Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 58 (2014) 172 – 178

Energy Procedia

Renewable Energy Research Conference, RERC 2014

Building Integrated Photovoltaic System with integral thermal storage: a case study

Laura Aelenei[a]*, Ricardo Pereira[a], Ana Ferreira[a], Helder Gonçalves[a], António Joyce[a]

[a]LNEG, Paço do Lumiar, Lisbon,

Abstract

During the last 20 years the research of Building Integrated Photovoltaic Systems (BIPV) related with different techniques and concepts has been widespread, but rather scattered. In BIPV systems photovoltaic panels functioning as an integral part of the building envelope, therefore, enhances the aesthetic appeal of the building. In addition of providing renewable energy, they may also contribute to improving the indoor climate when thermal energy released during the conversion process is withdrawer efficiently, passively or actively recovered (BIPV/T). The increase in BIPV/T research since 1990s, is a consequence of the growing interest of the construction industry in offering new alternatives to traditional approaches. The paper is reporting in the first part, a BIPV classification focused on the building integration aspect and on the characterization of the main parameters involved rather than on technologies used or the performance aspects. In the second part, the paper is focused on reporting the experimental results from a particular application, a case study developed in Portugal, where a thermal storage element, Phase Change Materials (PCM) integrates the BIPV.

Peer-review under responsibility of the Scientific Committee of RERC 2014

Keywords: BIPV-T, thermal storage, PCM

1. Introduction

Increasing energy consumption, shrinking resources and rising energy costs have significant impact on our standard of living for future generations. In this situation, the development of alternative, cost effective sources of energy for residential and non-residential buildings has to be a priority. Designing energy efficient and affordable

* Corresponding author. Tel.: +351 210 924 600; fax: +351 217 166 966.
E-mail address: laura.aelenei@lneg.pt

Peer-review under responsibility of the Scientific Committee of RERC 2014
doi:10.1016/j.egypro.2014.10.425

solutions integrated in buildings dealing with summer and winter climate challenges represents a very ambitious goal. In addition to this, in May 2010 it was published the recast of the Energy Performance of Buildings Directive which sets Zero Energy performance targets for all new buildings [1]. The integration of PV systems into buildings becomes an imperative in this context. As is well known, Zero Energy Building design does not only mean the adoption of energy efficiency measures, but also the integration of renewable energy systems in order to balance the building energy consumption. The advantages of PV systems integration in buildings envelope are numerous resulting in a growing interest in adoption of these technologies in building design and construction, from the electricity generator solutions to offset building demands, to exterior building material and components.

Nomenclature

A_i	Area of solution
P_i	Material price
Q^i	Quantity of energy necessary and/or produced

Integration element - BIPV systems are designed to displace the traditional building components totally or partially, assuring a cross-functional role. For example, a BIPV skylight is considered a part of the building envelope, a solar generator of electricity, and a daylighting element. According to a study of NREL [2], façade applications typically include vertical curtain wall, inclined curtain wall, and stepped curtain wall, while roof applications normally include inclined roofs and skylight monitors. A publication of IEA Task 41 [3], report a quite complex approach to the integration of PV solutions as a different building envelope component (tilted roof, flat roof, skylight, facade cladding, facade glazing, external device). The same publication report on two different approaches and definition of PV integration: BAPV-Building Added Photovoltaic systems where photovoltaic modules are most commonly considered just as technical devices added to the building and BIPV-Building Integrated Photovoltaic, where photovoltaic modules integrate the building envelope as constructive system.

Operation mode - Over the past years, different integration solutions and functioning modes have been studied and reported in the literature. As only approximately 16% of the solar energy incident on a PV device is converted to electricity; the remaining insolation absorbed is transformed into heat [4]. The energy transformed into heat can cause overheating problems in the case of BIPV [5]. Many studies related with BIPV systems have focused on the improvement of the indoor thermal comfort and reduce the building energy demands at the same time, and on the improvement of the efficiency of the photovoltaic system by limiting the temperature rise inside the system. Common approaches to BIPV temperature mitigation fall into two categories: natural ventilation and active heat recovery [6] or forced/mechanical ventilation. Experimental and numerical studies have shown that passive strategies can lower cell temperature, provide buoyancy driven natural ventilation [7], or serve as solar air collectors for preheating HVAC supply air [6]. In the last mentioned study, the authors investigate experimentally and numerically the effect of active heat recovery by a liquid cooled heat absorber on the performance of a BIPV/T collector and report correlations between PV performance and heat recovery. In the above mentioned study of Krauter et al. [5], both passively and actively cooled BIPV have been considered. However, since natural ventilation can be limited by the low rates of heat removal contingent on the need for low resistance to a buoyancy-driven flow and can suffer a reduced rate of heat transfer from the PV, mechanical ventilation can be more efficient owing to better convective and conductive heat transfer, although the required fan power sometimes reduces the net electricity gain [8].

Application - Application of this kind of systems can vary according with the building demands (space heating, DHW heating) or/and with strategies for enhancing module efficiency (cooling, ventilation). Another important issue associated with different applications is the circulating fluid under PV module that could be water or air. The choice of technique depends on the location and its application which dictates the usage of appropriate design considerations. For BIPV however, the most commonly used fluid is air because it provides cooling of the cavity under PV and heating for living space (heat recovery). Chow et all studied [8] a hybrid BIPV - solar system used in