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Proposed integration of a photovoltaic solar energy system and energy efficient technologies in the lighting system of the UTA-Ecuador

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Abstract

This research assesses the current fluorescent lighting system of the Faculty of Civil and Mechanical Engineering (FICM), Technical University of Ambato (UTA), Ecuador. The aim of this study is to present the main results obtained from an efficient lighting project to be implemented at FICM, UTA, and also proposes the integration of an existing photovoltaic solar energy system (PVSE-S) to supply the proposed efficient lighting system. In this study, the Society of Light and Lighting (SLL) Code for Lighting 2012 is used to determine the spacing or maximum distance between measurement points in classrooms. Lighting levels (lux) of 14 available classrooms are measured to estimate illuminance by using 70 measurements. DIALux software is applied to simulate three scenarios of proposed luminaries based on LED (lighting emitting diode) system. RC660B LED is selected due to the highest values of luminous flux, light efficiency and light output at minimum required power and area of installation. RC660B additionally denotes a considerably low value of Limit Value of Energy Efficiency (VEEI-Spanish acronymic) in comparison to fluorescent lamps (FL). Finally, this study proposed the use of a PVSE-S to power 2898 VA (volt-amperes) of the selected LED luminaries of seven classrooms in the FICM building.

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Keywords: lighting; photovoltaic solar energy integration; fluorescent lamp; LED.

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1. Introduction

Currently, one of the most pressing global debates is the saving of all forms of energy for the preservation of natural resources [1, 2]. Overall, buildings are responsible for 40% of the world's energy consumption and contribute to 30% of worldwide emissions [3, 4]. Specifically, in the area of lighting in buildings, new proposals of energy efficiency and use of renewables have been developed in recent years, consisting of: 1) improving the quality of luminaries in energy efficiency [5, 6]; 2) integration of renewable energy in buildings [7, 8]; and 3) lighting modelling before the construction of buildings [9, 10]. In these regards, configuration of lamps and luminaries, such as inside placement within interior spaces, reflectance and wall colors, and integration of renewable energy contribute to increase building energy efficiency and reduce energy consumption from fossil fuels [11]. Thus, the integration of a renewable energy system in a building can contribute to environmental impact reduction and this benefit can also increase when those technologies feed energy efficiency technologies as in lighting systems [12].

Regarding the integration of renewable energy into building development, different efforts are evident internationally. Article 2 of the Kyoto Protocol aims to implement policies for research and development of renewable energy resources, innovative and environmentally friendly technologies [13]. The European Union, for example, started the process of reforming energy policy to achieve greater energy sustainability. In this sense, two fundamental lines were successfully proposed: electricity generation with renewable energy and energy saving in buildings [10, 14]. Regions such as Latin America and Asia are also in line with those initiatives, encouraging the efficient use of energy and the incorporation of renewable energies in buildings [15-19]. In general, the use of meters and sensors, to monitor energy use and evaluate indoor environmental conditions in buildings, has taken a major boost around the globe to reduce energy consumption and associated greenhouse gas emissions [20].

Lighting at universities classrooms play a vital role for the development of academic activities. However, energy consumption of lighting represents up to 29 % the share in university buildings [12]. Thus, it is paramount to analyze the required and adequate illumination at efficiency levels of energy consumption along with the likely integration of renewables into university buildings. The quality of illumination can be determined from illuminance isolines or isolux curves, which connect the points where the luminous flux has the same value [21]. Isolines also represent the distribution and levels of light in space [22-24]. The level of illumination is measured in lux, which is the ratio of the luminous flux to the illuminated surface [25]. For academic activities, the average of illumination is in between 300 and 700 lux [26].

Furthermore, the use of efficient lighting, high-performance luminaries, incorporating low-energy equipment and high-luminance lamps require the implementation of appropriate new lighting technologies. There are different types of lamps classified according to their luminous performance and application. LED is a lighting device with the highest standards of energy efficiency used worldwide [27, 28]. LED light can contribute between 30% and 50% of electricity savings in buildings at remarkable luminous efficiency by far in comparison to FL [29].

Renewable energy technologies might have various applications in buildings including its use in lighting [30]. The use of photovoltaic solar panels (PVSP) as a source of renewable and sustainable energy for lighting in buildings is shown as a solution of great technological impact to energy saving [31, 32]. Although photovoltaic cells have low levels of efficiency in converting all photons into electron current, its performance is in line with LED requirements [33]. New studies report high-efficiency systems that uses photovoltaic cells to power LED lighting systems [34]. However, LED lamps can operate directly from an AC power supply since LED lamps include a driver required to convert the AC (alternating current) from the power supply to the regulated DC (direct current) voltage used by the LEDs. As LED basically works with direct current, provided PVSE-S would avoid the use of drivers, the generation of harmonics and power factor to the electrical network [35].

As in FICM, UTA, there is installed an arrange of PVSP that provides an average apparent power of 3000 VA, this study purposes its use to power the lighting system of FICM. This research aims to study the current FICM´s lighting systems based on FL to be replaced by one of a base of three proposed lighting systems based on LEDs, in terms of illuminance level, energy consumption and efficient use of energy. This study also proposes the integration of a photovoltaic solar system to power the selected LED lighting system of FICM building.