TÜV Rheinland (Shanghai) Co., Ltd
Solar/ Fuelcell Technologies

Test Report

Qualification of a Solar Collector in accordance with
DIN EN 12975-1: 2011; DIN EN 12975-2: 2006

TÜV Report No.: **154026306_EN_P_10_Report_Gao**

Shanghai, 28 October 2013

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TÜV Rheinland (Shanghai) Co., Ltd. 200072 Shanghai
B1-13/F No.177, Lane 777, West Guangzhong Road, Shanghai 200072, P.R. China
Solar Outdoor Laboratory Address:
No. 24, Lingyuan Road, Yongding Town, 651400 Yongren City, Yunnan province, P. R. China

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on

Qualification of a Solar Collector in accordance with

DIN EN 12975-1: 2011; DIN EN 12975-2: 2006

Client:	Haining Oupairineng Solar Water Heater Co.,Ltd Wanshou Industrial Zone 314412, Yanguan Town, Haining City Zhejiang Province P.R.China
TÜV Quotation No.:	52081164
TÜV Order No.:	154026306
Order of:	13.05.2013
Date of Receipt of Test Item:	13 June 2013
Commencement of Test:	27 September 2013
TÜV Client No.:	486540
Inspector:	P.Gao +86 (0)21 60811633
Business Field:	Solar Energy
No of Pages:	17
Appendix:	12 to 17

Summary of collector performance test results:

Manufacturer	Haining Oupairineng Solar Water Heater Co.,Ltd		
Brand	ONOSI		
Collector type	ONS-HPC-10		
Year of manufacture	2013		
Length	2015 mm	Absorber area	0.81 m²
Width	812 mm	Aperture area	0.95 m²
Height	158 mm	Gross area	1.64 m²
Weight (empty)	35 Kg	Mass flow	0.028 kg/(m²s)
Heat transfer medium	Water	Test pressure:	150 kPa

Thermal performance

	Aperture area (A_a)	Absorber area (A_A)
Conversion factor η_0	0.701	0.824
Heat transfer coefficient a_1	1.780 W/(m²K)	2.093 W/(m²K)
Temperature dependent heat transfer coefficient a_2	0.017 W/(m²K²)	0.020 W/(m²K²)

Output power per collector unit

	Irradiation		
$T_m - T_a$ in K	400 W/m²	700 W/m²	1000 W/m²
10	247	446	645
30	201	400	599
50	141	341	540

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1 Summary of test results

Qualification of a Solar Collector in accordance with

DIN EN 12975-1: 2011; DIN EN 12975-2: 2006

Manufacturer	:	Haining Oupairineng Solar Water Heater Co.,Ltd Wanshou Industrial Zone 314412, Yanguan Town, Haining City Zhejiang Province P.R.China
Brand	:	ONOSI
Collector type	:	ONS-HPC-10

Test	Date		Summary of main test results
	Start	End	
Thermal performance	28 September 2013	15 October 2013	No visual damages
Final inspection	23 October 2013		No visual damages

All above listed tests of the standard DIN EN 12975-2:2006 were passed successfully in accordance with the criteria.

2 Setting of tasks

A complete collector test in accordance with DIN EN 12975-2:2006 of the Haining Oupairineng Solar Water Heater Co.,Ltd collector ONS-HPC-10 should be performed with the aim of Solar Keymark certification.

3 Basis of testing

EN 12975-1:2011 *„Thermal solar systems and components – Collectors – Part 1: General requirements“*

EN 12975-2:2006 *“Thermal solar systems and components – Collectors – Part 2: Test procedure”*

Solar Keymark – Specific Scheme Rules v20.00 March 2013: *“Specific CEN Keymark Scheme Rules for Solar Thermal Products”*

Cologne, 28 October 2013

Responsible for collector testing

Dipl.-Ing. P. Gao

Assistant Manager

Dipl.-Ing. M. Kottwitz

4 Sampling

Prototype samples	○
Samples from pilot production	◙
Samples from serial production	○
Selection of test samples acc. to Solar Keymark scheme rules	◙
Random selection of test samples acc. to SRCC scheme rules	○

5 Description of the collector construction

Manufacturer	Haining Oupairineng Solar Water Heater Co.,Ltd
Brand name	ONOSI
Collector Type	ONS-HPC-10
Category	Evacuated tube-collector
Date of manufacture	2013
Serial number	ONS/HPC10-20130606005
Drawing numbers	ON S-HPC-ZZ(1); ON S-HPC-ZZ(2); OPRN-C-TZ005(2); OPRN-C-TZ002(2); ONS-HPC-RG24 etc.

