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30.3734.0 - Comparative Tests PVT vs ST collectors

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Solar Thermal Energy & Thermal Storage Department

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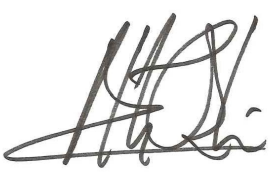

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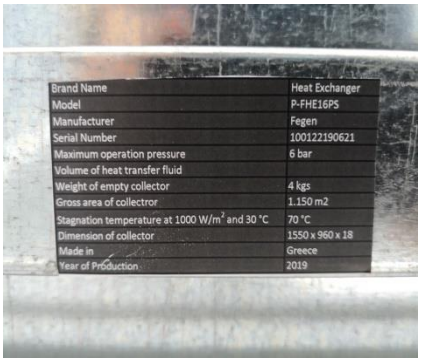
1. BACKGROUND

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.



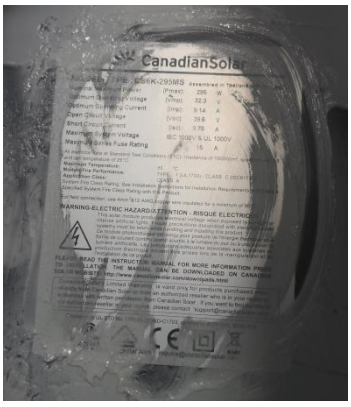


Figure 1. PVT sample. PVT collector composed by PV module Canadian Solar CS6K-295MS, serial number: 11810481170589 and Heat exchanger P-FHE16PS, serial number: 100122190621.

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]. Regarding the PVT collector, thermal performance tests 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 5º and 35º 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 42,8º Longitude -1,6º

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 28/05/2020 - tilt 5º - Solar Thermal Collector

Time period 8:37:31 – 20:46:45	Irradiance G_{hem} (W/m^2)	Ambient air Temperature ϑ_a (ºC)	Inner Temperature ϑ_i (ºC)	Outlet Temperature ϑ_e (ºC)	Flow rate $\dot{m}$ (Kg/s)
Min.	72	17,6	29,8	30,3	2,2
Max.	1.004	32,1	30,3	39,3	2,4
Average	677	28,2	30,3	35,6	2,3

Table 2. Day 28/05/2020 - tilt 5º - PVT Collector

Time period 8:37:31 – 20:46:45	Irradiance G_{hem} (W/m^2)	Ambient air Temperature ϑ_a (ºC)	Inner Temperature ϑ_i (ºC)	Outlet Temperature ϑ_e (ºC)	Flow rate $\dot{m}$ (Kg/s)
Min.	72	17,6	30,0	29,6	2,2
Max.	1.004	32,1	30,4	34,0	2,4
Average	677	28,2	30,3	32,4	2,3

Table 3. Day 29/05/2020 - tilt 35º - Solar Thermal Collector

Time period 8:27:41 – 20:20:07	Irradiance G_{hem} (W/m^2)	Ambient air Temperature ϑ_a (ºC)	Inner Temperature ϑ_i (ºC)	Outlet Temperature ϑ_e (ºC)	Flow rate $\dot{m}$ (Kg/s)
Min.	79	16,1	29,8	29,9	2,3
Max.	1.034	30,6	30,4	39,5	2,4
Average	674	26,8	30,2	35,5	2,3

Table 4. Day 29/05/2020 - tilt 35º - PVT Collector

Time period 8:27:41 – 20:20:07	Irradiance G_{hem} (W/m^2)	Ambient air Temperature ϑ_a (ºC)	Inner Temperature ϑ_i (ºC)	Oulet Temperature ϑ_e (ºC)	Flow rate $\dot{m}$ (Kg/s)
Min.	79	16,1	29,9	29,0	2,3
Max.	1.034	30,6	30,4	34,1	2,3
Average	674	26,8	30,2	32,2	2,3

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 m^2 and PVT: 1,64 m^2.

