TÜV Rheinland Energie und Umwelt GmbH
Solar Energy

Test Report

Energy Yield 2011

TÜV Report No.: 21217404-5

Cologne, 22nd November 2012

DAkkS
Deutsche
Akkreditierungsstelle
D-PL-11120-01-01

TÜV Rheinland Energie und Umwelt GmbH
51105 Köln, Am Grauen Stein, Tel.: +49 (0)221 806-2477, Fax: +49 (0)221 806-1350

TÜVRheinland®
Precisely Right.

Report-No.: 21217404-5

Energy Yield 2011

Client	Solarwatt AG Maria-Reiche-Str. 2a 01109 Dresden Germany
TÜV Quotation No.	435/1220110555
TÜV Order No.	21217404
Order of	30.06.2011
Date of receipt of test item	08.07.2011
Commencement of test	01.09.2011
TÜV Client No.	651149
Examiner	Dipl.-Ing. C. Bauerdick Tel.: +49 (0)221 806-2082
Department	Solar Energy
No of pages	9
Annex	0

TÜVRheinland®
Precisely Right.

Contents

Page

1 Setting of tasks

According to orders of below mentioned manufacturers the following module types have been tested in a one year energy yield comparison measurement within the project “Energy Yield 2010” performed by TÜV Rheinland Energie und Umwelt GmbH (TEU):

Participant	Module Type	Maximum Power (Pmax rated)	Cell Type
Solarwatt AG	M250-60 AC 10	245 Wp	mono
Solland Solar Cells BV	SCHOTT PERFORM MWT 235	235 Wp	poly
Yingli Green Energy Co., Ltd.	YL200C-24b	200 Wp	mono
	YL190P-23b	190 Wp	poly
Alfasolar GmbH	Pyramid 60H - 237 Wp	237 Wp	poly
REC Cells Pte. Ltd.	REC245PE	245 Wp	poly
Heliene Inc.	HEE 215 M	245 Wp	mono
Suntech Power International Ltd.	Pluto295Vdm	295 Wp	poly
	STP285-24/Vd	285 Wp	poly
Solarworld AG	SW 240 poly	240 Wp	poly
Schott Solar AG	SCHOTT POLY 235	235 Wp	poly
	SCHOTT POLY 185 DG	185 Wp	poly
Bosch Solar Energy AG	c-Si M 60 EU 30117	240 Wp	mono
Changzhou Trina Solar Energy Co., Ltd.	TSM-230PC05	230 Wp	poly

Table 1.1: List of participating module types

The results of the energy yield measurement are analysed quarterly. In the quarterly report every manufacturer is informed about the results of the own module in comparison to the others in an anonymous way.

2 Measurement procedure

2.1 Initial / Final measurements

After delivery of the required components two test specimen per module type participating in the project were subjected to the initial measurement testing sequence. This sequence includes a visual inspection, an electroluminescence (EL) image and determination of the electrical characteristics. The measurement of the I-V-characteristics is performed at STC under a class AAA pulsed solar simulator according to IEC 60904-9. A primary crystalline reference cell is used for solar simulator calibration.
After completion of the initial measurements the reference module is stored under laboratory conditions and the test module is used for energy yield measurement.

2.2 Energy Yield measurement

2.2.1 Measurement procedure

The entire measurement system is to be subdivided into the following three areas:

- Central logging of meteorological data
- Logging of module temperatures and global in-plane irradiance
- Performance measurement of the modules

The central logging of meteorological data serves the measurement of all relevant environmental conditions, as well as the provision of this data for all existing test equipment on the outdoor test rig.
Furthermore a measurement system is deployed to record the module temperatures and the global irradiation in plane, which are also logged in a 30 second interval. The temperatures are regarded together with the meteorological data.
A third system is run for the performance measurement, which comprises the MPP tracking and recording of the I-V-curve.
Each 30 minutes the MPP-tracking will be interrupted by a curve measurement. After completion the auto tracking will be performed again. The procedure of recording the I-V-characteristic and the MPP-tracking mode takes place cyclically as long as the irradiation does not drop below the defined threshold irradiation limit.

