Determination of the electrical energy yield. A comparative study of 12 PV-module types.

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Table of contents

1. Preface

In early spring 2009 (as in the previous year), TEC institute decided to determine crystalline PV-modules which produce very high energy yields.

2. Planning, Set-up and Implementation

2.1 Planning and preliminary consideration

After some thorough research, we decided on the following modules as test objects.

-aleo S16	polycrystalline
-Kyocera KC 175 GHT-2	polycrystalline
-Schott Solar Poly 165	polycrystalline
-Schott Solar ASE 300	polycrystalline
-Romag SMT 6(60)225	polycrystalline
-Tynsolar TYN-180 PC	polycrystalline
-Sharp NT 170 (E1)	monocrystalline
-Wuxi Shangpin SPSM-175D	monocrystalline
-Jiangyin Jetion JT 175 (35)	monocrystalline
-Yunnan Tianda TD 175 M5	monocrystalline
-ANTARIS ASM 175	monocrystalline (last year's winner)
-ANTARIS ASM 180	monocrystalline (follow-up model)

Each module type was wired up into a string, consisting of two, respectively three modules (depending on Mpp-voltage of each module type). Each string fed into the grid via a "Mastervolt Soladin 600" inverter.

Care was taken to ensure absolute identical operating conditions for all module types:

- Same test location (the institute's own roof)
- Same orientation (South)
- Same inclination angle
- Same cable lengths and wire cross sections
- No shading
- Cleanliness of the module surfaces
- Same rear ventilation conditions (module cooling)
- Same measuring devices to record data
- Etc.

As they are the most profitable months, June and July 2009 were chosen as testing period.

Because the tested modules had different external dimensions, the yield (measured in kWp) was related to the datasheet values (measured in kWp), in order to be able to compare the modules of different sizes realistically.

2.2 Measuring set-up and Implementation of Measuring series

As mentioned above, all module types work in feed-in mode. Module voltage and module current were measured on the DC side via digital multimeters, so that the actual module performance and the electrical energy yield can be calculated. The measuring interval was one minute. Additionally, the fed-in energy was measured per module type, using calibrated electricity meters. Furthermore, all measures named under 2.1 were taken. At the same time, the global irradiance (in W/m^2) was recorded on the same roof, using a pyranometer (as used in professional weather stations). Thus, yields could be interpreted realistically.

Fig. 1 shows one part of the tested modules

Fig 1: Part of the test set-up

Additional modules can be seen in the arrangement in fig. 2.

Fig. 2: Additional tested modules

Fig. 3 shows the pyranometer used

Measuring set-up with inverters, digital multimeters, meters and measuring computers (on the right and left image border).

Fig. 4: Measuring- and Feed-in station

3. Measuring results

3.1 Diagrams

Exemplarily, the following diagram shows the global irradiance curve from 06/29/09 until 07/06/2009.

