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State-of-the-art building integrated photovoltaics

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Abstract

Building integrated photovoltaic (BIPV) systems may represent a powerful and versatile tool for achieving the ever increasing demand for zero energy and zero emission buildings of the near future. In this respect BIPVs offer an aesthetical, economical and technical solution to integrate solar cells harvesting solar radiation to produce electricity within the climate envelopes of buildings. This work summarizes the current state-of-the-art of BIPVs, including both BIPV foil, tile, module and solar cell glazing products.

Keywords: Building integrated photovoltaic; BIPV; Solar cell; State-of-the-art

1. Introduction

As the world's demand and focus on renewable and non-polluting energy, together with energy efficiency, are ever increasing, zero energy and zero emission buildings are rapidly drawing attention. In order to become a zero energy or zero emission building, such a building need to harvest energy from its surroundings, where energy from the sun is one of the obvious choices. Building integrated photovoltaic (BIPV) systems, where solar cells are integrated within the climate envelopes of buildings and utilizing solar radiation to produce electricity, may represent a powerful and versatile tool for reaching these goals with respect to both aesthetical, economical and technical solutions.

Building integrated photovoltaic (BIPV) systems replace parts of the conventional building materials and systems in the climate envelope of buildings, such as the roofs and facades. BIPV systems are

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considered as a functional part of the building structure, or they are architecturally integrated into the building's design (Peng et al. [1]). Hence, the BIPV system serves as a building envelope material and power generator simultaneously (Strong [2]).

This work summarizes the current state-of-the-art of BIPVs, including both BIPV foil, tile, module and solar cell glazing products, also mentioning building attached photovoltaic (BAPV) systems. For further overview and elaborations including investigations of several possible research opportunities and pathways for the future BIPVs it is referred to the study by Jelle et al. [3].

2. Building integration of photovoltaic cells

Building integration of photovoltaic (PV) cells are carried out on sloped roofs, flat roofs, facades and solar shading systems. PV cells may be mounted above or onto the existing or traditional roofing or wall systems. However, BIPV systems replace the outer building envelope skin, thus serving simultanously as both a climate screen and a power source generating electricity. Hence, BIPVs may provide savings in materials and labour, in addition to reducing the electricity costs. Nevertheless, as the BIPVs act as the climate protection screens it is of major importance to have satisfactory or strict requirements of rain tightness and durability.

Several aspects have to be considered and evaluated related to the integration of the PV cells into the outer building envelope skin. One aspect is to ensure an air gap underneath the solar cells in order to provide an air flow reducing the temperature of the solar cells, as an elevated temperature decreases the efficiency of the solar cells, especially for mono- and polycrystalline Si cells. Another aspect to be considered are the inclination of the BIPVs, both with respect to existing and new buildings, as the solar cells necessarily need to follow the roof inclination (or the wall for that matter) to be integrated solutions. Geographical position and orientation towards the sun and area coverage are yet another aspects to be considered during integration of the BIPV systems. In fact, some BIPV manufacturers also offer dummy modules to provide a more aesthetical and consistent appearance of the roofs and facades.

Hence, in short BIPVs have to fulfil all the requirements, with respect to several properties, of the building envelope skins they are substituting. Various building physical issues like e.g. heat and moisture transport in the building envelope also have to be considered and accounted for.

Examples of solar cells integrated as BIPV tiles and BIPV modules are shown in Fig. 1. Furthermore, BIPVs as solar cell glazing products in the facade and on the roof are depicted in Fig. 2. Solar cell glazing products offer a solution for utilizing the fenestration with regard to daylight, solar heat gain, solar shading, miscellaneous architectural expressions, and finally solar energy gain by converting solar radiation into electricity.

Figure 1. Examples of BIPV tiles (left) and BIPV modules (right) (Applied Solar 2010 [4], DuPont 2011 [5]).