



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
Other 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-Z25	Solarwatt M220-60 GET AK, 230 W	Yingli YL210P-29b	Trina TSM-1800C01 1M180	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	168 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 %
+1.0 %	223.5 W / -0.7 %	231.6 W / +0.7 %	218.5 W / +4.1 %	180.6 W / +0.3 %	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, droopouts	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 - 5 W.

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%; e) 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 condi-

tions (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 lib WFG 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.eko-test.de

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