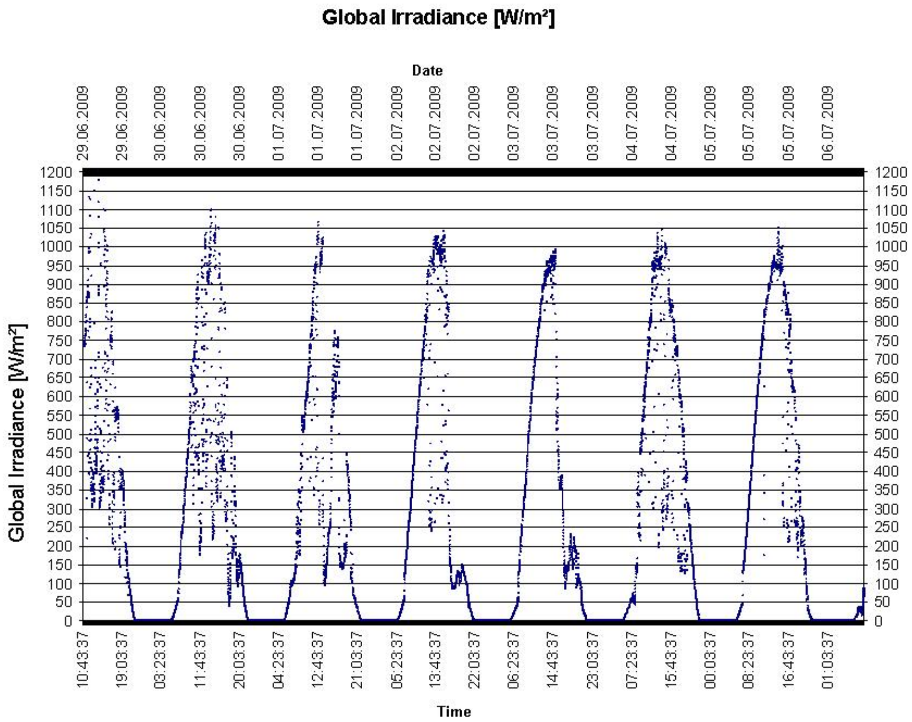

Fig. 5: global irradiance from 06/29/09 until 07/06/09

The recorded currents and voltages can be seen from 06/29/09 until 07/06/09, with the polycrystalline module "aleo S16" serving as an example.

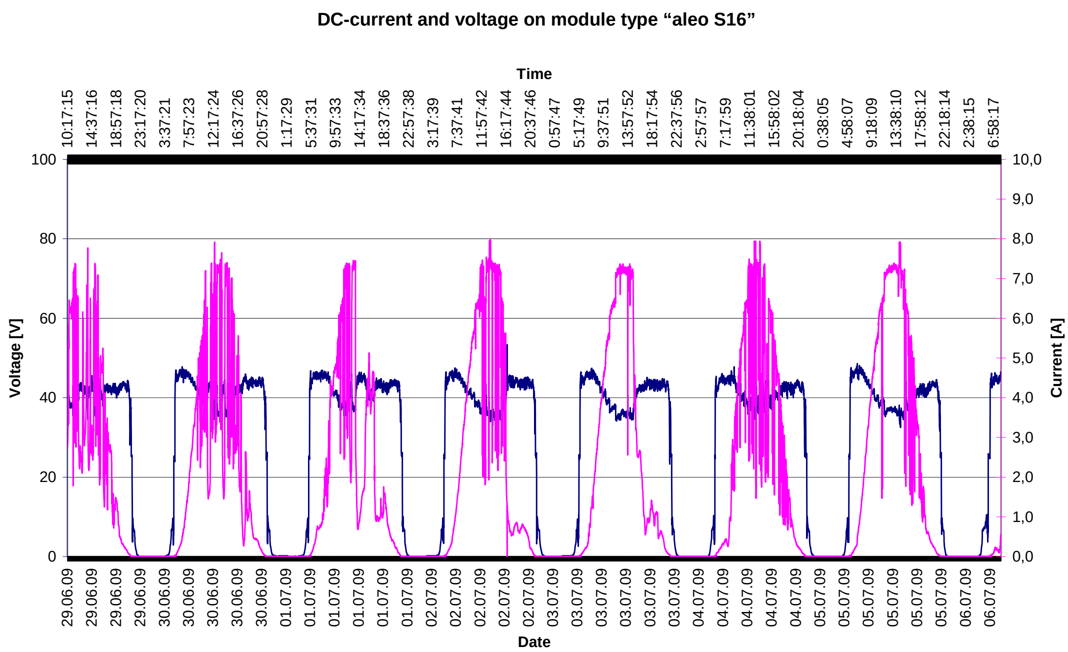

Fig. 6: DC-current and voltage on module type "aleo S16".

For the same period of time, performance curves could be established from this (see fig.7).