Collector & construction:

Gross dimensions l x w x t [mm]	2015 x 812 x 158 ①
Normative Absorber dimensions l x Øouter of inner tube [mm] x no. of tubes	1725 X 47 x 10 ①
Physical Absorber dimensions l x Øouter of inner tube [mm] x no. of tubes	1744 X 47 x 10 ①
Aperture dimensions l x Øinner of out-er tube [mm] x no. of tubes	1725 X 55 x 10 ①
Gross/ Aperture/ Absorber area [m²]	1.64 ① / 0.95 ① / 0.81 ①
Weight empty [kg]	35 ②
Fluid content [l]	0.60 ③

Absorber:

Construction type	Heat-pipe Sydney-Glass tube ②
Absorber Material	glass with aluminium heat transfer sheets ②
Absorber Grid	serial ②
Absorber thickness [mm]	1.60 ②
Effective Surface	all around ②
Surface treatment	CU/SS-N /AL ②

① Determinate by test laboratory
② reviewed manufacturer information
③ according to manufacturer information

Absorptance [ ]	0.91 ③
Emittance [ ]	0.06 ③

Absorber Piping:

Collector connection type / dimension [mm] / numbers	pipe / 22 / 2 ②
Header tube material / dimension [mm]	copper ② / 38 ②
Riser tube-header / tube-Absorber connection	brazed ② / mechanical ②
Riser tube material / $Ø_{outer}$ / thickness / overall length [mm]	copper / 24 / 1 / 67.2 ②
Number and Distance [mm] of riser tubes or fins on center position	10 / 75 ②

Cover:

Number of covers	1 ②	
Glazing to absorber space	3.7 ② (measured on one point)	
	Glas 1	Glas 2
Length / $Ø_{outer}$ / thickness [mm]	1800 / 58 / 1.6 ②	-
Material / surface and coating	Borosilicate glass / clear glass ③	-
Transmittance factor [ ]	0.910 ③	-

Casing:

Enclosure L x W x T [mm]	805 / 161 / 123 ②	
Enclosure material	aluminium alloy ②	
Enclosure backside material	not part of construction ②	
Frame fastening method	screws ②	
Insulation	Primary Material	Secondary Material
Material	Rock wool ②	-
Thickness [mm]	20 / 56 ②	-
Material thermal conductivity [W/Km²]	0.043 ③	-
Lateral insulation	Primary Material	Secondary Material
Material	-	-
Thickness [mm]	-	-
Material thermal conductivity [W/Km²]	-	-

Sealing`s:

Frame - Cover	not part of construction ②

① Determinate by test laboratory
② reviewed manufacturer information
③ according to manufacturer information

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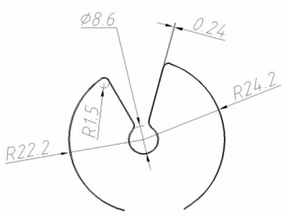
Frame Corner or side caps	Silicon base ②
Frame - back sheet	not part of construction ②
Grommet header tube	Silicon base ②
Grommet evacuated tube	Silicon base ②
Evacuated tube closure	Silicon base ②

Head pipe:

total length [mm]	1700 ②
Heating section length / -diameter [mm]	1625 / 8 ②
Condenser length / -diameter [mm]	75 / 24 ②
Material	copper ②
Fluid	water ③
Fluid content [l]	1.5 ③
Filling pressure [kPa]	$1.3*10^{-6}$ ③

Heat conduction plate (HCP):

HCP per tube	1 ②
	Unit I
HCP Form	 ②
HCP material	aluminum ②
Number of HCP Parts per tube	1 ②
HCP length / thickness [mm]	1630 / 0.24 ②

Limit values (given by manufacturer):

Max. operating temperature [°C]	185
Maximum operating pressure [kPa]	600
Recommended Heat transfer medium	Water Glycol mixture
Recommended operating mass Flow [l/(m²h)]	Not mentioned
Tilt angle limits [°]	30 to 70
Collector mounting	on roof and flat roof mounting in vertical position is possible
Other limitations	not mentioned

① Determinate by test laboratory
② reviewed manufacturer information
③ according to manufacturer information

6 Execution and evaluation

6.1 Visual inspection

Date	27 September 2013	Inspector	Reba Liu
Internal barcode no.	Serial no.	Description of defects	
154026306-1	ONS/HPC10-20130606005	No visual damages	