Table 5. Day 28/05/2020 at tilt 5º

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	36,8	17,3	29,7	**0,58**
FEGEN PVT – CSK6-16PS	14,9	9,1	29,7	**0,31**

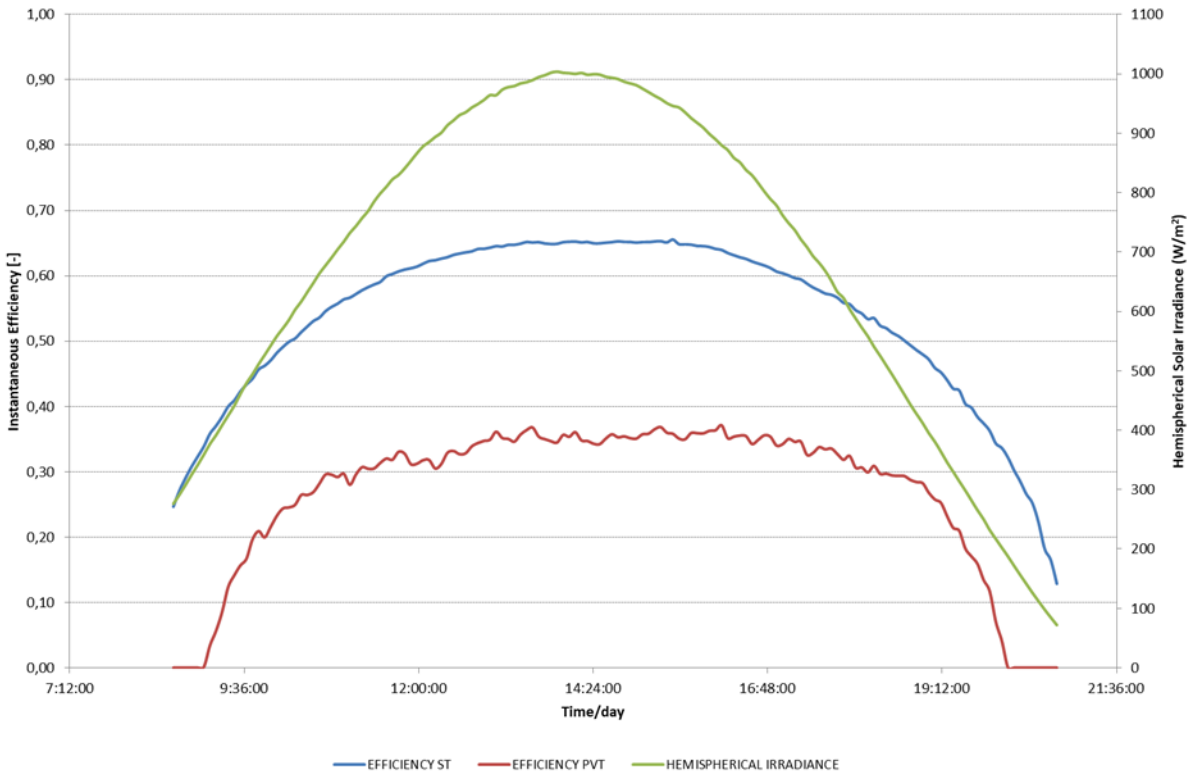


Figure 4. Comparative graph of thermal performance for both collectors at 5º / 28/05/2020

Table 6. Day 29/05/2020 at tilt 35º

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	35,1	16,5	28,3	**0,58**
FEGEN PVT – CSK6-16PS	13,5	8,3	28,3	**0,29**