2.2.2 Evaluation procedure

For the evaluation of the specific energy yield all in the data base stored data sets are taken into account. The following points are influencing the number of available data sets and the accumulated yield for each participant:

- Failures of hardware or software
- The irradiation threshold limit of 15 W/m²
- The MPP tracking of the electronic loads
- The number of modules to be compared

To accumulate the specific energy yield only data sets are used where all participating modules are operating in the MPP. The result cannot lead to an absolute produced energy yield but it keeps all participating products comparable.

3 Measurement results

3.1 Determination of maximum power at standard test conditions (STC)

Irradiance level: 1000 W/m², Module temperature: 25°C

Barcode	P_{max} / W	V_{mpp} / V	I_{mpp} / A	V_{oc} / V	I_{sc} / A	FF / %	P_{meas}/P_{rated} / %
20110004073	246.9	30.19	8.18	37.27	8.81	75.2	100.8
20110004074	246.5	29.93	8.24	37.31	8.82	74.9	100.6

The total measuring uncertainty of P_m is ≤ ± 2.5 %
The total measuring uncertainty of I_{sc} is ≤ ± 2.3 %
The total measuring uncertainty of V_{oc} is ≤ ± 1.0 %

TÜVRheinland®
Precisely Right.

3.2 Final determination of maximum power at standard test conditions (STC)

Irradiance level: 1000 W/m², Module temperature: 25°C

After measuring the I-V-curve of the reference module, the test module has been measured under both conditions, uncleaned and cleaned.

Barcode	P_{max} / W	V_{mpp} / V	I_{mpp} / A	V_{oc} / V	I_{sc} / A	FF / %	$P_{meas}/P_{initial}$ / %
20110004073	244.8	29.93	8.18	37.25	8.75	75.1	99.1
20110004074	244.5	29.86	8.19	37.21	8.75	75.1	99.2
20110004074	246.0	29.57	8.32	37.19	8.83	75.0	99.8

The total measuring uncertainty of P_m is ≤ ± 2.5 %
The total measuring uncertainty of I_{sc} is ≤ ± 2.3 %
The total measuring uncertainty of V_{oc} is ≤ ± 1.0 %

No clear statement in relation to the power degradation within the relatively short period of one year is possible. This is due to the measurement uncertainty which is larger than the expected degradation effect.

3.3 Evaluation of overall ranking

Technology based differences in energy yield of the modules can only be observed by looking at the specific energy yields related to the maximum power output measured by TÜV Rheinland (Pmeasured). Related to the module with the highest specific energy yield the difference between the PV module with the highest ranking and the PV module with the lowest ranking is 5.7%. For the assessment of the specific energy yields the consideration of measurement uncertainties is crucial. The following influences have to be taken into account:

1. relative accuracy of P_{MPP} tracking
2. relative measuring uncertainty of measuring P_{MPP} (outdoor)
3. relative inaccuracy of reproduction of STC measurement
4. relative measuring uncertainty of STC measurement

Under this consideration the total measurement uncertainty is +1% / -1.5%.

From 22 July to 31 August partial shading in the morning and in the evening was caused by scaffolding for building construction around the test field. Those data sets have been removed to keep the participating products comparable.

