteristic) with 2,000 measuring points is recorded. The product of current and voltage is power (measured in watts), this in turn multiplied by time is the yield (expressed in watts or kilowatt hours). So one only has to record an I/V characteristic often enough to know the yield. On the PHOTON test field, this is done once per second. The yield data is therefore the result of some 3,154,600 characteristic measurements per year. Each of these measurements takes about one hundredth of a second, after which the module goes back on-line. 99 percent of its operating time, it is under load.

Annual results of these measurements are currently available for 16 types of modules. When choosing a module, its manufacturing quality will be important, in other words its long-term stability and not just the yield. This, however, is the most important of all criteria and on the medium and long term, says a lot about the other qualities. Only good workmanship during manufacture leads to adequate yields.

Consideration of the test results can also serve to bring some clarity to three concepts that are often confused in sales talks: performance, efficiency and yield.

As already described, the output of a module is the product of current and voltage. These two values will vary depending on the irradiation conditions: a solar module has a higher output with a clear sky than it does with a cloudy one.

The efficiency is the ratio of performance and area: the higher the efficiency, the more power can be generated on a given surface area.

The performance and thus the efficiency is measured in so-called Standard Test Conditions (STC), namely with an irradiation of 1,000 watts per square meter, 25 degrees Celsius cell temperature and a light spectrum corresponding to 1.5 air masses. (Vertically incident solar rays take a shorter route back through the atmosphere than obliquely incident rays and therefore have to pass through a smaller mass of air, which in

Norbert Michalke / photon-pictures.com (2)

Measurements in the PHOTON laboratory: the STC-output of a module is determined by the flasher within a split second. The measurement of the yield will take a little longer – namely, one year on the free-field test facility.

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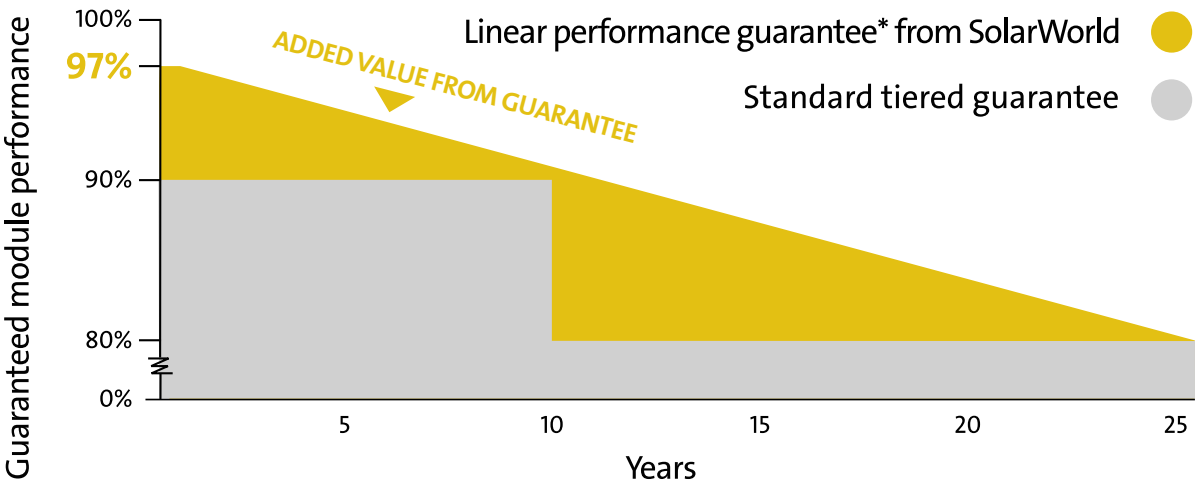

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SolarWorld provides double protection for investments in clean energy and is the first manufacturer to offer the following for all newly installed modules:

- **The 25-year SolarWorld linear performance guarantee*, insures at least 97% of the rated power in the first 12 months and a maximum reduction in power of 0.7%* per year thereafter**
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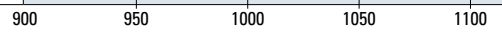
Results of the PHOTON yield measurements

