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Impact of different illuminance typical years models on a climate based method for the calculation of artificial lighting energy use in office buildings

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Abstract

Artificial lighting has a relevant impact on the electricity uses in not residential buildings. The method to assess such uses is based on standards, which hardly take into account the daylighting contribution and the time evolution of the outdoor illuminance conditions. Different models were adopted to build diffuse illuminance reference years, starting from satellite images. These models lead to different daylight availability during the year. The paper explores the impact that these models have on the artificial lighting energy uses by hourly monthly mean calculations. The test was carried out with a climate based method, which takes into account: the outdoor luminous environment, the reference indoor visual task and the building daylight characteristics. A typical office building was used for the test in Rome, Italy. Results allowed to compare the impact of each model and to select the most suitable one to be implemented in the climate based method to predict artificial lighting use in buildings.

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Keywords: daylighting; electric lighting; illuminance models; office buildings

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1. Introduction

The building sector account for more than 40 % of the energy consumption in Europe and has a significant impact on the achievement of the environmental and energy targets, at national and European level [1, 2]. According to the relevant EU Directive [3], the energy performances of building should be addressed to the whole relevant energy services, while efforts were focused on the space heating systems until few years ago. Global and local climate changes, as well as new user behavior and expectations are shaping energy end uses, with an increase relevance of electricity uses. Relevant studies carried out during the past years demonstrated the impact of the electric lighting on the energy uses in buildings. Concerning the not residential sector, it was found out this service accounts for 14 % of the total energy end uses in EU and 26 % in US [4, 5]. A Spanish research showed that the electricity uses for electricity lighting account for 31 % of the total final demand in commercial buildings [6]. This explains why energy savings in the lighting service are considered as highly competitive in technical and economical perspective [7].

The energy requirements for lighting in EU are assessed according to the specifications of the standard EN 15193:2007 – Energy performance of Buildings. Energy requirements for lighting. The standard provides an operational method and two calculation methods, which differ in accuracy and complexity [8]. The standard can be used in existing building as diagnosis or in new buildings as design tool. However, it has to be noted that this standard, as well as other tools, estimate the potential energy savings, mainly in terms of higher efficiency of the electrical devices (lamps, luminaries, control sensors and systems); on the contrary tools able to exploit the daylighting potentialities to achieve lighting energy savings, by means of advanced strategy and solutions, are seldom available. The reliability of prediction methods needs to be carefully addressed in a holistic approach, since the over/underestimation of the consumption respect to the effective performances is an obstacle to the technology spread, especially in the nearly zero energy building (nZEB) vision.

A critical issues is, in this view, the assessment of the daylight contribution, which does not take into account the climatic conditions of the interested locality. The Daylight Autonomy is a concept emerged in the past few years, which provides a relevant metric to assess the daylighting contribution and, as a consequence, the potential energy savings that can be achieved in buildings for the electric lighting service [9–11]. Climate based approaches are used for several aspects of the building performance and they are gaining interest for daylighting design methods, as discussed in [12]. The approach was also adopted for the definition of an Italian alternative [13], aimed at merging the climate based approach for daylighting with the calculation flux defined in [9].

2. Objective and methods

The calculation of the energy requirement for lighting applying a method alternative to [9] requires the implementation of a. illuminance database to be applied on the Italian territory. For this reason several luminous efficacy models were tested to build a Typical Meteorological Year (TMY) for global and diffuse horizontal illuminance values, respectively D_gh and D_dh, starting from the solar irradiation data [14].

The lighting performance are assessed through the LENI, performance indicator introduced in [9], expressed as the ratio of the electric energy use for lighting to the total useful floor area, taking into account both, the energy consumption for the lighting service and that of parasitic energy uses. Being the latter out of the scope of this study, the general equation to determine the energy uses is:

$$W = \sum \{ (P_n \cdot F_C) \cdot [(t_D \cdot F_O \cdot F_D) + (t_N \cdot F_O)] \} / 1000 [kWh/year] \tag{1}$$

where

P_n installed power in the zone, W;

F_c constant illuminance factor;

t_D daylight time usage, h;

F_O occupancy dependency factor;

F_D daylight dependency factor;

t_N non-daylight time usage, h.