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Performance assessment of an unglazed solar thermal collector for envelope retrofitting

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Abstract

Present trends on solar thermal systems for building integration define the need of integrated solar technologies for façades. Although other possibilities exist for solar thermal systems in new buildings, solutions for a suitable integration of solar thermal systems into building retrofitting actuations are needed.
This paper presents a solar thermal collector system which hybridizes already existing ventilated façade cladding systems into a low temperature solar thermal collector. Numerical and experimental data is presented.

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Keywords: Solar thermal systems; Building envelopes; Integration; Integrated Solar Collector Envelopes;

1. Introduction

The development of building envelopes in the last decades has resulted in complex engineered systems. Part of this complexity is driven by energy procurement policies, targeting at the reduction of primary energy consumption of buildings, which also results in reduced energy costs.

Energy-related materials and technologies have been integrated, into building envelopes, which can be classified in two main paths: Energy conservation, and energy collection. Energy conservation measures target at the reduction of heat transfer across envelopes and other related passive measures, which ultimately reduce Heating, Ventilation

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and Air Conditioning (HVAC) energy needs in buildings. Energy collection covers technologies which harvest energy from various local sources, thus reducing the primary energy consumption of the building. Technologies such as ground source heat pumps, solar photovoltaic, and solar thermal systems can be classified in this last category.

When related to solar thermal systems, their integration in envelope systems is commonly limited by the complexity of its integration possibilities with other elements in the building (envelope, structure, systems, etc.). Furthermore, due to their aesthetic relevance in the overall design of the building, a purely engineered approach, is often in conflict with the architectural expression of the building. To the authors' belief, there is currently a small and limited variety of solutions for the architectural integration of solar collectors within façades, which together with their complex assembly process and high investment costs, are clear barriers to the generalization of solar thermal technology in building skins.

Within project BATISOL [1], an innovative solar thermal system is proposed, where solar collector units are designed as hybridized construction components without functional or formal differences when compared to their traditional counterpart.

This paper discusses results from ongoing research projects exploring strategies to integrate and/or hybridize solar thermal technology into building envelopes. A numerical and component-level performance assessment is performed.

2. Solar thermal technology

The final overall performance of a solar thermal system relates not only to the solar thermal collector, but is impacted by all elements in the solar system, and even by the heating loads in the building served by the system. The overall design of the system ultimately impacts on the performance of the system, and it must be performed considering building user needs, their energy consumption profile, and the fluctuation of the available solar energy. Thermal storage must be incorporated and sized accordingly in order to compensate for the seasonal discrepancy between supply and demand.

Several experiences from the field demonstrate that combined solar systems, if properly sized, provide a relevant increase in overall system efficiency. In [2] experience from simulation resulted in a CoP 30–40% higher than for regular air-source heat pumps. Within the 2Sol system, developed at ETH Zurich [3], low-temperature input from photovoltaic/thermal collectors is used to regenerate a seasonal ground heat storage, reaching a CoP above 8 in new buildings, and above 6 in retrofit [4].

Solar thermal systems are complex devices which absorb, transfer and store solar energy. Solar collectors themselves are only capable of performing the first of these functions, where a fluid is commonly used to transfer the absorbed heat to other elements in the system. Various solar collector technologies are available within the building HVAC framework, which perform differently. For a given solar radiation level and ambient temperature, performance is characterized by the average fluid temperature. Therefore, the efficiency of solar thermal collectors can be broadly defined according to their type (Fig. 1). Main technologies are vacuum tubes, glazed flat plate collectors and unglazed collectors.

In high temperature applications, vacuum tube collectors are the main technology. These collectors are composed by a set of glass tubes where an absorber is suspended and insulated within vacuum cavities. Within the reviewed alternatives, the most successful integration strategies incorporate the glass tubes into the design, at balcony parapets or similar locations.

Glazed flat plate collectors are the most commonly used technology in buildings. In this case, the absorber plate is insulated by a glazed assembly in its surface, and a rear insulation layer. A number of integration solutions for flat plate collectors are available in the market, commonly linked to specific cladding systems or lightweight façades.

Unglazed collectors are the simplest technology of solar thermal collector, consisting only on an absorber that can be either metallic or polymer-based. Unglazed collectors are only sufficiently performing for applications that deliver fluid at lower temperatures. Currently, they are typically used for swimming pool heating systems, low temperature space heating or pre-heating of domestic hot water.