. 04 | April 2010 | 3,80€

ÖKO-TEST

LIFE WORTH LIVING

The TESTs

Reports and advice

Extra

25 years of ÖKO-TEST

REVIEW Photovoltaik panels

Packed with energy

Solar power is booming - even though the German government has said it will cut back substantially on its support. ÖKO-TEST magazine looked at 15 photovoltaic panels from German and other manufacturers. What we found was encouraging: most of them live up to their makers' claims.

The test results

■ House owners who have already installed solar can rest easy. The quality of most of the panels was good to very good. Only two products - from Ningbo Solar/Sig Solar and Suntech Power - were found to have serious weaknesses. Although we obtained these from the usual outlets, we later discovered that they had been manufactured in 2008.

Some manufacturers' products were grouped at the lower end of the performance tolerance band.

■ With one exception, all panels delivered the output claimed by the manufacturers under standard test conditions. In some cases the average value of the two samples tested was better than the manufacturer's performance tolerance. More than two thirds of manufacturers select their cells with negative tolerance values in mind - so that the output of the finished product may indeed be lower than the rated figure. If we found that the measured output was 0.5 percent and more below the rated output, i.e. towards the lower end of the tolerance band, we deducted one point. The average measured values for both samples of the Suntech STP190-18/ Ub panel were below the performance tolerance. We made no allowance for possible ‚measurement uncertainties'.

If there is a negative performance tolerance, we include this fact in ‚Other defects'. Only four manufacturers are consumer-friendly enough to select the cells for their panels in such a way that their products always achieve their rated output.

■ The panel's efficiency is calculated from the measured output generated from irradiation. Monocrystalline cells have an efficiency of around 14 percent and polycrystalline cells around 13 percent. Another parameter that depends on the quality of a solar panel is the fill factor, which was below 73 percent in four cases. Our experts found the efficiency and fill factor of the products from Ningbo Solar/Sig Solar and Suntech Power too low.

■ Solar panels should still produce power when there is not much sunlight. We compared the efficiency with low solar radiation of 100 with the figure for 1,000 W/m2. The efficiency of four of the panels dropped by over ten percent, which is not good enough according to our test lab. When panels become very warm, their output decreases - by around 20 percent at 70 degrees Celsius. Here, four products did not provide what we considered to be a minimum performance. The M220-60 GET AK, 230W panel from Solarwatt was worst in this regard.

When the sun beats down and the panels get hot, they produce less electricitiy

■ Photographs taken with electroluminescence and thermal imaging cameras revealed seven products with small imperfections such as fine cracks. In time, these could lead to the loss of sections of the panel and so degrade its performance. This had in fact already happened to the Sun Earth TDB125X125-72-P in some places.

The manufacturers' responses

Both the German Suntech subsidiary and Sig Solar, which markets Ningbo Solar products in Germany, pointed out to us that we had tested panels produced in 2008. However, they had been offered to us for sale through the normal channels. Both manufacturers stressed that these products were no longer in their range and that they had been replaced with products of improved quality and performance, i.e. with higher output. They also told us that the warranty terms for both of these items had been revised. ÖKO-TEST intends to test the current versions of these panels and publish the findings in a future edition of the publication.

Anna Mai ▷

Our test methods

Purchasing

We commissioned the Aachen-based PHOTON laboratory, which is a member of the PHOTON Group under whose umbrella the solar journal PHOTON is published. The test institute purchased 15 different photovoltaic panels with monocrystalline and polycrystalline cells, since these account for the biggest share of the market. The purchases included major German and foreign brands, primarily from China. Unfortunately, some brands like Solarworld and Conergy do not appear in our review because some manufacturers' panels were unavailable at the time.

Testing the power output

A quick check carried out on the test bench with two samples of each panel told us whether each panel was in order and was delivering its rated output. First, we measured the panel's maximum output under standard test conditions using the sun simulator, which is exactly how the manufacturer arrives at his own specification figures. This information can then be used to calculate other performance figures. As the sun does not always produce 1,000 watts per square metre, we reduced our test radiation to 100W per square metre to check how much electricity the cells would deliver under these unfavourable conditions. When the panels get warm, they produce lower outputs on the testbench than at moderate temperatures. For the layman, it is hard to believe that outputs are reduced when the sun is blazing down on the roof. With the aid of temperature coefficients, which we also worked out, we calculate how much the output is affected at 70 degrees Celsius - a temperature that is perfectly feasible under bright sunny conditions. The PHOTON test lab was also able to check, or screen, each panel for damage. When an electric current is applied, the irradiation of photons in the invisible infrared spectral range causes the cells to illuminate, and this can be captured with an electroluminescence camera. This technique is used to show up abnormalities or defects such as fine cracks, splits and cell impurities. Serious defects of this nature can cause a reduction in output, whilst smaller defects are likely to become worse in time. Photos taken by a thermal imaging camera helped our testers to evaluate product quality.