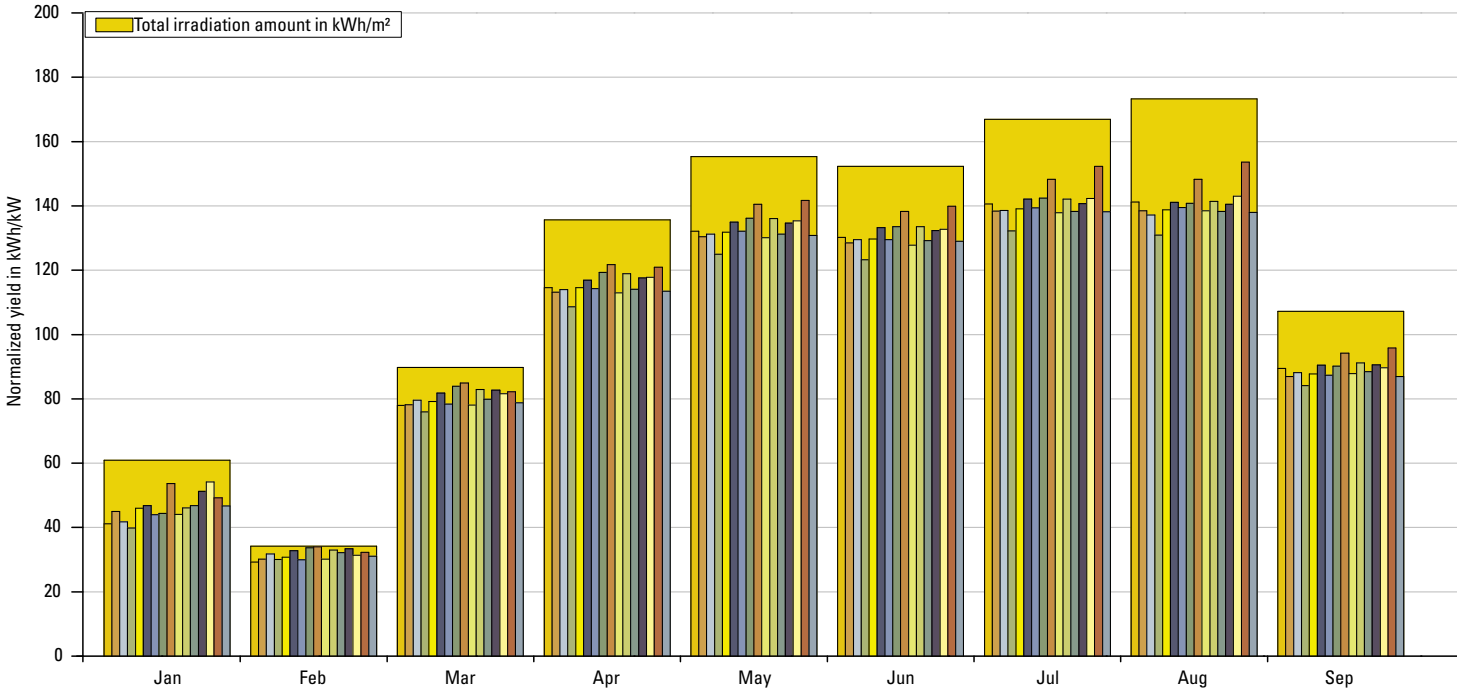
Results of yield measurements 2009

Manufacturer	Module type	Cell type	Country of origin	Year of installation	Rated performance (W)	»Rated« efficiency (%)*	STC performance	»STC« efficiency (%)** in kWh/kW**	Ertrag in kWh/kW**
Solarworld	Sunmodule Plus SW 210 poly****	poly	Germany	2006	210	12,5	212,6	12,7	1.084
First Solar	FS-265	CdTe	USA	2007	65	9,0	65,4	9,1	1.079
Photowatt	PW 1650-175W	poly	France	2006	175	13,0	171,5	12,8	1.038
Shell	Powermax Eclipse 80-C***	CIS H	USA	2007	80	9,3	87,6	10,2	1.037
Evergreen	EC-120***	ribbon	USA	2006	120	11,6	119,5	11,5	1.037
Evergreen	ES-180-RL***	ribbon	Germany	2007	180	12,0	183,9	12,3	1.036
Shell	SQ 150-C***	mono	Portugal	2006	150	11,4	155,2	11,8	1.033
CSI	CS6A-170P	poly	China	2007	170	13,0	174,5	13,4	1.009
