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Integrated solar thermal facade component for building energy retrofit

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Abstract

In the perspective of the ``nearly zero energy buildings'' as specified in the EPBP 2010/31/EU, herein a modular unglazed solar thermal facade component for facilitating the installation of active solar thermal facades has been conceived and designed to answer three considerations: (1) easily installable elements, offering high modularity to be sized for the specific needs of the buildings considered, (2) low-price unglazed technology, given by the industrial process already developed for the fridge evaporators, and (3) versatile modules to be used for both new buildings and for existing buildings for energy retrofitting.

The existing buildings stock offers a high-potential opportunity to improve the energy efficiency when using such a system. Indeed, the building envelope elements have a significant impact on energy consumptions and performances of the building, and this is a key aspect to consider during renovation.

Considering buildings integrating solar thermal (BIST) by the means of facade retrofitting of solar thermal collectors (STC) opens up new challenges for engineers. Facade usage, compared to the traditional roof installations, offers two interesting potentialities: (1) increased available surfaces, and (2) minimization of the unwanted overheating problem, that appears in summer, thanks to the vertical tilt (as the energy production is almost constant over the year). This allows sizing the STC according to the actual heat needs and avoids as much as possible energy fluxes mismatch.

The design methodology of such a modular component is the main contribution of the PhD work.

The challenges are tackled via a parametric approach. Dynamic simulation tools support the design choices for the energy systems of BIST and to optimize the interactions between the envelope and the STC with the criteria of reducing the overall energy consumption. This methodology is described and applied to the design of a modular prototype of an innovative facade component integrating unglazed STC.

First a variety of typologies of buildings are analysed as potential commercial targets of the facade component of unglazed STC integrated facade element. Both residential and non-residential buildings are considered. The purpose of this analysis is to match the heat loads for properly sizing the facade elements for each typology.

Benchmark models of buildings from the Department of Energy are used such as multifamily houses, hospitals, big and small hotels, schools, offices. These are simulated through EnergyPlus in three European locations (Stockholm, Zurich and Rome) in order to define the yearly heat loads for domestic hot water (DHW) and space heating (SH) needs.

Finally, the prototype is conceived and designed as a low-cost product to implement into facades with the criteria of optimizing the energy production. The unglazed STC is combined with a simple configuration of combisystem in order to define some rule of thumbs through Trnsys. By the fact that the energy is produced at lower temperatures, if compared with glazed flat plate collectors, this technology is potential applicable to those buildings having the proper heat loads and the suitable system layout.