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Intercomparison Performance Test of

PVT-Collectors

Summary

While market figures for solar thermal collectors are stagnating, the market for PVT-Collectors has shown steady average growth of about 8% per year between 2017 and 2024. The newly installed capacity in 2024 amounted to 37.5 MWth and 18.6 MWpeak. This is an increase of 13% compared to the installed thermal capacity in 2023. The cumulative installed PVT collector area by the end of 2024 was 1.7 million square meters, which relates to a thermal capacity of 866 MWth and an electrical capacity of 316 MWpeak (SOLAR HEAT WORLDWIDE, 2025 Edition).

This development underscores the importance of clearly and unambiguously defined KPIs to ensure proper classification and fair consideration of the technology in the transformation of the energy system toward sustainable solutions.

This article presents methods for characterizing the performance of PVT-Collectors and reports the results of an intercomparison test on PVT-Collectors that represent a cross-section of the current technology in the market.

Keywords: PTV-Collectors, Efficiency Testing, Monitoring, in-Situ, Intercomparison-Test

Field of application for the findings: Solar Thermal and PVT Collectors and Solar Loop Components

Addressed audience: Testing-laboratories, civil engineers, energy providing companies, district heating turnkey providers

1. Introduction

PVT-Collectors without thermal insulation of the heat exchanger, achieve heat yields primarily when the PVT collector is subcooled relative to the environment (see Figure 1). These convective heat gains from the environment and without solar radiation, at fluid temperatures below the ambient temperature, have not been considered coherently in the established performance evaluation of PVT-Collectors to date. Established certification and quality labels, such as the Solar Keymark or Solergy label, therefore neglect significant heat yields, which leads to in-transparency on the energy output of such products.

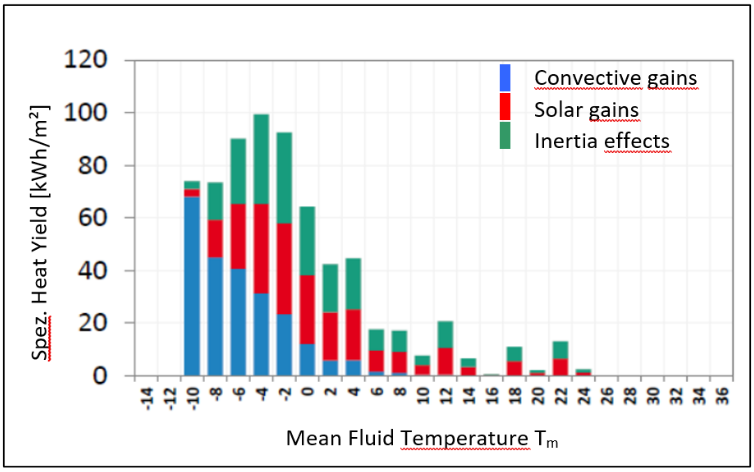

Fig. 1: Specific heat yield of PVT-Collectors, by convective and solar gains as well as inertia effects (Lämmle et al)

2. Characterization Method

For this reason, a method for quantifying these convective heat gains has been included in the recently published collector test standard ISO 9806:2025. The method is to be applied to all collector types that meet the following requirement:

$$a_1 + 1{,}5 \cdot a_3 \geq 30\ \mathrm{W/(m^2K)} \qquad \text{(eq. 1)}$$

This means that the method is not only available for PVT-Collectors, but for all collectors that have the potential to utilize convective heat gains due to their design.

The convective heat gains, i.e., the collector parameter a_1, are determined in a dark measurement without solar radiation, at a collector average temperature below the ambient temperature. The a_1 value determined in this way is fixed in the subsequent performance measurement to determine the other collector parameters in accordance with ISO 9806 (ISO 9806:2025). The specific test procedure and test conditions can be found in ISO 9806 (ISO 9806:2025).

For dark measurements, it must be ensured that the ambient temperature is measured without being influenced by the cooling of the PVT's air-brine heat exchanger. It is therefore recommended that this be measured at no more than 2 m from the PVT, but under no circumstances at the rear.

For both dark and radiated power measurements, the PVT must be installed on an open frame to allow free air flow at the front and rear. Installation on a simulated roof is rejected, as previous studies have shown that the air flow and temperatures that develop in the space between the panels depend heavily on parameters such as the field structure, the distance between the panels, the roof pitch and orientation, etc., and that it is not possible to provide a generally applicable, realistic representation.

All measurements are carried out using water as the heat transfer medium. The use of conventional water-glycol mixtures was discussed but rejected due to the high and therefore impractical testing cost. To compensate for the fluid properties of water-glycol mixtures that affect thermal output, the introduction of a safety factor is being considered. This will be determined by comparing the laboratory results with the monitoring results and presented in the full paper.