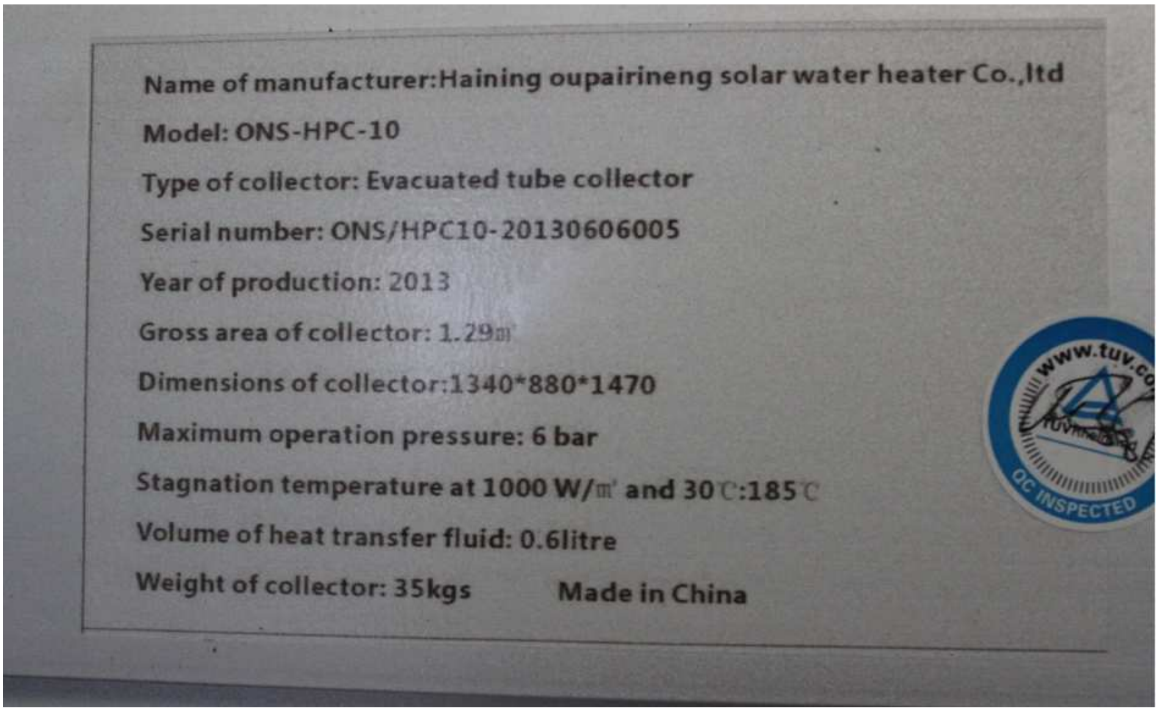


Fig. 1: test sample label (random selection)

7 Measuring results of thermal performance testing

7.1 Test method according to DIN EN 12975-2:2006 chapter 6.3

Serial no.	ONS/HPC10-20130606005	
Date (Start/End)	28 September 2013	15 October 2013
Inspector	Reba Liu	

7.2 Test conditions

Latitude [°]	26°04'
Longitude [°]	101°40'
Collector tilt [° from horizontal]	30 / 60
Collector azimuth [° from south]	0
Orientation of absorber or pipes	vertical
Mass flow [kg/(m²s)]	0.028
Aperture area A_a [m²]	0.95

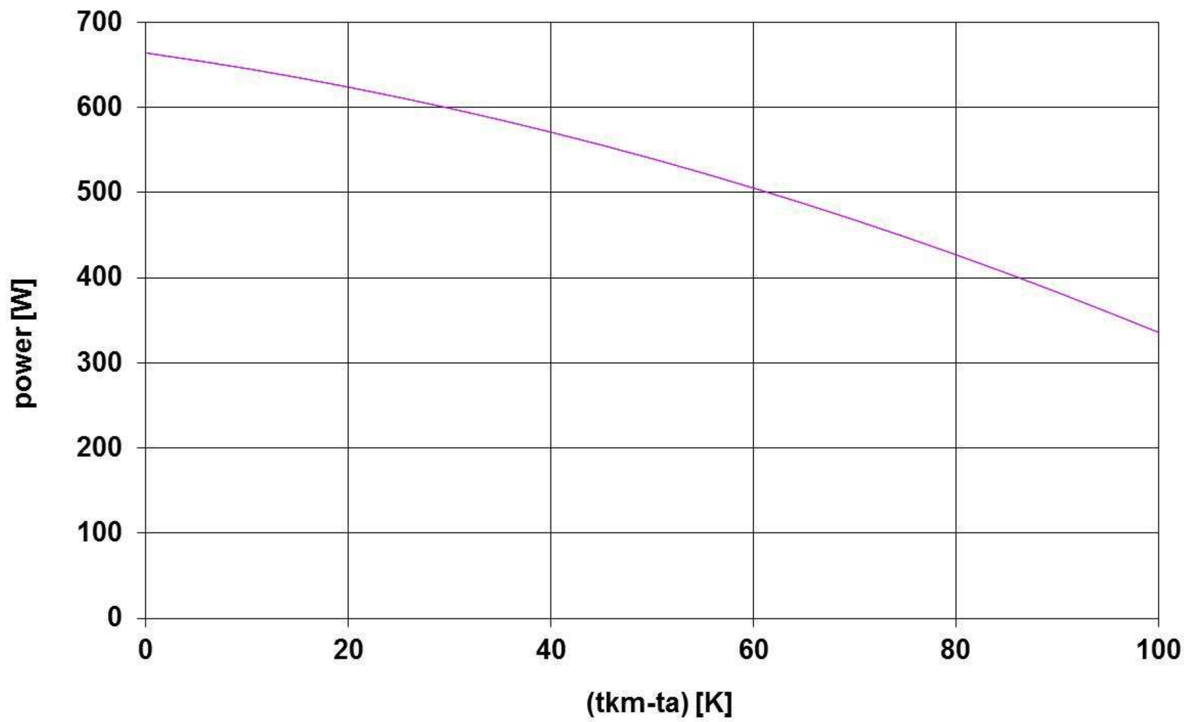
7.2.1 *Test results thermal performance*

