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Evening office lighting – visual comfort vs. energy efficiency vs. performance?

Friedrich Linhart*, Jean-Louis Scartezzini

Solar Energy and Building Physics Laboratory (LESO-PB), Swiss Federal Institute of Technology in Lausanne (EPFL), 1015 Lausanne, Switzerland

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ABSTRACT

During the study presented in this article, we compared two highly energy-efficient lighting scenarios for evening office lighting (i.e. electric lighting that is typically used for approxiamately 2 h in the evening). The first of these lighting scenarios (referred to as "Reference"-scenario, Lighting Power Density or LPD of 4.5 W/m^2) has been successfully in use in many office rooms of the Solar Energy and Building Physics Laboratory's experimental building, located on the campus of the Swiss Federal Institute of Technology in Lausanne, for several years. The second lighting scenario (referred to as "Test"-scenario, Lighting Power Density of 3.9 W/m^2) is more energy-efficient, creates higher workplane illuminances but leads to an increased risk of discomfort glare. The aim of this study was to meticulously compare the two lighting scenarios in order to find a lighting solution for evening office lighting that offers an optimal trade-off between energy-efficiency, visual comfort and visual performance.

For this purpose, objective visual performance tests (computer-based and paper-based) and subjective visual comfort assessments with 20 human subjects were carried out. The main hypothesis of our study was that the study participants would not perform worse under the more energy-efficient "Test" -scenario than under the "Reference"-scenario (which is extremely well accepted by the building's occupants).

We found that the two tested scenarios are comparable to usual lighting scenarios in other office rooms in terms of subjective visual comfort. The study participants preferred the "Test"-scenario to the "Reference"-scenario. Their performance in a paper-based task was significantly better under the "Test"-scenario than under the "Reference"-scenario. No significant differences in the performance during two computer-based tasks were found. We conclude that energy-efficient lighting with Lighting Power Densities of less than 5 W/m^2 is already achievable in today's office rooms without jeopardizing visual comfort and performance. Less powerfull electric lighting systems do not necessarily mean a decrease in visual comfort and/or performance; our results even show that better visual comfort and better visual performance can be achieved with less connected lighting power.

1. Introduction

Large fractions of today's buildings' electricity consumptions are due to electric lighting: Hinnells [1] for example states that "lighting in domestic and commercial sectors accounts for around 16% of all UK electricity demand". Li and Lam [2] as well as Li et al. [3] suggest that artificial lighting can account for 20–30% of a typical non-domestic building's electricity consumption. Wen et al. estimate that in the US, "roughly 40% of electricity consumption in commercial buildings is attributable to lighting" [4]. According to Franzetti et al., "it is generally assumed that about 30% of the energy consumption of office buildings come from artificial lighting" [5]. In 2007, Jenkins and Newborough wrote that "the energy consumption of lighting in buildings is a major contributor to carbon emissions, often estimated as 20–40% of the total building energy consumption" [6]. Krarti et al. had already put forward that 25–40% of the "energy consumption" in US commercial buildings is due to artificial lighting [7]. Even if those estimations are difficult to verify and and might not be completely consistent (the difference between 20% of a building's electricity consumption and 40% of its "energy consumption" is likely to be huge in most cases), these figures lead to one important finding: around the world, the scientific community seems to agree that discussing the articial lighting loads of buildings is extremely important and that energy-efficient lighting solutions have to be adopted.

However, electricity consumption and energy-efficiency are not the only topics to consider when it comes to designing appropriate

* Corresponding author. Tel.: +41 21 6934540; fax: +41 21 6932722.
E-mail address: friedrich.linhart@epfl.ch (F. Linhart).

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