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30.3734.1 - Comparative Tests PVT vs ST collectors

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**Solar Thermal Energy & Thermal Storage
Department**



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Report: Comparative Tests PVT vs ST collectors

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TABLE OF CONTENTS

1. BACKGROUND	4
2. SAMPLES DESCRIPTION	4
3. TESTING METHOD	6
3.1 METHODOLOGY	6
3.2 TEST CONDITIONS	7
4. RESULTS.....	8
4.1 DAILY THERMAL PERFORMANCE.....	8
5. CONCLUSIONS	9
6. REFERENCES	10



1. BACKGROUND

The purpose of this document is to describe a comparative performance test among one PVT collector and one ST collector. The objective of these tests is to assess the performance of a PVT collector constructed by attaching a heat exchanger in the backside of a commercial PV module. For this, the thermal yield of the PVT collector will be compared with the thermal yield of a reference commercial ST collector.

2. SAMPLES DESCRIPTION

On the 07th of May, the client sent to CENER one PVT sample and one ST sample to apply comparative tests. At receipt of the samples, any defect was registered by CENER.



Brand Name	Heat Exchanger
Model	P-FHE16PS
Manufacturer	Fegen
Serial Number	100122190621
Maximum operation pressure	6 bar
Volume of heat transfer fluid	
Weight of empty collector	4 kgs
Gross area of collector	1.150 m ²
Stagnation temperature at 1000 W/m ² and 30 °C	70 °C
Dimension of collector	1550 x 960 x 18
Made in	Greece
Year of Production	2019

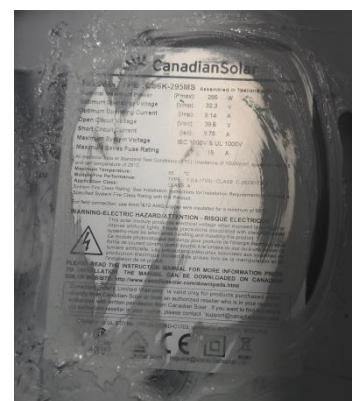


Figure 1. PVT sample. PVT collector composed by PV module Canadian Solar CS6K-295MS, serial number: 11810481170589 and Heat exchanger P-FHE16PS, serial number: 100122190621.



Figure 2. Solar Thermal Collector, Sammler Aris 2004 serial number: 103.739



3. TESTING METHOD

3.1 Methodology

The methodology for the performance comparison was to record and to compare the thermal performance of the two PVT and ST collectors operating under identical ambient conditions. The thermal performance measurement was based on the standard ISO9806:2017 [1]. The tests are carried out in a closed circuit. The inlet temperature of the fluid to the collectors is constant and close to the ambient temperature of the day. The outlet temperature is continuously cooled to reach again the initial set inlet temperature. Regarding the PVT collector, thermal performance test was made under maximum electrical power generation conditions.

This comparison was made during spring season in two complete days (clear days or almost clear days with low wind speed). According to client request, this comparison was performed at 5° and 35° with fixed tilt for the complete day.

Comparative graph and table energy values were performed in order to compare thermal performance of both collectors.



Figure 3. Assembly of solar components at fixed tilt
Testing location: Sarriguren, Spain Latitude 42,8° Longitude -1,6°



3.2 Test Conditions

Several parameters were monitored simultaneously for each collector such as Hemispherical Solar Irradiance, Inlet Temperature, Outlet Temperature, Ambient Temperature and Mass Flow rate for every 2 seconds. From these parameters instantaneous efficiency was calculated every 5 minutes. Find below daily average test conditions reached for each day.

Table 1. Day 25/08/2020 - tilt 5° - Solar Thermal Collector

Time period 09:01:08 – 20:59:58	Irradiance G_{hem} (W/m ²)	Ambient air Temperature ϑ_a (°C)	Inner Temperature ϑ_i (°C)	Outlet Temperature ϑ_e (°C)	Flow rate \bar{m} (Kg/s)	Wind speed u (m/s)
Min.	18	16,8	28,5	28,6	2,98	0,2
Max.	931	35,9	29,5	35,6	3,02	14,9
Average	608	29,1	29,2	32,9	3,01	1,6