3. Laboratory Intercomparison Test

When selecting PVT-Collectors for the intercomparison test, care was taken to ensure that they represent a technological cross-section of the market. Covered PVT-Collectors were not included, as they typically have a heat loss coefficient a_1 of less than 20 W/(m²K). Selected were two identical PVT-Collectors with and without thermal insulation of the heat exchanger, as well as two PVT-Collectors whose heat exchangers feature a finned structure to increase the heat transfer area and thereby enhance convective gains.

The intercomparison test is carried out by three test laboratories accredited for determining the thermal performance of collectors. The applied methods include dark testing and stationary indoor performance measurements, as well as quasi-dynamic outdoor performance measurements.

The comparison of the results from the three test laboratories will be based on the identified parameters, the efficiency characteristics and the power output curve under standard reporting conditions according to ISO 9806 (ISO 9806:2025), the Gross Thermal Yield (GTY) and the Gross Electrical Yield (GEY).

4. In-Situ Validation

The resulting data are additionally compared with real monitoring data from a PVT system in Germany. For this purpose, the system was equipped with appropriate measurement technology and data transmission. The PVT-System is installed on a multi-family house and consists of 56 air-brine PVT-Collectors with a total area of 129 m² in conjunction with a heat pump. Additionally, 56 PV Modules with a total area of 129 m² are installed. Figure 2 shows the part of the PVT system installed on the west roof of the building. The operating behaviour of the entire PVT/heat pump system is being measured and analysed. For the parameterization of the PVT collectors in the field, and thus for comparison with the laboratory results, a subfield (orange marking) was equipped with additional sensors. Sensors were installed for volume flow measurement, temperature measurement at the inlet and outlet of the subfield, determination of global and diffuse radiation, wind speed, and the air temperature between the roof surface and the back of the PVT collectors. The measurements are stored in a database and are available for comparison with the laboratory test data of the collectors. The very same collector is used as one of the laboratory specimen.

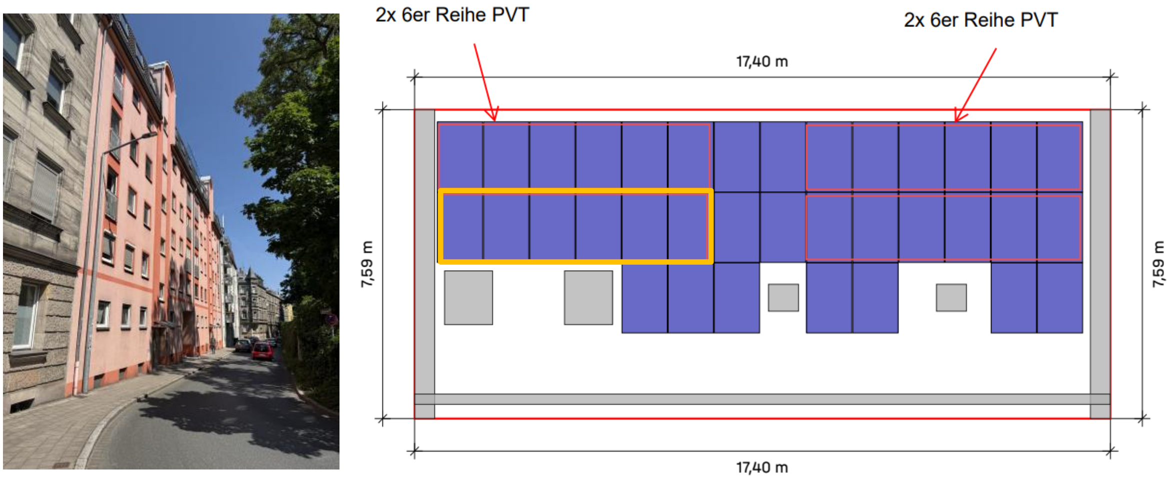

Fig. 2: Sketch of the PVT system (right picture) installed on the west roof of the building (left picture)

5. Conclusion

The methods described in ISO 9806 (ISO 9806:2025) provide the market with standardized procedures for quantifying convective heat gains for the first time. The paper discusses how well the differentiation of the technologies in the market are matched by this approach and how meaningful the results are. It is validated between three different laboratories and validated against field measurements. The suggestion is to use those results in further down marketing process like EU Energy Labelling, Solar Keymark, Solergy and others to provide a coherent competitive market information. The paper is showing short comings and limitations of the method as well and explains why specific effects like condensation and icing are not covered in the performance characteristics.

6. Acknowledgements

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Literature

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Symbols

Symbol	Description	Unit
a1	Heat loss coefficient	W/(m2K)
a3	Wind speed dependence of the heat loss coefficient	J/(m3K)