Kyocera	KC170GT-2	poly	Japan	2006	170	13,3	177,5	13,9	1.005
Solar-Fabrik	SF 145A***	EFG	Germany	2005	145	11,8	146,0	11,9	1.000
Isofoton	I-110/24***	mono	Spain	2006	110	12,8	101,1	11,8	1.000
BP Solar	BP 7185 S***	mono	Spain, India	2005	185	14,7	186,2	14,8	999
Solarfun	SF160 M5-24 (175 W)	mono	China	2007	175	13,7	174,5	13,7	998
Sunways	MHH plus 190 (190 Wp)***	poly	Germany	2005	190	13,4	198,6	14,0	993
Schott Solar	ASE-300-DG-FT (300 W)***	EFG	USA	2007	300	12,4	308,5	12,7	993
Sharp	NT-R5E3E	mono	Japan	2005	175	13,5	188,0	14,4	953

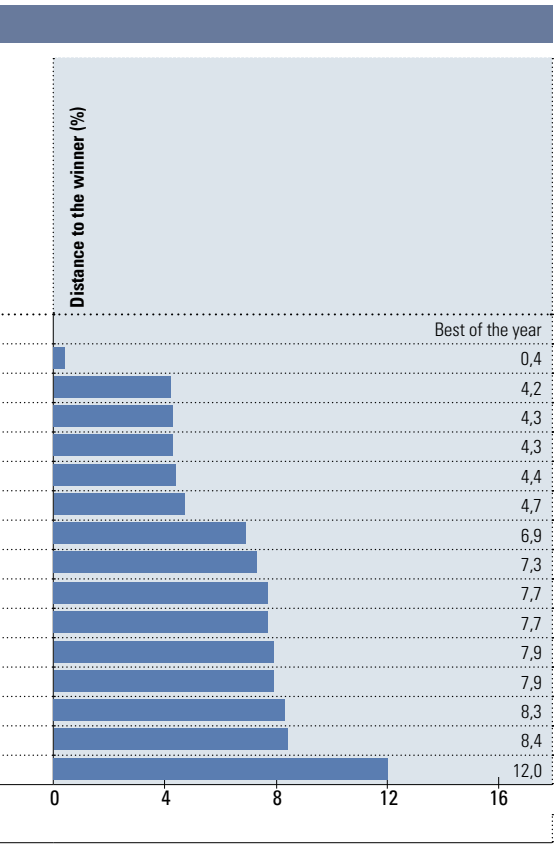


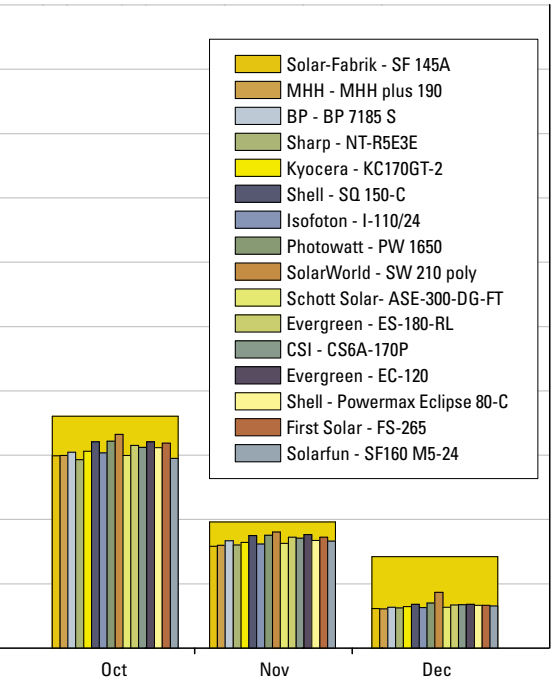
*normalized with the rated performance, ** normalized with the STC performance, ***no longer manufactured, ****previous name SW 210 poly