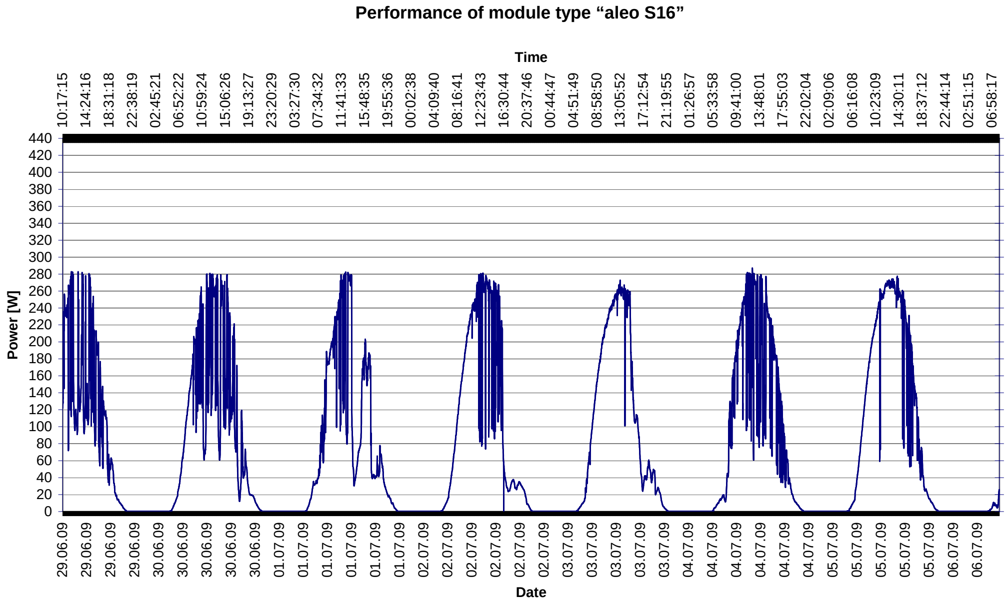

Fig. 7: Performance of module type “aleo S16”, from 06/29/09 until 06/07/09

The energy yield could be calculated from this output (which can be seen in fig.8).

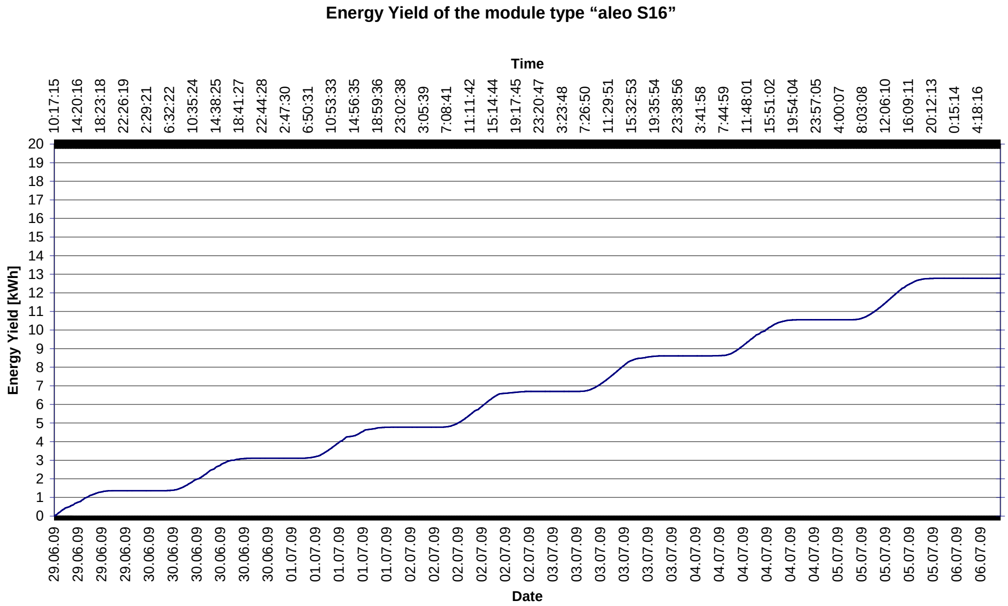

Fig. 8: Energy yield of the module type “aleo S16”, from 06/29/09 until 07/06/09

3.2 Analysis of the Measurement results

Output and energy yield were determined for all 12 module types. To be able to compare the energy yield of the module types to each other, the respective yield had to be related to the module types. It had to be taken into account, whether two or three modules were in a string (dependent on the Mpp-voltage of the modules). The datasheet values were as follows.