Table 2. Day 25/08/2020 - tilt 5° - PVT Collector

Time period 09:01:08 – 20:59:58	Irradiance G_{hem} (W/m ²)	Ambient air Temperature ϑ_a (°C)	Inner Temperature ϑ_i (°C)	Outlet Temperature ϑ_e (°C)	Flow rate \bar{m} (Kg/s)	Wind speed u (m/s)
Min.	18	16,8	28,6	28,1	2,97	0,2
Max.	931	35,9	29,5	32,3	3,02	14,9
Average	608	29,1	29,3	30,7	2,98	1,6

Table 3. Day 26/08/2020 - tilt 35° - Solar Thermal Collector

Time period 09:15:34 – 20:25:14	Irradiance G_{hem} (W/m ²)	Ambient air Temperature ϑ_a (°C)	Inner Temperature ϑ_i (°C)	Outlet Temperature ϑ_e (°C)	Flow rate \bar{m} (Kg/s)	Wind speed u (m/s)
Min.	12	20,5	27,1	28,1	3,01	0,2
Max.	1023	31,7	29,4	36,4	3,03	6,7
Average	666	28,1	29,1	33,3	3,02	1,3

Table 4. Day 26/08/2020 - tilt 35° - PVT Collector

Time period 09:15:34 – 20:25:14	Irradiance G_{hem} (W/m ²)	Ambient air Temperature ϑ_a (°C)	Inner Temperature ϑ_i (°C)	Outlet Temperature ϑ_e (°C)	Flow rate \bar{m} (Kg/s)	Wind speed u (m/s)
Min.	12	20,5	27,2	27,3	2,96	0,2
Max.	1023	31,7	29,4	32,3	2,98	6,7
Average	666	28,1	29,2	30,7	2,97	1,3



4. RESULTS

4.1 Daily Thermal Performance

From the acquired data for each day, comparative graph and table energy values were performed in order to compare thermal performance of both collectors. The reference area for these energy calculations was the total area of collectors, ST: 2,12 m² and PVT: 1,64 m².

Table 5. Day 25/08/2020 at tilt 5°

Collector Type	Solar Thermal Energy Production (MJ)	Solar Thermal Energy Production (MJ/m ²)	Solar Irradiation on collector plane (MJ/m ²)	Daily Thermal Efficiency (%)
Solar Thermal Sammler Aris 2004	31,4	14,8	25,2	0,59
FEGEN PVT – CSK6-16PS	13,0	8,0	25,2	0,32

