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ScienceDirect

Energy Procedia 122 (2017) 211–216

Energy Procedia

www.elsevier.com/locate/procedia

CISBAT 2017 International Conference – Future Buildings & Districts – Energy Efficiency from Nano to Urban Scale, CISBAT 2017 6-8 September 2017, Lausanne, Switzerland

Evaluation of a solar thermal glass façade with adjustable transparency in cold and hot climates

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Abstract

The paper presents the evaluation of a new glass façade system, titled FLUIDGLASS, which combines four functions in one element: a solar thermal collector, a heating/cooling device, a transparent thermal envelope and an adaptive shading system. The collector panel is a combination of fluid and glass layers. By controlling the temperatures or the transparency of the circulating fluid the passive façade is transformed into an active thermal system capable of reacting to changing environmental conditions. The expected impact is a significant improvement in the thermal performance of the building envelope and high thermal comfort for different climate zones. The validation by simulation and measurement results indicate that no additional energy beyond that which is provided by the façade element is necessary to reach the thermal comfort temperatures. Surpluses of solar collector gains can contribute to the usage on a district level with seasonal storage.

Peer-review under responsibility of the scientific committee of the CISBAT 2017 International Conference – Future Buildings & Districts – Energy Efficiency from Nano to Urban Scale

Keywords: Adaptive Façade, Solar Collector, Thermal Comfort, Heating/Cooling System

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Peer-review under responsibility of the scientific committee of the CISBAT 2017 International Conference – Future Buildings & Districts – Energy Efficiency from Nano to Urban Scale
10.1016/j.egypro.2017.07.347

1. Introduction

Intense use of energy from non-renewable resources is one of the biggest problems of our time. To counteract climate change, efficient use of energy is becoming more relevant than ever. In 2007, European Union decision-makers set the target of reducing the EU's annual energy consumption by 20% by 2020 [1]. It is needless to say that efficient energy use must be implemented in all sectors of human activity, however worldwide, a significant part of the total energy demand stems from the building industry. For the EU this portion is estimated at 40%. Measures to reduce the associated greenhouse gas emissions are, on the one hand, an increased use of renewable energies and, on the contrary, a reduction in energy consumption [2]. Consequently, the built environment needs to be designed, built, operated and refurbished with much higher energy efficiency. To find an optimum between these aims and thermal comfort of the building occupants is one of the biggest challenges of modern sustainable building design.

Nomenclature

TRNSYS	TRaNsient SYstem Simulation software
HVAC	Heating, Ventilation and Air Conditioning

The FLUIDGLASS project is facing this challenge and aims at developing a new and innovative concept of solar thermal façades for use at building and district level. The basic idea is to reduce solar gains during the cooling season, but without violating requirements regarding necessary daylight and vice versa for heating season to increase flexibility and energy efficiency at the same time. The multi-layer glazing element works by circulating fluid through internal and external window panes An intermediate thermal barrier separates these two fluid layers. Fig. 1 shows the general assembly principle, which has been described in detail by Gstoehl et al. [3] and Stopper et al. [4].

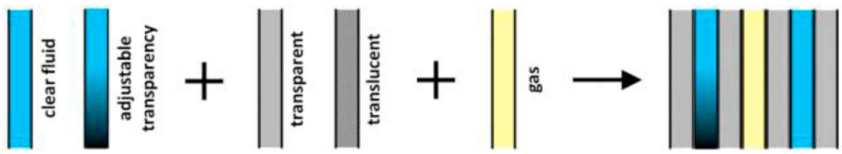

Fig. 1. modular layer approach: fluid + glass + barrier.

By controlling the temperatures of the inner fluid layer, the façade system can reply to variations in interior and exterior environmental conditions. Besides, the fluid can be tinted by black magnetic particles to partially or entirely block the solar irradiation, working at the same time as a solar collector.

During summer day the outer layer is colored (cf. Fig. 2a) to minimize solar gains and keep the heat outside the building, yet visual transmittance is still possible. The absorbed heat gains of the outer fluid can be used elsewhere in the building or on the district level. The inner layer can be used as a cooling panel by circulating cold water if required during day or night. This potential is immense beneficial especially to buildings where windows cannot be opened. During summer night the cooler outside temperatures can be used to re-cool the warm water from the tank by circulating it through the outer fluid layer. For the winter day situation, if necessary, the inner fluid can be tinted to protect against glare, but still, benefit from solar gains and let the heat inside the building. Also, it is used as a heating panel by circulating hot water (cf. Fig. 2b). On a typical interim day, the outer fluid is slightly darkened depending on heating or illuminance demand. The inner fluid can be operated as heating or cooling panel if required.