Module Type	Peak Power
-aleo S16	180 Wp
-Kyocera KC 175 GHT-2	175 Wp
-Schott Solar Poly 165	165 Wp
-Schott Solar ASE 300	300 Wp
-Romag SMT 6(60)225	225 Wp
-Tynsolar TYN-180 PC	180 Wp
-Sharp NT 170 (E1)	170 Wp
-Wuxi Shangpin SPSM-175D	175 Wp
-Jiangyin Jetion JT 175 (35)	175 Wp
-Yunnan Tianda TD 175 M5	175 Wp
-ANTARIS ASM 175	175 Wp (last year's winner)
-ANTARIS ASM 180	180 Wp (follow-up model)

The following energy yields in kWh per kWp [kWh/kWp] resulted from the above measuring series. This is for the time period from 06/01/2009 until 07/31/2009.
See diagram fig. 9 (order as in table above).

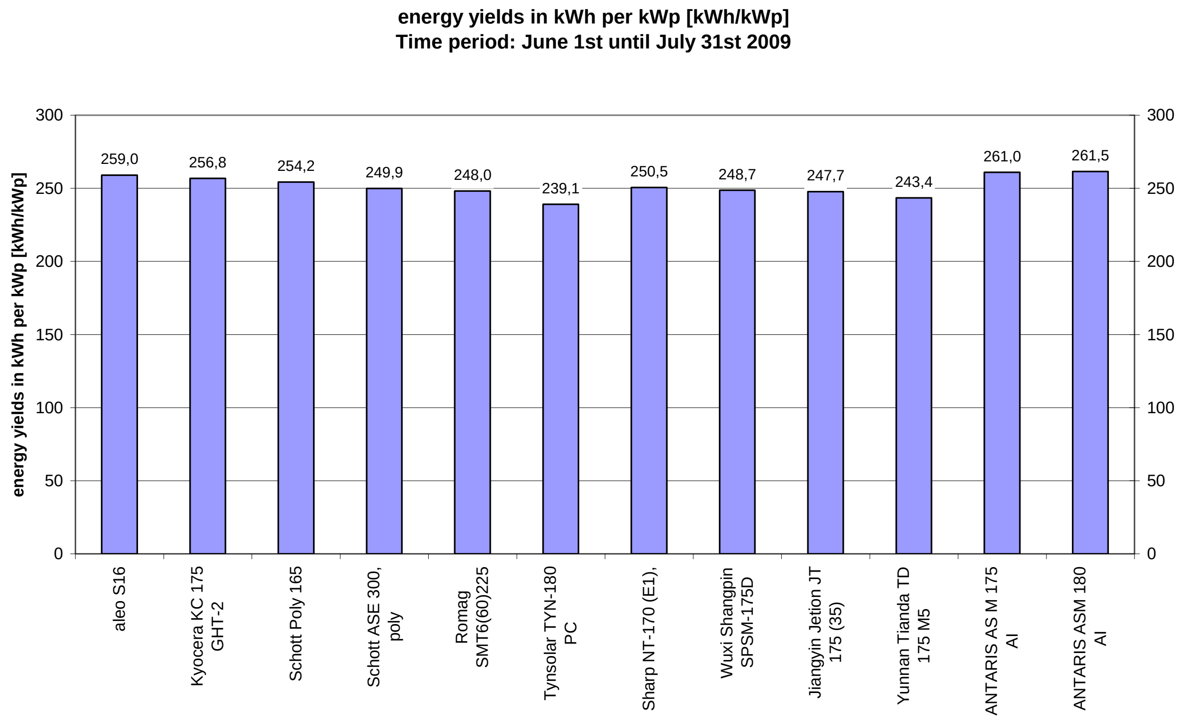

Fig. 9: Supplied energy per module type, related to nominal kWp, order as in table above.

