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Sustainable energy planning. Design shading devices with integrated photovoltaic systems for residential housing units.

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Abstract

The study scopes to optimize the characteristics of shading devices (SDs) with integrated photovoltaic panels (PVs) that are designed for residential building facades. The SDs are located on the external part of a window facing south, in a distance from the external wall, in order that a semi - outdoor space is created. The research deals with the integration of solar technologies in buildings. Focusing on the optimization of the relationship between the energy technologies and the architectural design. Concerning the design process we took into consideration the definition of user's visual comfort and the optimization of the design process of the final product. This experiment focuses on the integration of flexible shadings in order to use the external space as a consecution of the internal space. Methodologically the parameters of the research are defined and the decision on the type of the experiment is taken according to the summer at three different weather conditions in Crete. So, the physical model type of experiment was preferred to the computer simulation model. The results are being categorized and the process is being evaluated according to the above mentioned parameters. The research seeks to highlight how experimental shading devices with integrated PVs can achieve better view for the users while performing as energy production and reduction machines. Finally as a result the daylight analysis value is compared with the human's comfort view to outside and the energy needed for the performance of the examined unit during the day. Our main goal is to optimize the comfort in combination with the energy generated and the best suited space for the everyday activities.

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1. Introduction

The electricity consumption of buildings is part of the overall energy consumption of a country. Due to this fact, together with the increase of renewable energy resources (RES), there is an interest of their integration in buildings. The assessment of local photovoltaic (PV) potential plays a critical role in the development of planning policies and financing schemes for the successful deployment of PV systems in cities [1]. A way of integrating RES in buildings is by placing PVs. PVs have been proved ideal for buildings because their placement can lead to partial or total energy independence. The possible positions of PV panels on the buildings is the facade, the roof and the shading devices. The use of shading devices is essential for south oriented facades, especially in Mediterranean climates [2]. The SDs determine the daylighting of the building and it is highly related with the visual comfort of the users. The use of daylight in buildings, with its variations, its spectral composition, and the provision for external views, is of great importance for the comfort and well-being of occupants [3].The idea of integrating SDs with Photovoltaic panels (Building Integrated Photovoltaic (BIPV)) derived from the need to cover energy needs and use RES specially in the Mediterranean area in order to produce energy and supply electricity for artificial lighting or other energy use. BIPV systems are photovoltaic modules integrated into elements of building envelope, such as the roof or the façade. These systems are very important because they serve the dual function of building skin, replacing conventional materials, and energy generator. They modify the architectural appearance of the construction [4].

Besides the large available area on vertical walls, the use of photovoltaic modules and solar collectors on facades may lead to other interesting benefits such as the combination of energy production with other functions of the buildings, such as heat insulation (Quesada et al., 2012) or illumination, by using semi-transparent photovoltaic modules on windows [2].

This research evaluates south facing SDs that were designed for a residential building facade respecting the sun glazing and the lighting. There is also a provision for the energy production.

The solar energy that reaches earth, at any time depends, on the weather conditions, the position, the orientation and the area of the surface. In fact, several factors like the global radiation on a horizontal surface, the ground reflectance and the day of the year constitute the parameters of a complex function that determine the amount of solar radiation incident on an inclined surface at any time [5]. In the text below we are going to talk about the design method of the SDs, describe the experiment process, and evaluate the results.

1.1. International scientific experience on the subject

FThe awareness of the available area on vertical walls, which in a modern city far exceeds the available area on roofs thus of setting the relatively lower irradiation falling in non-optimum inclination, has recently lead to the development of methodologies for the analysis of the solar assessment of facades (Carneiro etal.,2010;Redweiketal,2011;Hofierka and Zlocha, 2012). This paper is based on previous international research made on the subject of BIPV and especially on the research of M. Mandalaki who has constructed the basic model of the experiment in 2011, in order to test the integration of the SDs in an office building facade.

When talking about shading, there is a need to clarify the type of the building and specify the use of the space, we intend to shade. This research concerns residential housing units facing south. The demand in shading and visual comfort differs from an office building to a housing unit. The space of an office is usually limited to an exclusive use, on the contrary, the living room of a house may have several everyday uses, in variable hours of the day that require a different design approach, which will be discussed further more.