Market and prices

We have not included prices because these are in constant flux; they also vary depending on product availability and on order quantities. There are also regional differences: panels are more expensive in the country's solar strongholds such as Southern Germany. If you are interested in having a solar system fitted and ask a specialist installer for a quotation, you may find that he does not list the cost of the panels separately. Every installer calculates the final price differently. Panel prices are stated per watt or kilowatt. The PHOTON test institute which acted on our behalf purchased two panels at a time from wholesalers at a cost of between EUR 1.39 and 2.15 (plus VAT) per watt at the beginning of 2010. Generally speaking, the Chinese panels were in the lower and the European ones in the upper price range.

Our ratings

Because what counts with PV modules is how much current they produce, our power output measurements were the most important single factor in our ratings. We deducted points for below average output and problems like non-working cells. We based our scores on the average of the two samples tested. If the manufacturer provides a negative output tolerance in order to allow the panel's real measured power to deviate from the quoted rating, we include this fact under ‚Other defects'. After all, he could easily have selected the cells to give a higher output, as other manufacturers have done.

Photo: Schott Solar

In the PHOTON test lab, in a dark, screened-off room, the panels are first tested under standard conditions. Here, at 25 degrees Celsius, they are subjected to a flash of 1,000 W/m2. The test is then repeated with reducing light intensity - down to 100W.

The electroluminescence photos show differences in brightness between the cells. The more photons each cell section radiates, or the brighter it is, the more electricity it produces. Dark spots, such as those clearly visible on the Sun Earth TDB125X125-72-P, are no longer functional. This test method also reveals the presence of tiny cracks not visible to the naked eye.

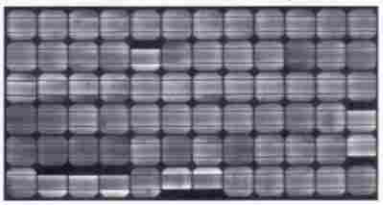

Photo: Labor

Thermography captures a solar panel's heat radiation and allows us to see temperature differences in the panel when power is being generated. These temperature differences show up damaged areas that are no longer producing electricity as well as local hotspots caused by cell defects. The dropouts on the Sun Earth TDB125X125-72-P are easily identified here. The photo is a mirror image of an electroluminescence image.

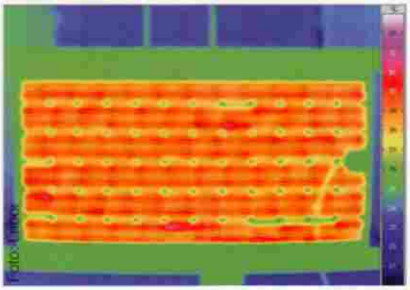

Foto: Labor

TEST PV panels	Aleo S_18, 225 W	Schott Poly 220	Sovello SV-X-205-fa1	Upsolar UP-M185M	Bosch c-Si M 60, 230 W	CNPV-220P	Kyocera KD210GH-2PU
Supplier	Aleo	Schott Solar	Sovello	Upsolar	Bosch	CNPV	Kyocera
Type of cells	polycrystalline	polycrystalline	polycrystalline (string ribbon)	monocrystalline	monocrystalline	polycrystalline	polycrystalline
Manufactured in	Germany	EU (cells: Germany)	Deutschland	China	Germany	China	Europe
Product warranty	10 years	5 years	5 years	5 years	10 years	10 years	5 years
Dimensions	166 x 99 cm	169 x 99 cm	150 x 80 cm	158 x 81 cm	166 x 99 cm	165 x 99 cm	150 x 99 cm
Weight	21 kg	23 kg	19 kg	15 kg	21 kg	20 kg	18 kg
Nominal power	225 W	220 W	205 W	185 W	230 W	220 W	210 W
Manufacturer's performance tolerance	0 - 4.99 W	0 / +	0 - 2.5 %	**+/- 3 %**	**+/- 2.5 W**	**+/- 3 %**	**+/- 5 %**
Measured power / deviation from nominal	230.5 W / + 2.5 %	222.4 W / + 1.1 %	208.0 W / + 1.5 %	189.6 W / + 2.5 %	232.9 W / + 1.3 %	224.0 W / + 1.8 %	210.3 W / + 0.1 %
Module efficiency	14.0 %	13.3 %	13.3 %	14.8 %	14.2 %	13.7 %	14.2 %
Change in panel efficiency under low light (100 W/m²)	- 7.7 %	- 7.2 %	- 9.3 %	- 9.3 %	- 5.4 %	- 6.8 %	**- 13.9 %**
Fill factor	75.5 %	73.3 %	74.3 %	76.3 %	74.7 %	**72.7 %**	74.2 %
Change in output under heat (70 °C)	- 19.8 %	- 19.7 %	- 20.0 %	- 19.5 %	**- 20.9 %**	- 20.2 %	- 19.5 %
Recognisable imperfections and defects (electroluminescence and thermography)	no	slight	no	no	no	no	no
Performance rating	very good	very good	very good	very good	good	good	good
Ohter defects	no	no	no	**yes**	**yes**	**yes**	**yes**
Other defects rating	very good	very good	very good	good	good	good	good
Remarks	4)						
Overall rating	**very good**	**very good**	**very good**	**very good**	**good**	**good**	**good**