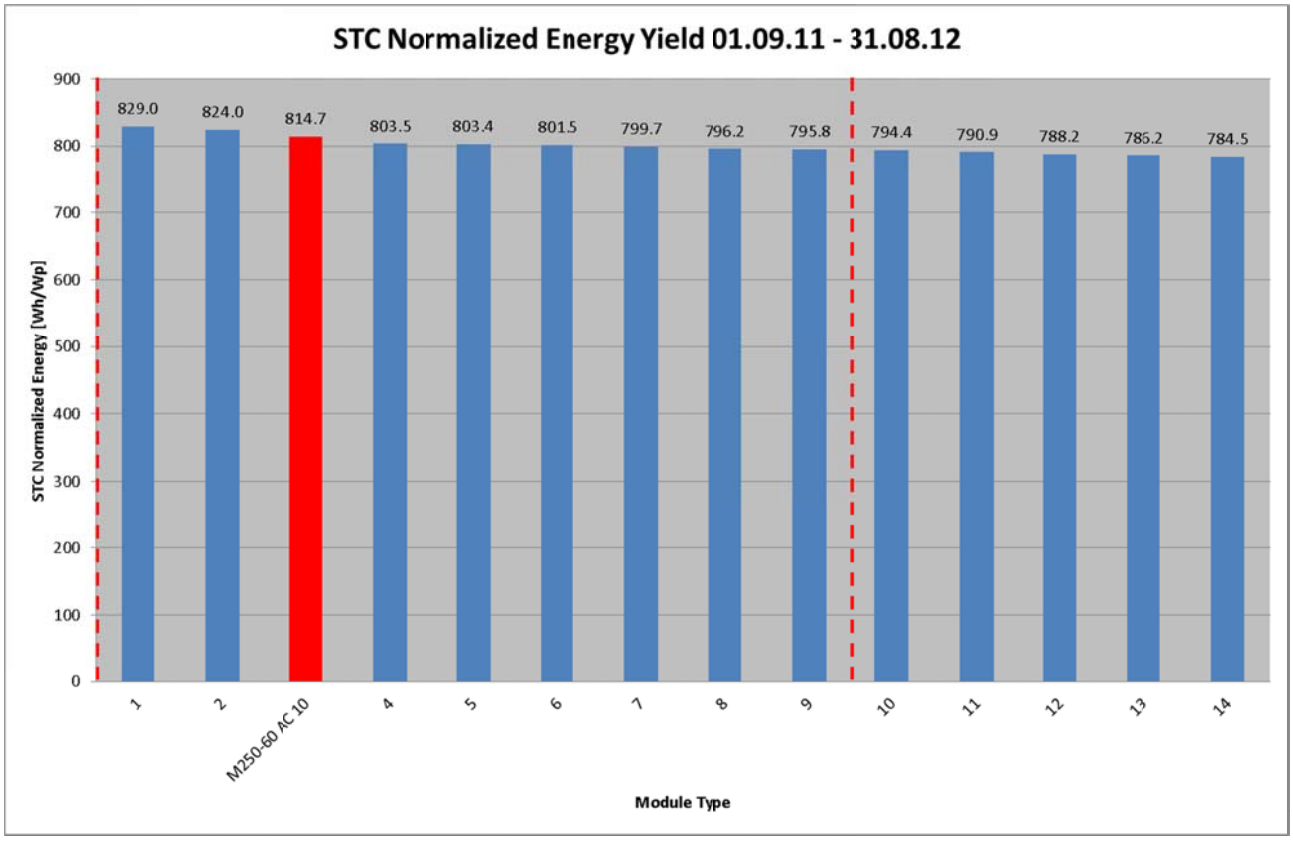

Fig. 4.1: *STC normalized Energy Yield entire period with tolerance range*

Under these circumstances a tolerance range as shown in Fig. 4.1 can be derived, which covers all theoretically possible positions within the overall ranking, whereas the red column represents the most likely position.

Additionally to the STC normalization the specific energy yield has been normalized to the label rated power.

Since the participating products have not been purchased on the market, no statement about the general rating procedure is possible. The following graph (Fig. 4.2) cannot be used to compare the energy yield of the modules to each other.

