Outdoor performance of a trapeze solar-thermal collector for facades intergation

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Abstract: Increasing the share of solar energy convertors installed on buildings asks for using all the suitably positioned places, including facades. However, well-known technical and acceptance barriers have to be overcome for these visible areas. Following this constraints a new solar-thermal flat plate collector was designed and developed, having rather small area (0.63 m^2) and trapeze shape, that allows a higher coverage degree of the buildings' facades. A first prototype (demonstrator) was developed and proved a nominal efficiency of 62.38% during indoor testing on the solar simulator. Considering the perimterer/area ratio, this efficiency can be considered very good. Further on, the results obtained over one year monitoring the trapeze collector outdoor installed, in terms of output thermal power and efficiency are compared with those obtained for a commercial collector (with 2.1 m^2 area and nominal efficiency of 85.1%), vertically installed on the same façade as the trapeze collector. To extend the study, these data were compared with the output of a similar commercial collector, tilted installed (at an optimal angle of 35^o) on the laboratory terrace. These data represent the design input of a solar-thermal façade, consisting of nine trapeze collectors, outdoor installed.

1. Introduction

The progress expected in increasing the solar share for meeting the thermal energy demand in single- and multi-family houses is directly linked to the development of solar-thermal facades (STF). Acceptable STFs must meet functionality prerequisites (high nominal efficiency, steady outdoor efficiency and output) and additional conditions, related to architectural and societal acceptance. This asks for "atypical" collectors, either in terms of shape or color, or both. Following this state of the art a novel solar-thermal collector was developed. (Visa et al., 2015) with a trapeze shape and an active area of 0,67 m^2. The indoor testing showed promising results considering the rather small area (thus higher side losses), thus the next step was to start outdoor testing, to validate all the technical solutions embedded in the prototype.

2. Results and Discussions

One year testing (October 2015 – September 2016) was programmed for the prototype vertically installed on the façade of a laboratory building, in the R&D Institute of the Transilvania University of Brasov, Romania (mountain temperate climate, 45.65^{o}N, 25.59^{o}E at 600 m above the sea level). Comparative investigations employed two commercial (and highly efficient collectors, with a nominal efficiency of 85.1%): one vertically installed on the same façade and the other tilted installed at the optimal angle (calculated for an optimized yearly output), on the horizontal roof platform of the laboratory building. The thermal energy output was recorded all over the testing period and the instantaneous and average monthly efficiencies were calculated. The global solar radiation in the horizontal plane and the diffuse radiation in the horizontal plane are measured using CMP22 KIPP&ZONNEN pyranometers and the direct

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radiation on the solar rays' direction is measured using the CHP1KIPP&ZONNEN pyreheliometer. Based on, the radiation on the vertical and on the tilted collectors is calculated.

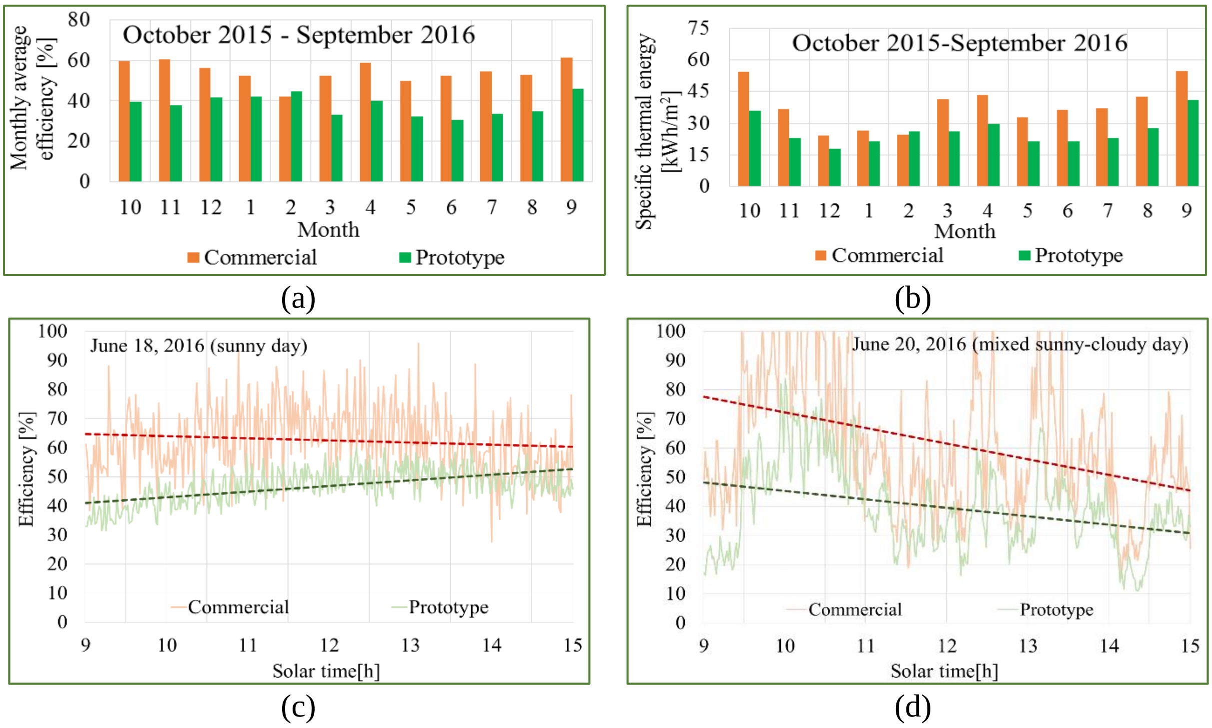

Fig. 1. (a) Average monthly solar to thermal conversion efficiency and b) monthly solar output over one year; (c) typical conversion efficiency during a sunny and (d) a mixed day for the commrcial collector and prototype, vertically installed in outdoor conditions

As the results in Fig. 1a and b show, there is an obvious drop in the average monthly efficiency (and thermal output) of both vertically installed collectors, with a significantly better behavior for the prototype, particularly during the cold season (month 1…3, thus January to March), showing that the insulation solutions are well chosen. Further on, in a typical example, two days were selected in June (month 6), a month that has a mild weather, thus being expected to avoid overheating (and consequent losses). This effect is significant during the sunny day, Fig. 1c, when the prototype's efficiency steadily increases (opposite to the larger commercial collector) and is still preserved during a sunny-cloudy day, Fig. 1d, when the decrease in the efficiency slope si lower for the prototype. These data (and other similar) show that small-sized collectors better behave on facades (although their actual efficiency is lower. Considering the aesthetical features, these results well recommend the trapeze collector for façade integration. Similar results (but with increased advantages) were registered also for the winter month.
Once validated the prototype, a façade consisting of nine trapeze collectors variously colored was developed and is under testing.

3. References

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