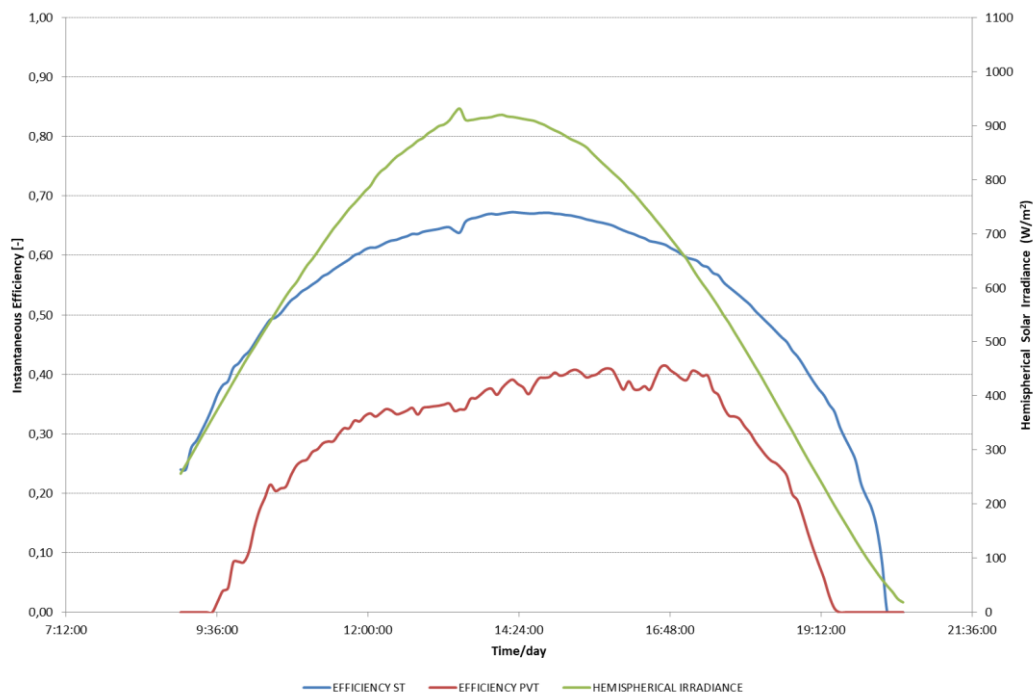


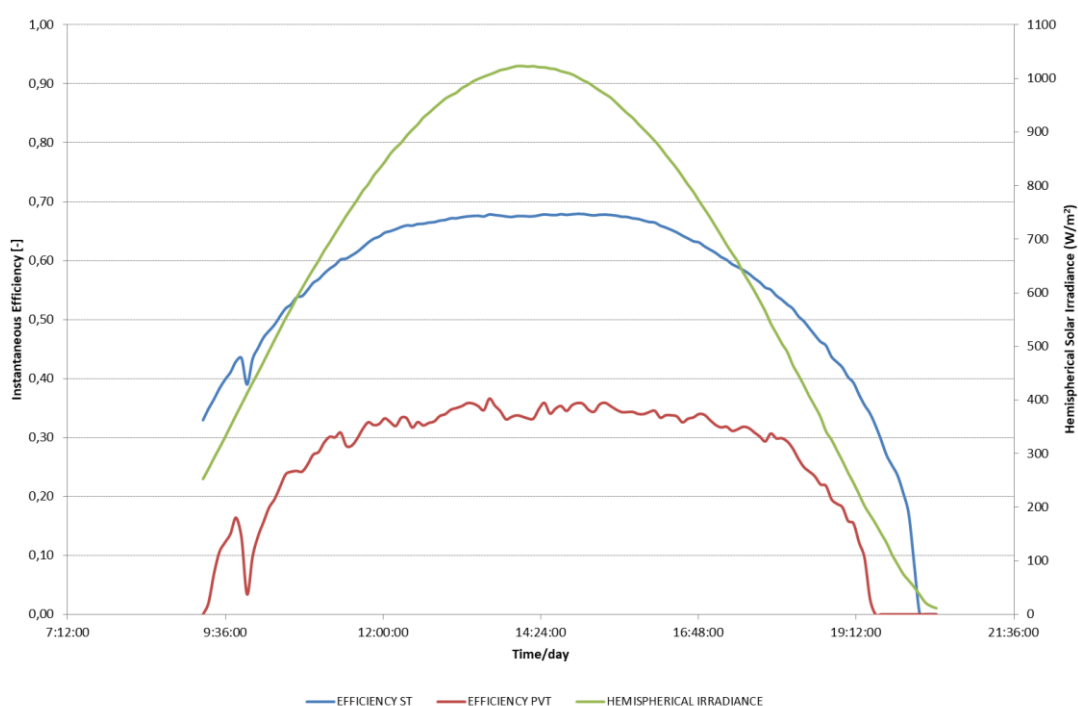
Figure 4. Comparative graph of thermal performance for both collectors at 5° / 25/08/2020

Notes:

1.- Near the solar noon, a reflection is observed on the radiation sensor for about ten minutes. In terms of comparison, this effect was considered no significant on the study performed.

**Table 6. Day 26/08/2020 at tilt 35°**

Collector Type	Solar Thermal Energy Production (MJ)	Solar Thermal Energy Production (MJ/m ²)	Solar Irradiation on collector plane (MJ/m ²)	Daily Thermal Efficiency (%)
Solar Thermal Sammler Aris 2004	34,9	16,5	26,8	0,62
FEGEN PVT – CSK6-16PS	13,4	8,2	26,8	0,31

**Figure 5. Comparative graph of thermal performance for both collectors at 35° / 26/08/2020****Notes:**

1.- At the beginning of the day around 10:00 in the morning, a readjustment of the inlet temperature was carried out and the efficiency of both collectors decreased around twenty minutes until the temperature stabilization was correctly again. In terms of comparison, this effect was considered no significant on the study performed.



5. CONCLUSIONS

The main conclusions that we can observe in the valid period of this study are:

- The daily performance obtained by both collectors at 5° and 35° tilt is very similar. In the case of the thermal solar collector, there is a difference of 4,8 % between these two days and in the case of the PVT collector there is a difference of 3,1 %.
- The daily performance obtained by the solar thermal collector is 46 % higher than the hybrid collector for the 5° tilt and 50% for the 35° tilt.

These conclusions can only be applied for the samples tested, location and meteorological conditions at the time of the test.

6. REFERENCES

[1] International Standard ISO 9806:2017 “Solar Energy – Solar thermal collectors - Test methods”