Second order fit to data

$$\dot{Q} = A \cdot G\left(\eta_0 - a_1 \frac{(t_m - t_a)}{G} - a_2 \frac{(t_m - t_a)^2}{G}\right)$$

Conversion factor η_{0a} [ ]	0.701 (based on aperture area)
Heat transfer coefficient a_{1a} [W/(m²K)]	1.780 (based on aperture area)
Temp. dependent heat transfer coefficient a_{2a} [W/(m²K²)]	0.017 (based on aperture area)
Incidence angle modifier K_θ (40.2°/ 40.2°) [ ]	1.32 (based on aperture area)
Effective heat capacity c [kJ/(m²K)]	109.446 (based on aperture area)
Time constant τ_c[s]	Not necessary for quasi-dynamic test method

Power curve per collector unit (for G = 1000 W/m²)



Maximum power [W_{peak}] (G=1000 W/m²) per collector unit	**664**

Details of any damage and problems:
No visual damages

For more details about thermal performance test see Appendix 1: Thermal performance test results.

8 General remarks

All results only refer to the test samples that were subjected to testing. Symbols are in accordance with ISO 9488 and ISO 9806-1 Annex A.

The extended total measuring uncertainty for the outdoor performance test is:

$\eta \leq \pm$ 2.45 % (for irradiation levels above 700 W/m² and K=2)

To minimize back side reflectivity during thermal performance test, a black plastic film with low reflectivity (< 20%) was used!

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Appendix 1: Thermal performance test results

Evaluation of quasi-dynamic collector test based on aperture area and mean temperature of heat transfer fluid (multi linear regression/ simulation)

Based on aperture area:		
Aperture collector area used for curve:	0.95 m²	
The quasi-dynamic collector model is defined by		
$Q/A_a = F'(\tau\alpha)_{en} K_{\theta b}(\theta) G_b + F'(\tau\alpha)_{en} K_{\theta d}(\theta) G_d - c_6 u G^* - c_1(t_m-t_a) - c_2(t_m-t_a)^2 - c_3 u(t_m-t_a) - c_4(E_L-\sigma T_a^4) - c_5 dt_m/dt$		
Mass flow during test [kg/(m²s)]	0.028	
Operating pressure during test [kPa]	150	
Based on aperture area		
	Value	Unit
$F'(\tau\alpha)_{en}$	0.672	[ ]
$K_{\theta d}$	1.285	[ ]
$b_0(\theta)$	0.060	[ ]
c_1	1.780	[W/(m²K)]
c_2	0.017	[W/(m²K²)]
c_3	not determined	[J/(m³K)]
c_4	not determined	[W/(m²K)]
c_5	109.446	[kJ/(m²K)]
c_6	not determined	[s/m]

Angle [°]	10	20	30	40	50	60	70
$K_{\theta b\ longi}$ () [ ]	1.00	1.00	0.99	0.98	0.97	0.94	0.88
$K_{\theta b\ trans}$ () [ ]	1.02	1.08	1.20	1.34	1.54	1.62	1.62
Incidence angle modifier K_θ (40.2°/ 40.2°) [ ]	**1.32** (based on aperture area)						

Comparison between measurement and regression (see Figure A1.4):

Total energy deviation [%]	1.69
Objective [%]	3.42

The "objective" describes the ratio of the integrated absolute energy difference between measurement and simulation/ regression to the total measured energy during the complete test sequence.

Calculation of collector parameters

Conversion factor η_0	$= F'(\tau\alpha)_{en}\ K_{\theta b}(\theta_{l,t}{=}15.0°)\ 0.85 + F'(\tau\alpha)_{en}\ K_{\theta d}(\theta)\ 0.15$
Heat transfer coefficient a_1	= c1
Temperature dependent heat transfer coefficient a_2	= c2
Effective heat capacity c	= c5

