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ADItech

30.3734.2 - Comparative Tests PVT vs ST collectors

Autumn season

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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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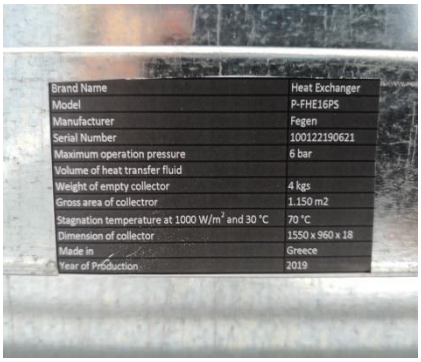
1. BACKGROUND

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.



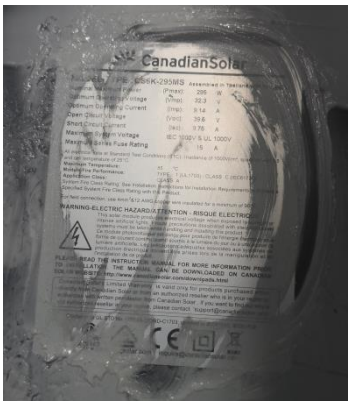


Figure 1. PVT sample. PVT collector composed by PV module Canadian Solar CS6K-295MS, serial number: 11810481170589 and Heat exchanger P-FHE16PS, serial number: 100122190621.

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]. 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 autumn 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 21/11/2020 - tilt 5º - Solar Thermal Collector

Time period 09:33:49 – 15:38:49	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/min)	Wind speed u (m/s)
Min.	227	5.9	15.11	15.66	2.99	0.21
Max.	536	15.9	15.43	18.18	3.00	2.12
Average	440	12.0	15.27	17.36	2.99	0.68

Table 2. Day 21/11/2020 - tilt 5º - PVT Collector

Time period 09:33:49 – 15:38:49	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/min)	Wind speed u (m/s)
Min.	227	5.9	15.22	15.03	2.97	0.21
Max.	536	15.9	15.47	16.65	2.97	2.12
Average	440	12.0	15.34	16.10	2.97	0.68

Table 3. Day 18/11/2020 - tilt 35º - Solar Thermal Collector

Time period 08:59:53 – 17:01:41	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/min)	Wind speed u (m/s)
Min.	180	5.3	19.95	20.74	2.97	0.18
Max.	851	18.9	20.20	26.01	2.98	1.60
Average	632	14.9	20.10	24.07	2.98	0.56

Table 4. Day 18/11/2020 - tilt 35º - PVT Collector

Time period 08:59:53 – 17:01:41	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/min)	Wind speed u (m/s)
Min.	180	5.3	20.11	19.45	2.99	0.18
Max.	851	18.9	20.30	22.49	3.00	1.60
Average	632	14.9	20.20	21.61	2.99	0.56

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 21/11/2020 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	9.7	4.6	9.8	**0.47**
FEGEN PVT – CSK6-16PS	3.6	2.2	9.8	**0.22**