In fig. 10, the modules are shown according to their energy yield.

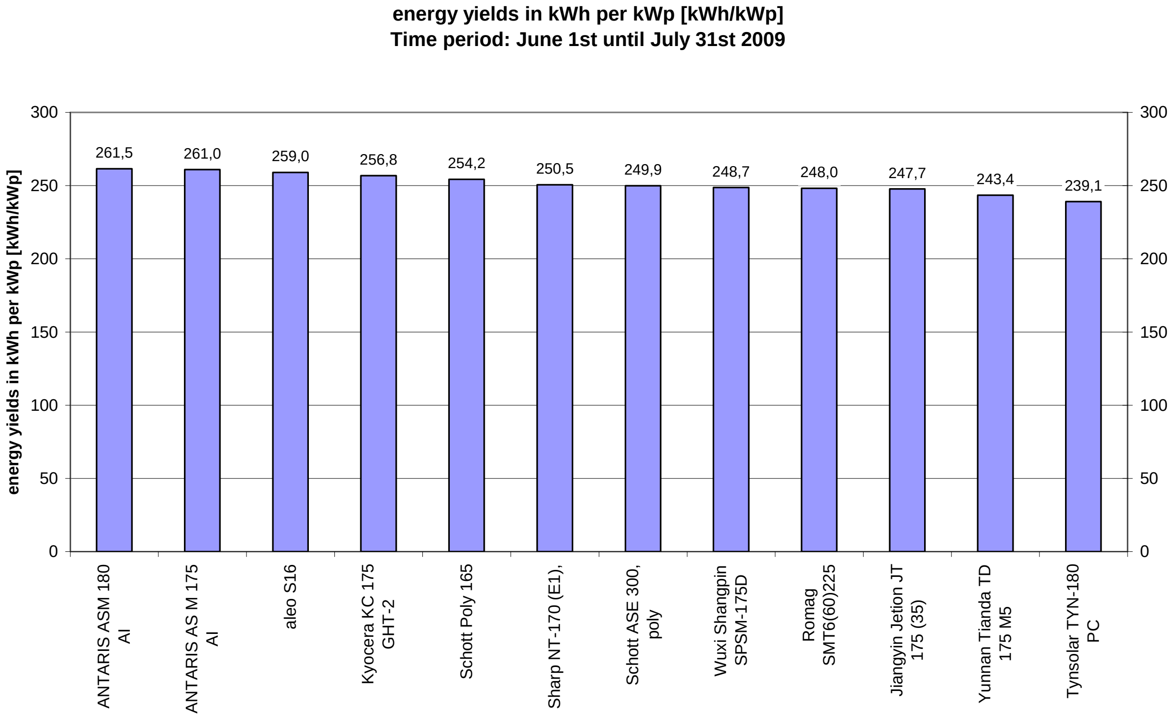

Fig. 10: Energy supplied per module type, related to nominal kWp, ranked according to energy yield.

4. Conclusion

-The previous year’s winner “ANTARIS ASM 175”, continued to show very strong performance and landed second place within a field of well-known manufacturers

-the follow-up model “ANTARIS ASM 180” claimed first place – however, with only a paper-thin advantage.

-remarkably, the leading modules were pretty close to each other. The “Schott Solar Poly 165” was only 2.8 percentage point behind the leading module, which meant that it was still within the common tolerance range of (+/- 3%).

-the model “Tynsolar TYN-180 PC”, which landed 12th place, is missing 8.6 percentage points compared to first place.

5. Equipment

Device:	Manufacturer:	Type:
Inverter	Mastervolt	Soladin 600
Multimeter	Voltcraft	VC 820
Electricity Meter	AEG	Form J16 G
Measuring Computer	Dell	Modell DHM
Measuring Computer	IP Ideas Plus	TYP: 10242 S2600
Software	Microsoft	VB 6.0
Software	Microsoft	Excel 2003

Waldaschaff, 10/05/09

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