Presentation of the used data set for regression

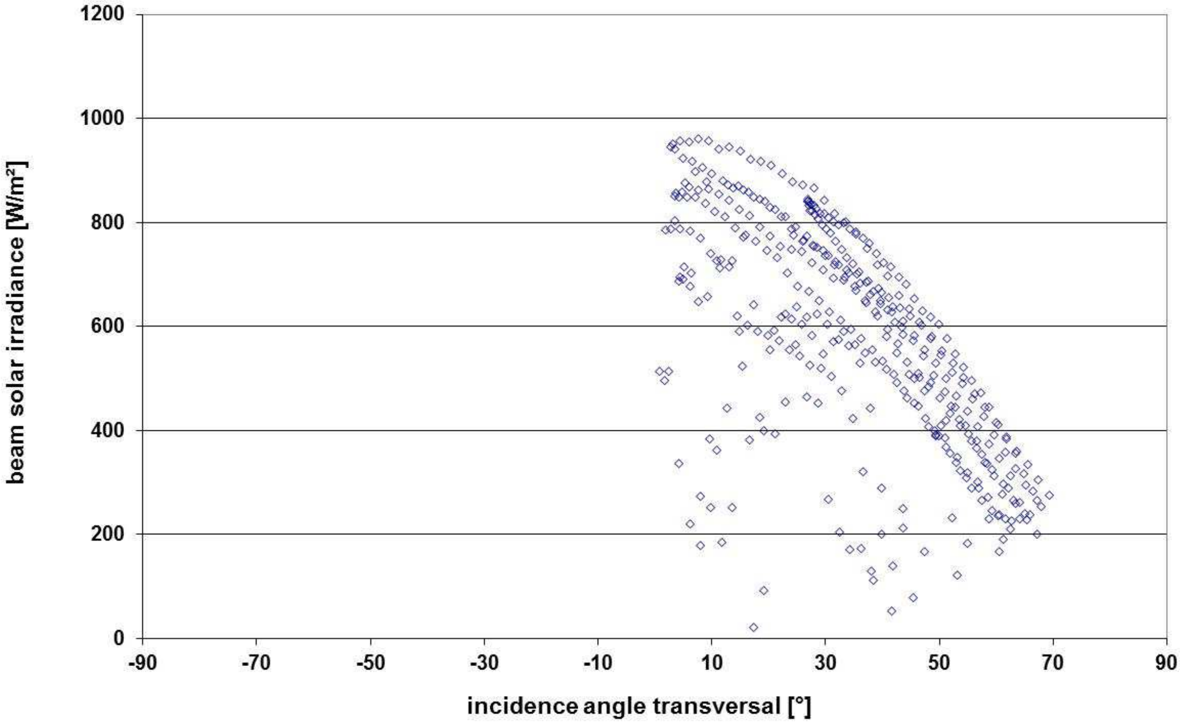

Figure A1.1: Direct solar irradiance over its incidence angle

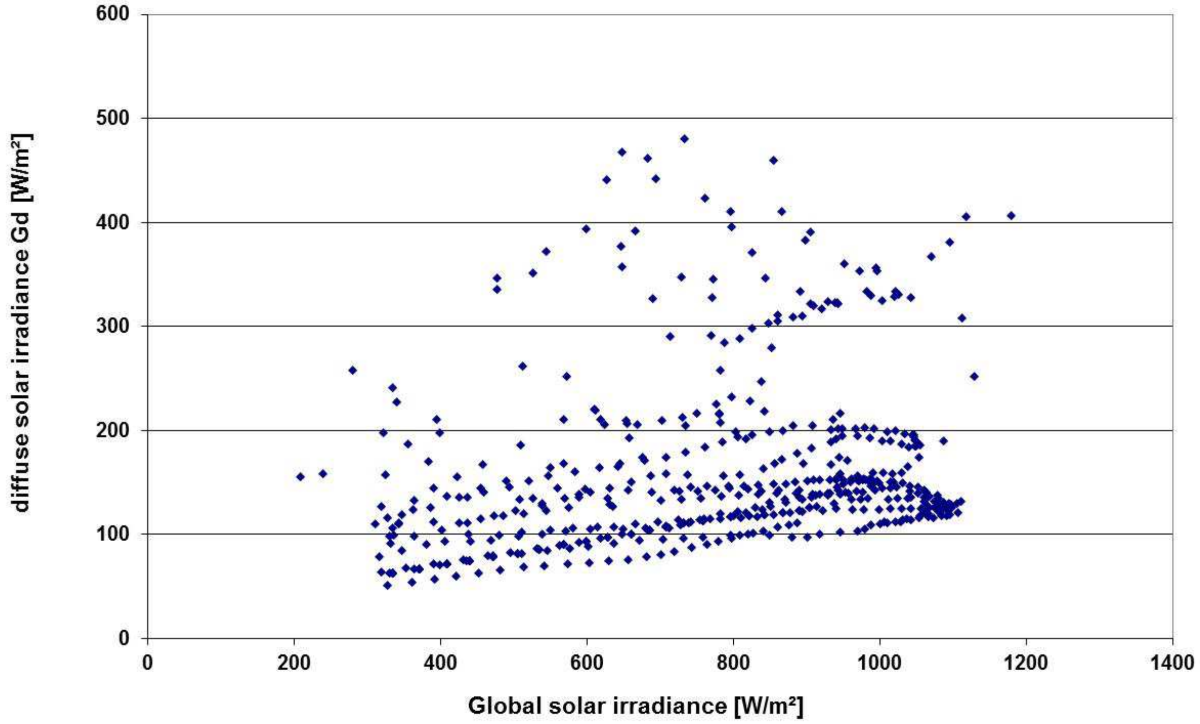

Figure A1.2: Diffuse solar irradiance over global irradiance