Monthly normalized yield in 2009 in kWh/kW and total irradiation amount (module level) in kWh/m² (2009: 1215.47 kWh/m²a)



The annual yield of the modules on the PHOTON test field in monthly resolution: you can clearly see the summer months form a major part of the total yield – with all types of modules, including those manufactured with thin film technology. The bottom line is the ability to generate as much energy as possible in direct sunlight. Good »weak irradiation« capabilities however, play a minor role.





turn affects the light spectrum.)

For technical reasons, it is not possible to manufacture solar modules with a perfectly constant power output. Therefore, there are always two relevant values: the rated performance and actual performance. The former is the manufacturer's specified value for a particular type of module.

It is always an average with certain tolerances – the smaller they are, the better. The actual performance, however, is determined for each module using a flasher. This is also done in standard test conditions, which is why it is called STC performance. The corresponding measurement log (»flasher log« or »flasher-list«) should be enclosed on delivery. To illustrate the differences between rated and STC performance and their respective impacts on the efficiency, both values are listed in the yield measurement table below: the rated performance and the resulting »rated efficiency« and the STC performance and »STC efficiency.«

Of course the efficiency says something about the quality of the solar module. However, only modules using the same technology are comparable. It would be nonsense to compare a thin-film module to a crystalline one. And ultimately, the operator is only interested in the question of how many kilowatt hours of electricity his module generates. The often-heard claim that modules with a high efficiency were better than others and should cost more is therefore not quite true. In the PHOTON test, the module with the lowest efficiency (First Solar FS-265) came second and was only barely beaten by the winner (SolarWorld Sunmodule SW 210 poly). The module with the highest efficiency (BP Solar BP 7185 S), came 12th with a large distance to the lead. And the SolarWorld module is also equipped with polycrystalline cells just like the MHH plus 190 (190 Wp) from Sunways, which has a significantly higher efficiency to boot. Nevertheless, it provides significantly lower yields.

Also interesting for the operator is the question of how close the rated performance is to the STC performance. The purchase price is usually determined by performance – the rated performance. If it is higher than the actual value, you pay for something that you don't get. Conversely, if the STC performance is higher than the rated performance, you get a few watts for free.

In the PHOTON yield test, the measured yields are always normalized with the STC performance. This is a small injustice in the assessment of those manufacturers that – laudable in itself – tend to declare the performance rating more conservatively, to which the purchaser however has no claim. The last place in the yield analysis 2009, the module Sharp NT-R5E3E, demonstrates this most clearly, as there is a particularly large gap between the 175 watts performance rating and the actually measured STC performance of 188 watts (average of three mounted specimens on the test field). If one were to normalize the yield of this module with the rated performance instead of the STC performance, 1023 kilowatts hours per kilowatt instead of 953 would be the result, and thus a much better placement overall. Those types of modules for which the STC performance is lower than the rated performance (Photowatt PW 1650-175W, Evergreen EC-120, Isofoton I-110/24) would, however, fall back.

On the other hand, normalization with the rated performance would clearly favor manufacturers that are deliberately overmodest with their performance ratings and who – apparently – can report good yield data for systems equipped with their modules this way. Above all, testing is about comparability, and this can only be guaranteed if the yield is normalized with the STC performance. To make purchasing easier, solar modules should always come with a flasher protocol and be priced according to the indicated performance rating.

Above all, the specific yield, based on the measurable STC performance value, is not just a sample calculation, but also an indicator of the technological maturity and manufacturing quality of a solar module. If it develops 100 watts of power under standard test conditions but slacks disproportionately with irradiation conditions far more common in practice, it will provide poor yields. If it works well in various conditions however, you will see some good yields in the end. And exactly that – converting available light into electricity as effectively as possible – is what it's all about. *js*

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