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Effect of LED lighting on the cooling and heating loads in office buildings

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HIGHLIGHTS

- Application of heat control strategy reduces total energy consumption of LED lighting.
- Convective heat from LED lighting should be emitted outdoors during cooling period.
- Seasonal optimization of convective heat lowers total energy consumption.

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ABSTRACT

LED lighting has the potential to provide energy savings, and in many countries, there are policies to encourage its use owing to its higher efficiency and longer life in comparison to other lighting fixtures. However, since 75–85% of the light electric power in LED lights is still generated as heat, the sole use of LED lighting in a building could have a negative effect on the cooling load. In this paper, we study the heating properties of LED lighting and establish a management strategy to exploit these properties to reduce the energy used for heating and cooling of buildings. Using a simulation program, the energy consumption of the Green Building in Daejeon, Korea, and the virtual building provided by the U.S. Department of Energy (DOE) was computed according for different light fixtures. A control strategy is more applicable to LED lighting than to general fluorescent lighting, especially for the cooling of a building, because the use of a return-air duct and the heat sinks on the LED fixtures allow the heat to be better directed. Deployment of LED lights in combination with such a control strategy can help to increase the energy efficiency of a building.

1. Introduction

Increased energy consumption and CO_2 emissions in urban environments have made strategies to save energy and improve efficiency a priority in the energy policies of most countries [1]. Energy consumption for lighting in buildings, in particular, is a major contributor to CO_2 emissions, and has been estimated to account for 20–40% of the total energy consumption in buildings [2–4].

According to a recent review, investing in energy-efficient lighting is one of the most cost-effective ways to reduce CO_2 emissions, and other studies have shown that existing technology could reduce electricity use for lighting by 50% [5–7].

Of the existing technology, LEDs have particularly shown a rapidly increasing trend with regard to their light efficacy. This is demonstrated in the research conducted by Jenkins et al. in the UK, in which it was estimated that energy savings of 56–62% in a typical 6-storey office building could be achieved, resulting mainly from the change in the usage from fluorescent lights to LED lights (thus improving the lighting efficiency) and reduction in night-time usage [8]. Further, LED lights have 9–10 times longer lives than fluorescent lights. For these reasons, LED technology is being considered as the next generation of lighting [9].

Therefore, many countries have implemented national LED lighting projects. Through the ‘Next Generation Lighting Initiative’, the United States is aiming to develop LED technology with a luminous efficiency of 200 lm/W and to have a 50% share in the global lighting market by 2020. Japan, through the ‘Light for the 21st Century project’, has set a goal of a 20% reduction in lighting energy by widespread installation of white LED lighting and development of 120 lm/W LED technology [10,11]. According to the 2010 revised Japanese Energy Basic Plan, Japan plans to replace 100% of existing lights with highly efficient technologies (including LED and organic EL lighting) by 2020 [12]. The EU has issued the LED Quality Charter setting a high-quality voluntary standard to be used in Euro-

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