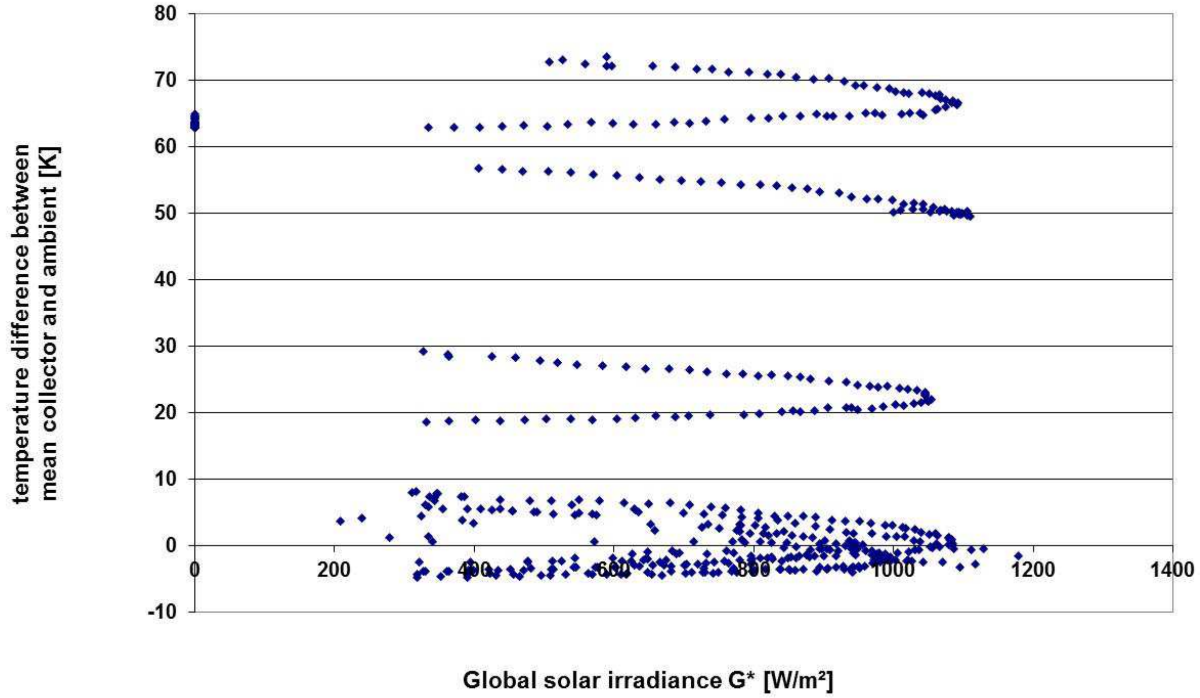

Figure A1.3: Temperature difference between mean collector and ambient temperature over global irradiance

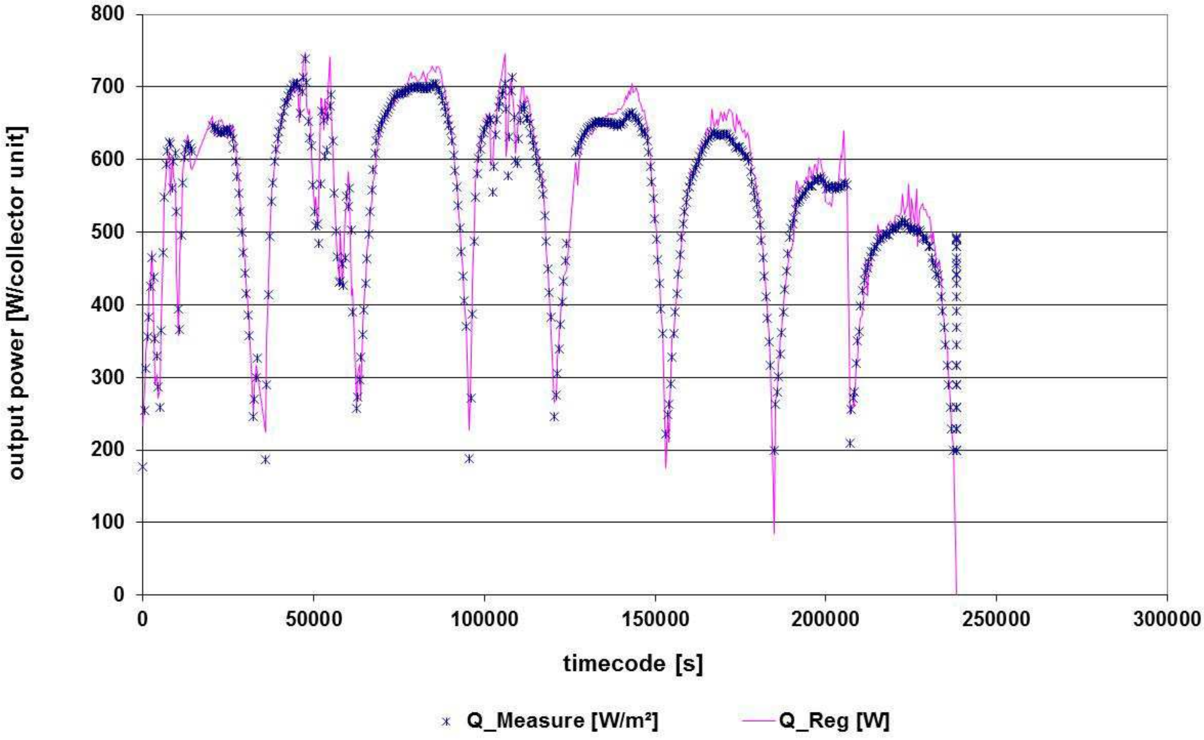

Figure A1.4: Measured and calculated power over time (full data set)