Glossary of technical terms

The nominal power stated by the manufacturer is the maximum power produced by a panel under standard test conditions (STC): solar radiation of 1,000 W/m2, panel temperature of 25 degrees Celsius and a specific type of solar radiation and solar spectrum (air mass = 1.5). This specification is often stated in kilowatts peak (kWp), ‚peak' meaning the maximum output measured under STC.

Panel efficiency is the relationship between the electrical power produced by a solar panel and the solar energy it captures. A high efficiency results in more output per surface area. Crystalline modules generally have an efficiency of between 13 and 14 percent. The remainder is losses, which for physical reasons cannot be greatly reduced. Maximum efficiency is normally calculated at an average irradiation of around 700 W/m2.

The performance tolerance is the tolerance band within which the manufacturer's power rating must lie. Because of variations in silicon cell quality, manufacturers have to sort their cells into groups producing the same output. The ideal situation is to have the narrowest possible bandwidth in the finished panel, because this allows the solar array to be optimised, since the weakest link in the chain ultimately determines the performance of the array. Manufacturers state the performance tolerance in watts or in percent. In some cases there is no negative figure, which means the manufacturer guarantees that his panels will exceed the minimum performance. Others select their cells to be within a performance tolerance that includes a negative figure. Typical values are +/-3 or even +/-5 percent. Add to this a measurement uncertainty of +/-4 percent and the result can be as much as a nine percent shortfall.

The fill factor describes the quality of the current-voltage curve and is a measure of the cell's quality. It is defined as the ratio of a solar cell's maximum obtainable power and the product of its open-circuit load voltage and short-circuit current. The ideal, theoretical figure is 1, but this is not physically possible. Crystalline cells can reach values or around 75 percent, which is stated as a fill factor of 0.75.

The temperature coefficient shows how much the output power is reduced as the panel heats up. It is generally around -0.45 percent per Kelvin for crystalline modules. The lower the figure, the better, as this indicates that less power will be lost when it is hot in the summer.

