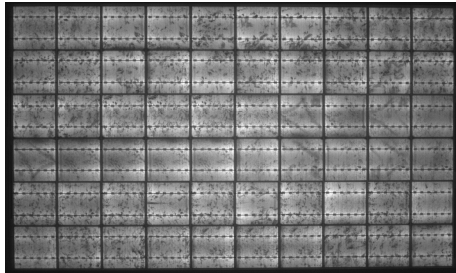


The German consumer magazine Öko-Test has tested PV modules from 15 manufacturers.



Example: Electroluminescence Measurement

Goal of the test

- Determination of PV module performance
- Identification of potential weak points

Test procedure

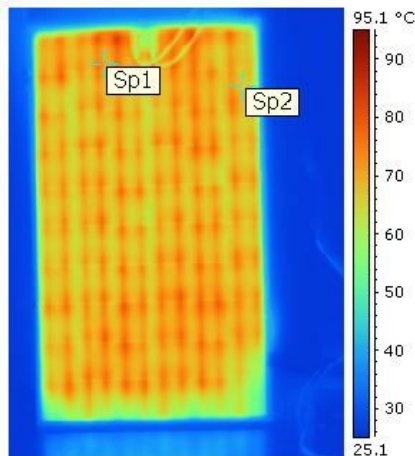
- Purchasing on the market January till February 2010
- Sampling could not be influenced by manufacturers

Tests at Photon Laboratory in Aachen

- Power measurement at 1000 W/m² and 100 W/m²
- Determination of Temperature Coefficient
- Electroluminescence Measurement
- Thermal Imaging

Tested Module

- SCHOTT POLY™ 220



Example: Thermal Imaging

Source: Öko-Test April 2010, www.oekotest.de
German consumer magazine devoted to consumer protection and ecology

Criteria for Assessment by Öko-Test (1/2)



Positive Power Tolerance

- More than two thirds of the manufacturer in this test have sorted their modules with negative tolerances
- Only four manufacturer are consumer oriented and deliver modules with more power than stated as nominal power
- Criterion: *measured module power is equal or higher than nominal power*

Fill Factor

- The fill factor describes the Current-Voltage-Curve and is a key parameter in evaluating the performance of PV modules .
- The fill factor is defined as the ratio of actual maximum obtainable power divided by Product of Open Voltage and Short Circuit Current
- Criterion: *Fill Factor >73%*

Source: Öko-Test April 2010, www.oekotest.de
German consumer magazine devoted to consumer protection and ecology

Criteria for Assessment by Öko-Test (2/2)



Performance at low light conditions

- Even at low light conditions, the modules should give enough power
- Öko-Test is comparing module efficiency at irradiation of 100 W/m² and 1000 W/m²
- *Criterion: Efficiency Loss: less than 10% under low light conditions*

Performance at high module temperature

- Even at high temperatures, the modules should give enough power
- *Criterion: Power Loss less than 20% at 70° C compared to 25° C*

Potential Defects in Electroluminescence Measurement

- In a long term perspective cracks in Cell Structure can influence the module power
- *Criterion: Recognized Potential Defects: Low*

Source: Öko-Test April 2010, www.oekotest.de
German consumer magazine devoted to consumer protection and ecology

SCHOTT Poly 220™.

Very Good - tested by Öko-Test.



Feature	Criteria	Result
■ Power Measurement vs. Nominal Power	> - 0.5 %	+ 1.1 %
■ Fill Factor of Module	> 73.0 %	73.3 %
■ Degradation of Module Performance at Low Light	< 10.0 %	7.2 %
■ Degradation of Module Performance at High Temp.	< 20.0 %	19.7 %
■ Recognizable Potential Defects	low	low
Test Result Performance Measurement	Very Good	
Further Defects	No	
Test Result Further Defects	Very Good	
Overall Assessment	Very Good	







Source: Öko-Test April 2010, www.oekotest.de
 German consumer magazine devoted to consumer protection and ecology

3.1.004 OKO-TEST 04 2010



SCHOTT Poly™ 220 in Comparison (1/2)

<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div></div>								
TEST	Photovoltaikmodule	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
Manufacturer		Aleo	Schott Solar	Sovello	Upsolar	Bosch	CNPV	Kyocera
Type of Cells		polykristallin	polykristallin	polykristallin (String Ribbon)	monokristallin	monokristallin	polykristallin	polykristallin
Made in		Deutschland	EU (Zellen: Deutschland)	Deutschland	China	Deutschland	China	Europa
Product Guarantee		10 Jahre	5 Jahre	5 Jahre	5 Jahre	10 Jahre	10 Jahre	5 Jahre
Dimension		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
Power Tolerance		0 - 4,99 W	0 / +	0 - 2,5 %	+/- 3 %	+/- 2,5 W	+/- 3 %	+/- 5 %
Measured Module Power / Difference to Nominal Power		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 of measured power at low light conditions		- 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 of Power at High Temp.		- 19,8 %	- 19,7 %	- 20,0 %	- 19,5 %	- 20,9 %	- 20,2 %	- 19,5 %
Potential Defects in EL Test		nein	gering	nein	nein	nein	nein	nein
Test Result Power Performance		sehr gut	sehr gut	sehr gut	sehr gut	gut	gut	gut
Further Defects		nein	nein	nein	ja	ja	ja	ja
Test Result Further Defects		sehr gut	sehr gut	sehr gut	gut	gut	gut	gut
Footnote		4)						
Overall Assessment		sehr gut	sehr gut	sehr gut	sehr gut	gut	gut	gut