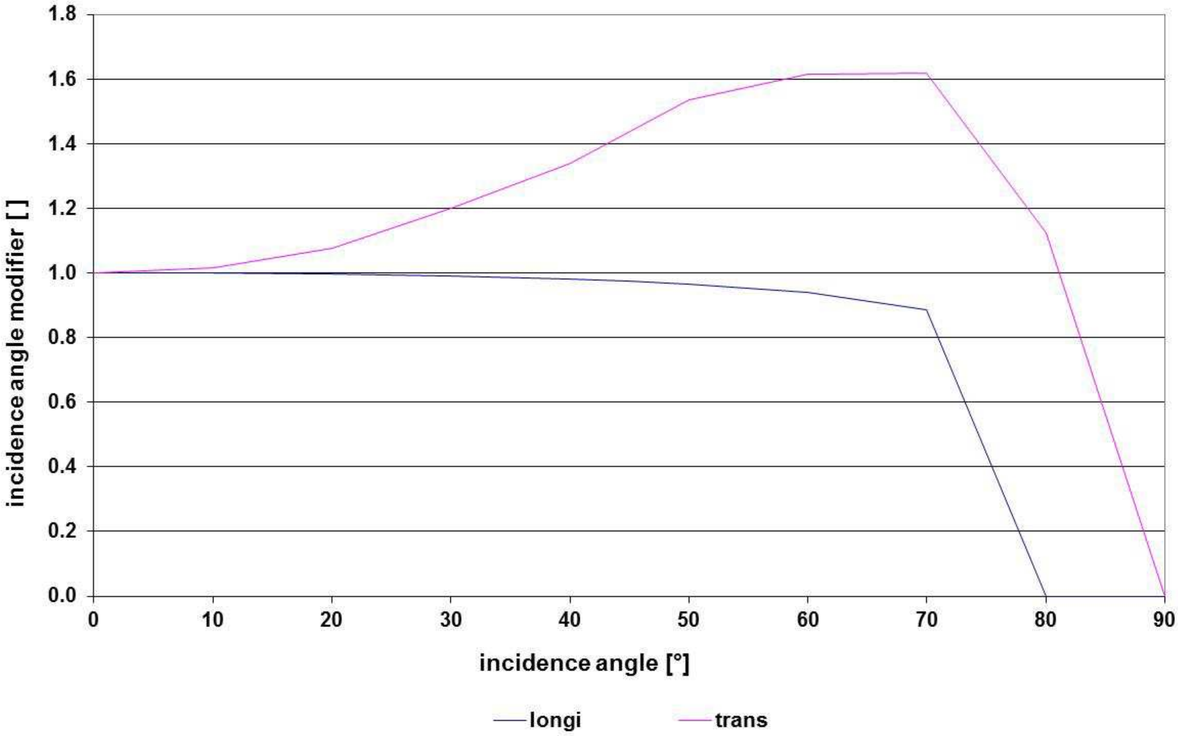

Figure A1.5: incidence angle modifier over incidence angle

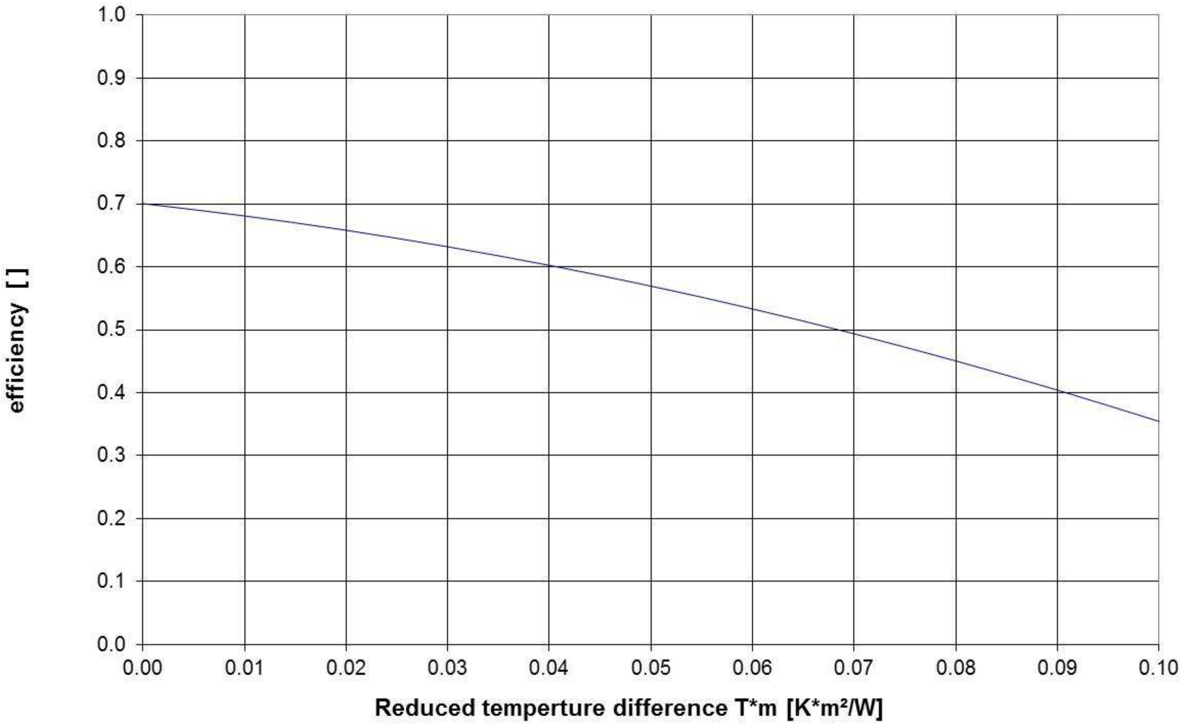

Figure A1.6: efficiency curve over reduced temperature difference at 1000W/m² irradiation

