Trapeze and triangle solar-thermal collectors: implementation prerequisites and solutions

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Abstract:
Solar energy conversion into thermal or electrical energy represents a European priority, offering clean alternatives to the use of fossil fuels. Considering the international trends, specific actions are required for clean, sustainable, efficient and affordable thermal energy production, particularly for buildings' use, as domestic hot water (DHW), heating and cooling. An alternative for the production of domestic hot water (DHW) and partially of heat using solar energy towards Nearly Zero Energy Buildings is represented by the development novel solar-thermal systems architecturally integrated.
The paper presents novel solutions for solar-thermal collectors with trapeze and triangle shape and coloured absorber, designed and developed as building units. The purpose is to develop solar facades with increased architectural acceptance and large degree of coverage (the collectors have an active area of 0.63 m^2 for the trapeze and 0.22m^2 for the triangle shape).

1. Introduction

To the best of our knowledge, the approach combining novel shapes and novel colours for solar thermal collectors was not reported in the literature yet. Previous research found that units of three trapeze collectors, interconnected in various vertical and horizontal configurations may represent an improved solution for optimal functioning, and easy mounting and maintenance (Comsit et al., 2014). Meanwhile the coverage degree of the available surface may be consistently increased by using a combination of triangle and trapeze collectors.

2. Conceptual Design

The actual implementation of solar facades with atypical collectors raises specific issues if the facades have rather irregular shape, as for the single-family houses in Fig. 1. The design of the built integrated renewable energy solutions must follow the functional and aesthetic architecturally integration and social acceptance. Considering the architectural integration as a "form follows function" matter, the problem of solar technologies implementation into the buildings and more specific into facades, was approached as a shape (aesthetic) issue simultaneously combined with requirements meant fulfil the functional demand (Visa et al., 2015). This approach was based on a controlled and coherent process, combining the functional, constructive, and aesthetic aspects in order to reach a high quality for architectural integration of solar energy conversion systems. As multiple concepts for the collectors and facades were generated through this process, testing prototypes for non-rectangular shape were developed.

3. Results and discussions

Beyond the functional challenges risen by the hydraulic interconnections, another pre-requisite is imposed by the aesthetical constraints that require minimizing the exposure of the pipes,

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vents, elbows, etc. The paper discusses the main challenges faced for two types of facades: with "portrait" (Fig1.a) and, respectively with "landscape" (Fig.1.b) installed units of three trapeze collectors combined with triangle collectors or multi-triangle units.
The interconnecting solutions are analysed considering both, functional and aesthetical constraints, correlated with the coverage degree and with the costs. Alternatives of these arrangements are analysed, based on a set of criteria and associated scoring and the optimal solutions are modelled in terms of thermal output, considering four typical days in the year (the solstices and the equinoxes) in a mountain temperate climate (45^{o}N, 25.59^{o}E).
The results show, as expected, that the coverage degree will significantly influence the overall output of the facades; vertically mounted collectors have slightly lower conversion efficiency and a lower coverage degree but the interconnecting solutions are more permissive.

Fig. 1. Solar-thermal facades using groups of triangle solar-thermal collectors and trapeze collectors with (a) „portrait"mounting and (b) „landscape" mounting

The integrated concept is validated considering the implementation issues from the functional, constructive and also aesthetical aspects providing solutions for solar thermal triangle and/or trapeze based configurations by analysing specific types of facades. The study comparatively analyses solutions for embodiment and the integration problems, inherent in the case of specific implementations, describing the evaluation design criteria and the resulted concepts. The investigation of the solutions for mounting, casing, insulation, piping, interconnectivity, low and easy maintenance, etc., formulates a set of answers to these issues specific to implementation exploitation.

References:

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