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Plus-Energy façades with smart materials for future building envelopes

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Abstract

Façade constructions and their opaque areas show great potential for generating energy by using photovoltaics (PV). The performance of PV modules decreases with increasing cell temperature. To reach lower module temperatures even in insulated façade constructions without rear ventilation, a composite construction using smart materials was examined. By mounting phase change materials (PCM) on the backside of the PV module, the PCM can absorb thermal energy from the PV module by melting from solid to liquid during the day. Rising module temperatures can thus be buffered. At night, the thermal energy in the PCM is released back into the ambient air.

For future applications, the article outlines an approach of integrating hybrid panels in façade constructions. These elements combine PV modules and thermal collectors in order to generate thermal and electrical energy with a high efficiency due to the low temperatures of the PV cells.

Keywords: phase change materials (PCM); photovoltaics (PV); PV module; energy; mullion-transom façade; monitoring; hybrid-panel; thermal collector.

1 Introduction

In December 2015, the Paris Agreement was adopted within the United Nations Framework Convention on Climate Change (UNFCCC). Many UNFCCC members will make efforts to keep the increase in the average global temperature between 1.5 and 2 °C in order to reduce the risks of climate change [1]. As a result, the climate protection plan 2050 drawn up by the federal government of Germany in 2016 stipulates a nearly climate-neutral building sector by 2050 [2]. To achieve these objectives, a combination of energy efficiency and renewable energies will be necessary [3]. One option for generating energy from renewable sources is the installation of PV modules on buildings. The useable mounting space on roof areas is limited, which increasingly puts forward the potential capacity of façades. In addition to a variety of external impacts, the efficiency and power output of the PV module decreases due to rising temperatures [4]. When integrated into a warm façade, the module temperature can be up to 55 K higher than the ambient temperature. For crystalline modules, this can reduce the annual energy gain by up to 10.5 % [5]. To reach lower module temperatures and thus higher efficiency, the use of smart materials for the building envelope is aimed at. A possible option is to cool PV modules using rear-mounted phase change materials (PCM). Accordingly, an opaque insulated façade panel for warm façades consisting of a PV module and PCM is to be created. The feasibility of this will be analyzed within the course of this paper.

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