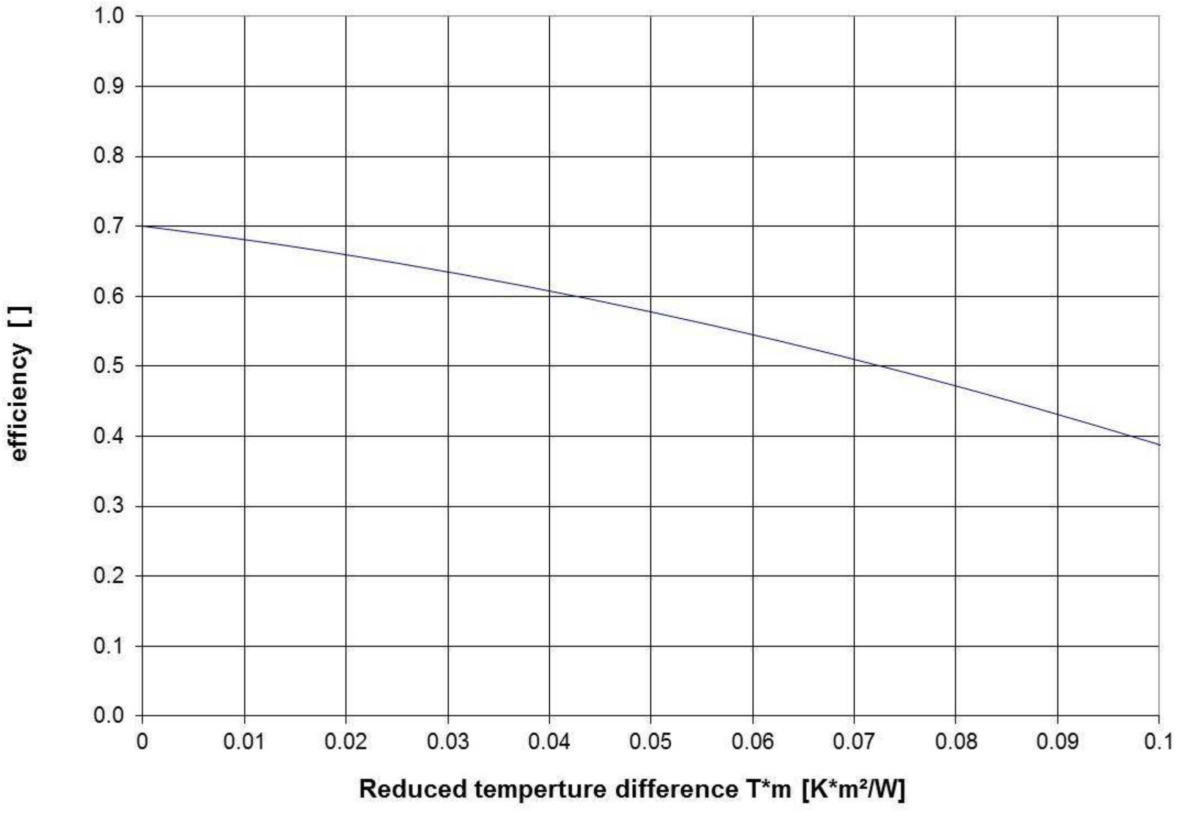

Figure A1.7: efficiency curve over reduced temperature difference at 800W/m² irradiation

Appendix 2: Photo documentation

Fig. 2: incoming inspection

Fig. 3: performance test