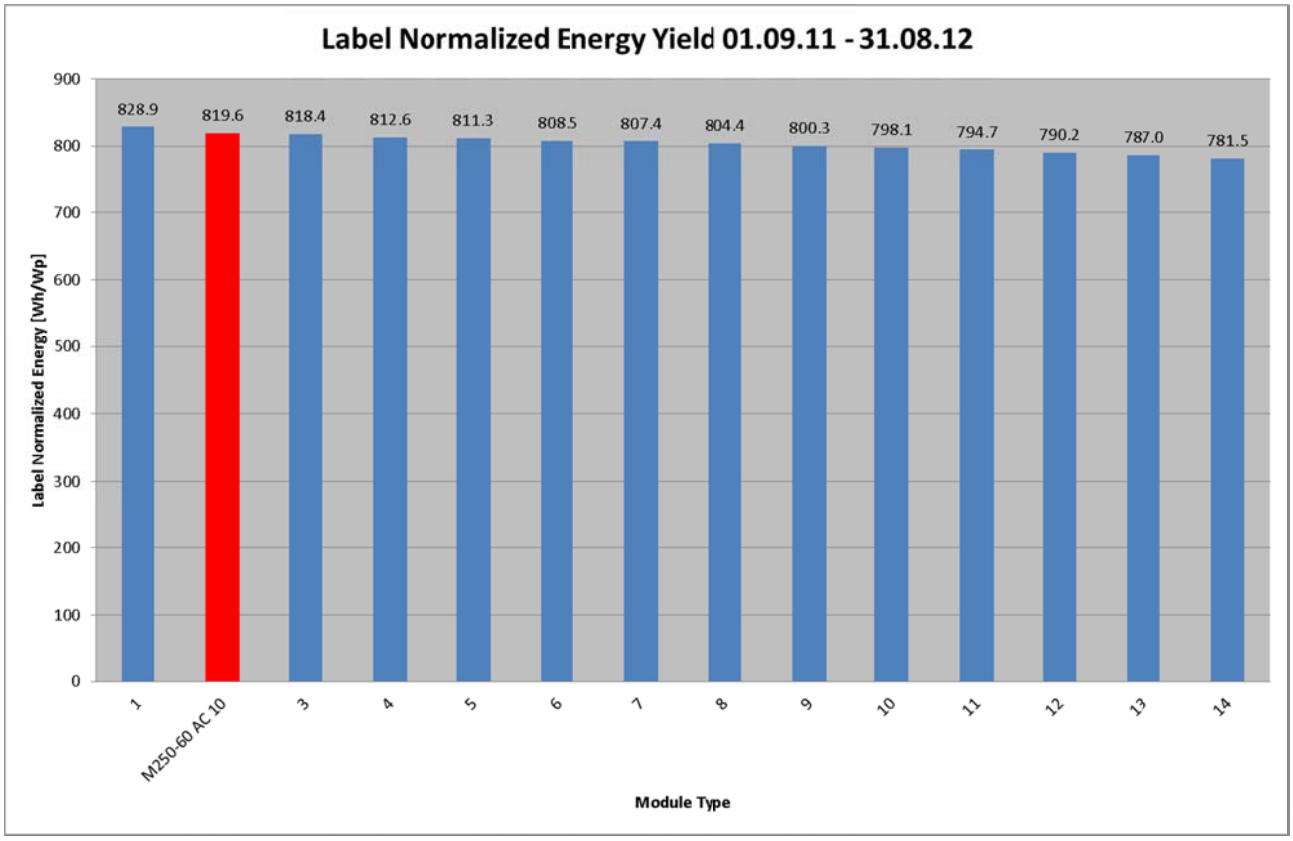

Fig. 4.2: *Label normalized Energy Yield entire period*

Nevertheless, the power rating of both modules provided by Solarwatt AG do not show any abnormalities. The maximum power measured by TEU is within the range stated on the module label.

Cologne, 22nd November 2012

Business field manager Solar Energy	**Responsible for measurement**
ppa.	i. A.
Dipl.-Ing. W. Vaaßen	Dipl-Ing. C. Bauerdick