REC Premium 210	Solarfabrik SF 200A-225	Solarwatt M220-60 GET AK, 230 W	Yingli YL210P-29b	Trina TSM-180DC01	Solarfun SF160-24-1M180	Sun Earth TDB125X125-72-P	Suntech STP190-18/Ub
REC	Solar-Fabrik	Solarwatt	Yingli	Trina	Solarfun	Ningbo Solar / Sig Solar	Suntech Power
polycrystalline	polycrystalline	mono-crystalline	polycrystalline	mono-crystalline	mono-crystalline	mono-crystalline	polycrystalline
Sweden	Germany (Cells: Singapore)	Germany	China	China	China	China	China
63 months	7 years	5 years	5 years	5 years	5 years	2 years	5 years
167 x 99 cm	167 x 100 cm	168 x 99 cm	165 x 99 cm	158 x 81 cm	158 x 81 cm	158 x 81 cm	148 x 99 cm
22 kg	24 kg	24 kg	20 kg	16 kg	15 kg	16 kg	17 kg
210 W	225 W	230 W	210 W	180 W	180 W	160 W	190 W
+/- 5 %	**+/- 2.5 W**	0 - 5 W	**+/- 3 %**	**+/- 3 %**	**+/- 5 %**	**+/- 5 %**	**+/- 3 %**
212.2 W / + 1.0 %	223.5 W / **- 0.7 %**	231.6 W / + 0.7 %	218.5 W / + 4.1 %	180.6 W / + 0.3 %, **large deviation in both panels**	179.3 W / - 0.4 %	159.9 W / - 0.1 %	184.1 W / **-3.1 %**
12.9 %	13.4 %	13.9 %	13.4 %	14.1 %	14.0 %	**12.5 %**	**12.5 %**
- 8.7 %	- 9.1 %	- 6.6 %	**- 11.2 %**	- 8.3 %	**- 12.4 %**	- 5.3 %	**- 19.0 %**
72.5 %	73.6 %	75.0 %	74.0 %	75.9 %	74.2 %	**70.2 %**	**72.2 %**
- 20.0 %	- 17.6 %	**- 22.3 %**	- 19.4 %	- 19.5 %	**- 20.4 %**	**- 20.6 %**	- 19.3 %
no	slight	slight	slight	slight	slight	**yes, dropouts**	slight
good	good	good	good	good	satisfactory	poor	poor
yes	**yes**	no	**yes**	**yes**	**yes**	**yes**	**yes**
good	good	very good	good	satisfactory	satisfactory	good	good
6)				1)	1) 5)	2)	3)
good	**good**	**good**	**good**	**satisfactory**	**fair**	**poor**	**poor**

Bold signifies defects.
Abbreviations: W = watts
Remarks: 1) Warranty terms not in German. 2) The module was produced in August 2008 and, according to the manufacturer, ‚has not been part of our standard range for over two years'. The manufacturer also said that it had been produced in the ‚old factory' and was not typical of current quality and performance standards. Nowadays, modules are at least 180 watts, with a performance tolerance of 0 - 3% and a manufacturer's warranty of 7 years. 3) According to the supplier, the panel we tested was from 2008 production and therefore not to the latest engineering or production standards. The warranty conditions have also changed since that time. 4) Because of temporary supply problems, the manufacturer supplied the test panels. 5) According to the supplier, the performance tolerance was changed +/- 3 % after the panel was produced in 2009. 6) According to the supplier, the product number is now RECAE 210. Since January 2010, cell selection has been positive, the performance tolerance is now 0 - 2% or 0 - 5W.
Key: Products with the same overall rating are listed in alphabetical order. The ‚Performance rating' was reduced by two points for: a panel efficiency of under 13.9% for monocrystalline cells together with identifiable defects (non-working spots).
One point was deducted if: a) the power rating was only barely met (from -0.5% down on the rated power with no allowance for measurement tolerances) and/or the power output was outside the manufacturer's performance tolerance; b) there was a difference greater than 5% in the measured power of the two test samples;c) the efficiency of a polycrystalline cell panel was under 12.9%; d) the fill factor was under 73%; d) the panel's efficiency fell by more than 10% with reference to 1.000 W/m2 under low light conditions (100 W/m2); e) the panel's output fell by more than 20.25% under hot conditions (70 °C), equivalent to a temperature coefficient of more than -0.45%/K.
One point was deducted from the ‚Other defects rating' for: a) a negative performance tolerance; b) warranty information not printed in German. The ‚Overall rating' is based on the ‚Performance rating'. A satisfactory ‚Other defects rating' reduces the ‚Overall rating' by one point.
How we tested: Power output measurement under standard test conditions: irradiation 1,000 W/m2 at panel level, cell/panel temperature 25 °C, air mass 1.5; Pasan Sun Simulator IIIb MFG 502. Low light performance: as standard output measurement, but with 100, 200, 400 and 700 W/m2 irradiation. Temperature coefficient: Sun simulator measurement of current-voltage characteristics at 1,000 W/m2 and an air mass of 1.5. Temperature of the solar panel stepped up in regular intervals to over 70 °C.; temperature coefficients were used to derive the output under hot conditions (70 °C) by multiplying with the temperature difference of 45 degrees. Recognisable imperfections and defects: a) by electroluminescence: Apply a voltage to the panel connectors and measure the photon radiation of the cells using an electroluminescence camera. b) by thermography under load: Apply power to the panel, measure the heat buildup with a thermal imaging camera, resolution 1.23 megapixels (1.280 x 960 pixels). The test results are rounded to one decimal place. Dimensions and weights are approximate. Dimensions are rounded to the nearest centimetre and weights to the nearest kilogram.
Test items, date of purchase: January - February 2010.
Suppliers directory: see www.oekotest.de