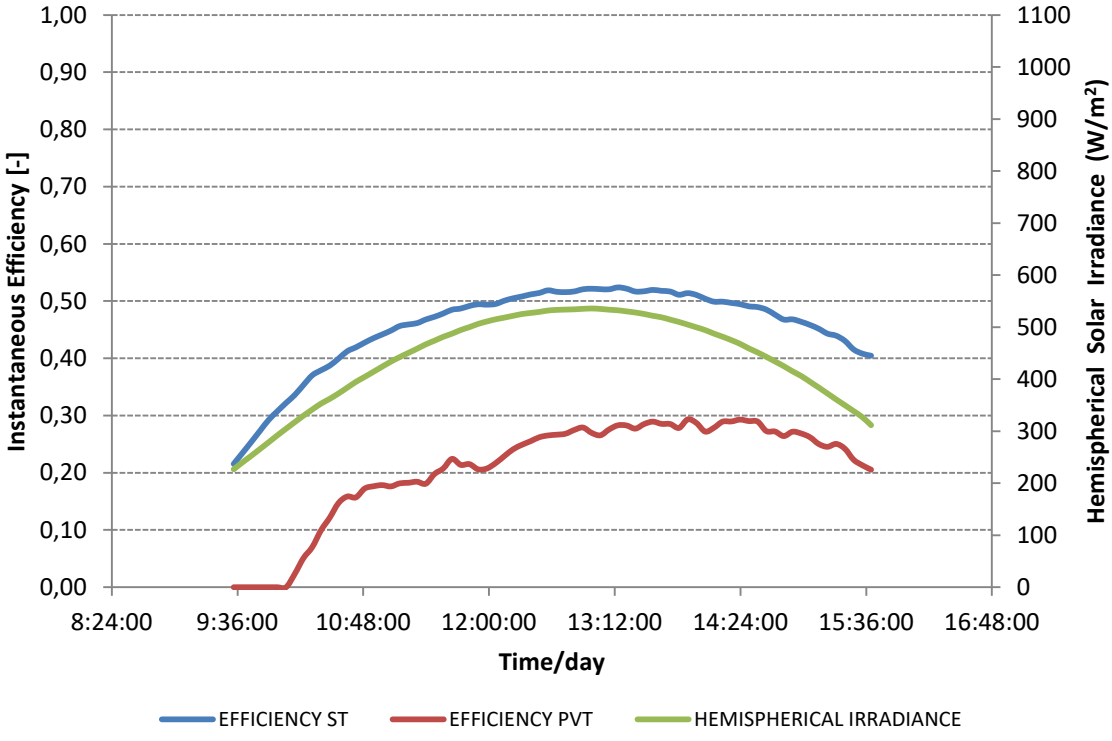


Figure 4. Comparative graph of thermal performance for both collectors at 5º / 21/11/2020

Notes:

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Table 6. Day 18/11/2020 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	24.7	11.6	18.9	**0.61**
FEGEN PVT – CSK6-16PS	9.0	5.5	18.9	**0.29**

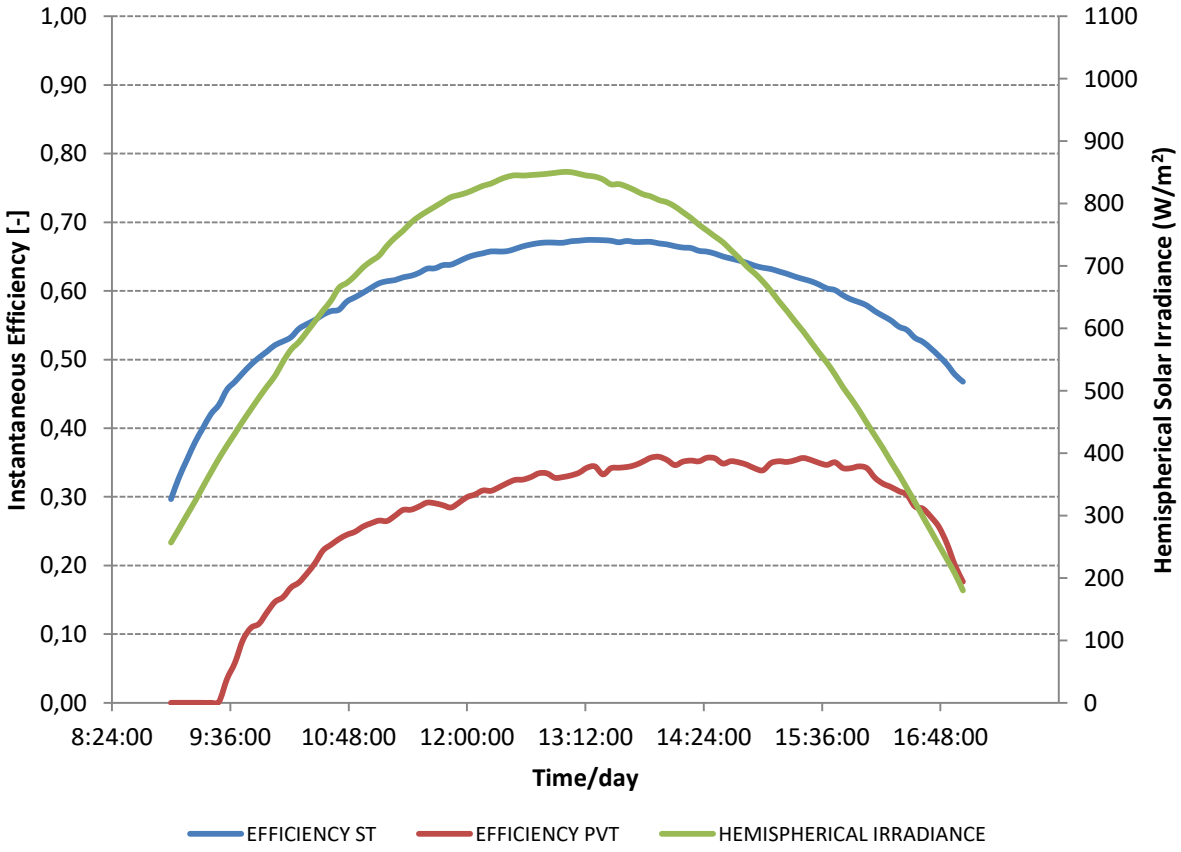

Figure 5. Comparative graph of thermal performance for both collectors at 35º / 18/11/2020

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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 5º and 35º of inclination differs considerably. In the case of the thermal solar collector, there is a difference of 22.9 % between these two days and in the case of the PVT collector there is a difference of 24.1 %. It is clear the influence of the incidence angle modifier at this testing period time in both cases.
- The daily performance obtained by the solar thermal collector is 52.3 % higher than the hybrid collector for the 5º tilt and 52.4% for the 35º 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”