ÖKO-TEST
RICHTIG GUT LEBEN



Evaluation

Sehr gut	= Very Good
Gut	= Good
Befriedigend	= Meets requirements
Ausreichend	= Barely Acceptable
Mangelhaft	= Not sufficient
Nein	= None
Gering	= low
Ja	= Yes

Source: Öko-Test April 2010, www.oekotest.de
German consumer magazine devoted to consumer protection and ecology

3.1.004 OKO-TEST 04 2010

GreenTops
השקעה בטוחה באנרגיה ירוקה

SCHOTT Poly™ 220 in Comparison (2/2)

ÖKO-TEST
RICHTIG GUT LEBEN



TEST Photovoltaikmodule	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
Manufacturer	REC	Solar-Fabrik	Solarwatt	Yingli	Trina	Solarfun	Ningbo Solar / Sig Solar	Suntech Power
Type of Cells	Art der Zellen	polykristallin	polykristallin	monokristallin	polykristallin	monokristallin	monokristallin	polykristallin
Made in	Hergestellt in	Schweden	Deutschland (Zellen: Singapur)	Deutschland	China	China	China	China
Product Guarantee	Produktgarantie	63 Monate	7 Jahre	5 Jahre	5 Jahre	5 Jahre	2 Jahre	5 Jahre
Dimension	Abmessung	167 x 99 cm	167 x 100 cm	168 x 99 cm	165 x 99 cm	158 x 81 cm	158 x 81 cm	148 x 99 cm
Weight	Gewicht	22 kg	24 kg	24 kg	20 kg	16 kg	16 kg	17 kg
Nominal Power	Nennleistung	210 W	225 W	230 W	210 W	180 W	160 W	190 W
Power Tolerance	Leistungstoleranz laut Hersteller	+/- 5 %	+/- 2,5 W	0 - 5 W	+/- 3 %	+/- 5 %	+/- 5 %	+/- 3 %
Measured Module Power / Difference to Nominal Power	Gemessene Leistung / Abweichung zur Nennleistung	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 %, große Abweichung der beiden Module	179,3 W / - 0,4 %	159,9 W / - 0,1 %
Module Efficiency	Modulwirkungsgrad	12,9 %	13,4 %	13,9 %	13,4 %	14,1 %	14,0 %	12,5 %
Change of measured power at low light conditions	Veränderung des Modulwirkungsgrads bei schwachem Licht (100 W/m²)	- 8,7 %	- 9,1 %	- 6,6 %	- 11,2 %	- 8,3 %	- 12,4 %	- 5,3 %
Fill Factor	Füllfaktor	72,5 %	73,6 %	75,0 %	74,0 %	75,9 %	74,2 %	70,2 %
Change of Power at High Temp.	Veränderung der Leistung bei Wärme (70 °C)	- 20,0 %	- 17,6 %	- 22,3 %	- 19,4 %	- 19,5 %	- 20,4 %	- 20,6 %
Potential Defects in EL Test	Erkennbare Auffälligkeiten und Mängel (Elektrolumineszenz und Thermografie)	nein	gering	gering	gering	gering	ja, ausgefallene Stellen	gering
Test Result Power Performance	Testergebnis Leistungsprüfung	gut	gut	gut	gut	befriedigend	mangelhaft	mangelhaft
Other deficiencies	Weitere Mängel	ja	ja	nein	ja	ja	ja	ja
Test Result Other Deficiencies	Testergebnis Weitere Mängel	gut	gut	sehr gut	gut	befriedigend	befriedigend	gut
Footnote	Anmerkungen	6)				1)	1) 5)	2)
Overall Assessment	Gesamturteil	gut	gut	gut	gut	befriedigend	ausreichend	mangelhaft

ÖKO-TEST
RICHTIG GUT LEBEN

Photovoltaikmodule
SCHOTT POLY™ 220

sehr gut

Ausgabe 4/2010

Evaluation

Sehr gut = Very Good

Gut = Good

Befriedigend = Meets requirements

Ausreichend = Barely Acceptable

Mangelhaft = Not sufficient

Nein = None

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Ja = Yes

Source: Öko-Test April 2010, www.oekotest.de
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3.1.004 OKO-TEST 04 2010

GreenTops
השקעה בטוחה באנרגיה ירוקה

Reason for downgrades in modules assessment



- **High degradation of module performance at high temperatures**
(Bosch, Solarwatt, Solarfun, Sun Earth)
- **Negative Power Tolerance**
(Bosch, CNPV, Kyocera, REC, Solarfabrik, Yingli, Trina, Solarfun, Sun Earth, Suntech)
- **Measured power lower than nominal power**
(Solarfabrik, Solarfun, Sun Earth, Suntech)
- **High degradation of module performance under low light conditions**
(Kyocera, Yingli, Solarfun, Suntech)
- **Fill Factor**
(CNPV, REC, Sun Earth, Suntech)
- **Recognizable Defects in Electroluminescence**
(Sun Earth)

Source: Öko-Test April 2010, www.oekotest.de
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3.1.004 OKO-TEST 04 2010