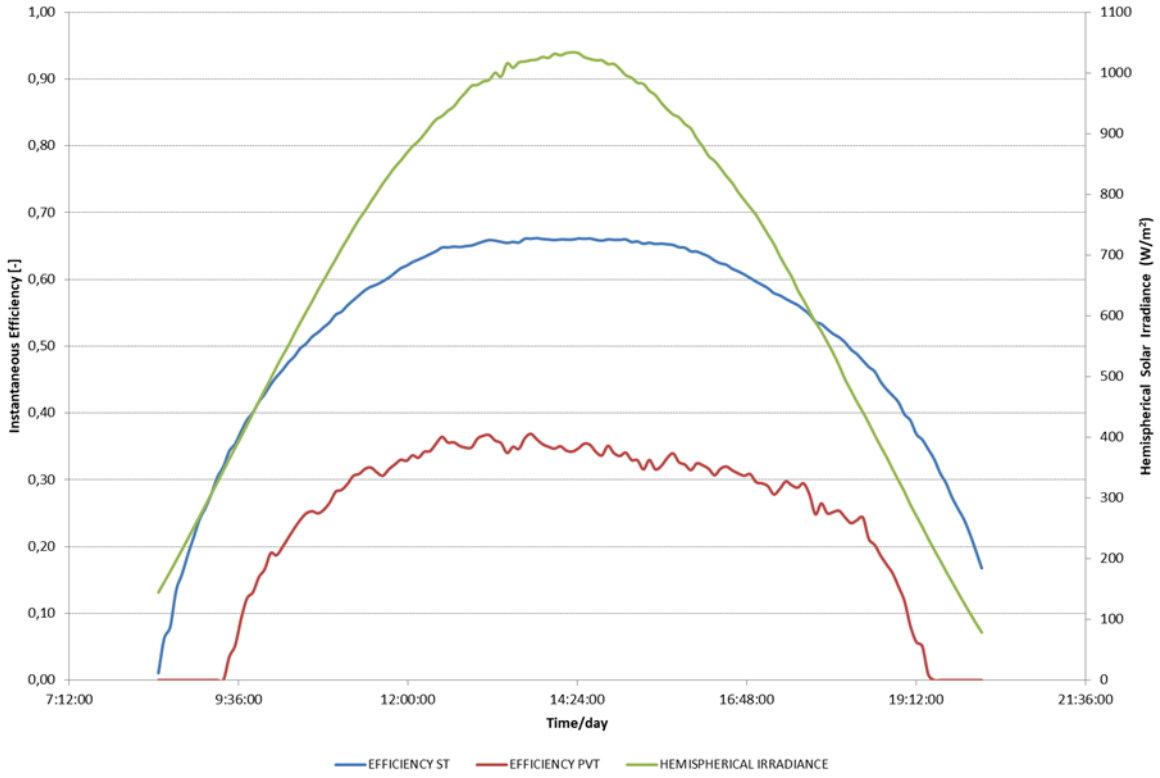


Figure 5. Comparative graph of thermal performance for both collectors at 35º / 29/05/2020

4.2 Daily Thermal Performance – Valid Period

Unfortunately, it was identified that PV performance decreased significantly due to the thermal collector shadowed the PVT collector from 16:45 at 35º inclination and from 17:30 at 5º inclination. For this reason, it was decided to discard the measured data from these times and to recalculate the energy parameters in the valid measurement period. Find below in tables 7 and 8 the final energy values:

Table 7. Day 29/05/2020 at tilt 35º 8:27:41 up to 16:45

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	29,6	13,9	23,2	**0,60**
FEGEN PVT – CSK6-16PS	11,6	7,1	23,2	**0,31**

Table 8. Day 28/05/2020 at tilt 5º from 8:37:31 up to 17:15

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	31,7	14,9	24,8	**0,60**
FEGEN PVT – CSK6-16PS	12,9	7,9	24,8	**0,32**

5. CONCLUSIONS

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

- The daily thermal performance obtained by both collectors at 5º and 35º tilt is very similar. In the case of the thermal solar collector, there is not any difference between these two days and in the case of the PVT, there is a difference around 3%.
- The daily thermal performance obtained by the solar thermal collector is 47 % higher than the hybrid collector for the 5º tilt and 48 % for the 35º tilt.
- Although the hybrid collector was shadowed by the thermal collector during some hours at the end of the day, it was observed that the thermal performance obtained by the PVT collector was very similar in both measurement periods.

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”