Available online at www.sciencedirect.com
SCIENCE DIRECT®
Energy Conversion and Management 47 (2006) 1133–1145
ENERGY CONVERSION & MANAGEMENT
www.elsevier.com/locate/enconman

Lighting and energy performance for an office using high frequency dimming controls

Danny H.W. Li *, Tony N.T. Lam, S.L. Wong

Department of Building and Construction, Building Energy Research Group, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon, Hong Kong SAR, PR China

Received 20 December 2004; accepted 29 June 2005
Available online 10 August 2005

Abstract

Artificial lighting is one of the major electricity consuming items in many non-domestic buildings. Recently, there has been an increasing interest in incorporating daylight in architectural and building designs to reduce the electricity use and enhance greener building developments. This paper presents field measurements for a fully air conditioned open plan office using a photoelectric dimming system. Electric lighting load, indoor illuminance levels and daylight availability were systematically measured and analyzed. The general features and characteristics of the results such as electric lighting energy savings and transmitted daylight illuminance in the forms of frequency distributions and cumulative frequency distributions are presented. Daylighting theories and regression models have been developed and discussed. It has been found that energy savings in electric lighting were over 30% using the high frequency dimming controls. The results from the study would be useful and applicable to other office spaces with similar architectural layouts and daylight linked lighting control systems.

Keywords: Daylight availability; Energy savings; Frequency distribution; High frequency dimming controls; On–off controls

* Corresponding author. Tel.: +852 27887063; fax: +852 27887612.
E-mail address: bcdanny@cityu.edu.hk (D.H.W. Li).

0196-8904/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enconman.2005.06.016

1. Introduction

In subtropical Hong Kong, a certain amount of electricity is used for creating a visually comfortable built environment through electric lighting. It has been reported that artificial lighting is the second major electricity consuming item in commercial buildings, representing 20–30% of total electricity use [1]. Companies begin to realise that an efficient use of energy can reduce operating costs, and the staff would be more productive working in a better indoor environment. Daylight is often considered the best source of light for good colour rendering and closely matches human visual response. The amount of daylight entering a building is mainly through window openings that provide the dual function of admitting light into the indoor spaces and connecting the outside world to the inside of a building. People expect good natural lighting in their working environment. In recent years, there has been an increasing interest in incorporating daylight in architectural and building designs [2,3]. Daylighting is recognized as an important and useful strategy in displacing the need for high grade energy (electricity) used for interior lighting [4]. Energy savings from daylighting schemes mean not only lower electric lighting demand and reduced peak electrical demands but also less cooling energy consumption and the potential for a smaller heating, ventilating and air conditioning (HVAC) plant. It is not difficult to understand that utilization of daylight is a design approach with great energy saving potential [5].

Daylighting design techniques are often best illustrated through field measurements that form an essential part in providing reliable operational and energy performance data and establishing design guidelines [6]. The theory of electric lighting savings due to daylight is well understood, and theoretical models have been developed to predict the energy savings for different fenestration designs [7]. Empirical data obtained via field measurements, however, would help confirm their usefulness, suitability and accuracy [8,9]. Actual lighting energy expenditures in existing buildings and their characteristics are important information for building owners and operators to develop energy conservation strategies and management programmes [10]. Previously, we conducted field measurements on daylighting for air conditioned cellular offices [11]. This paper studies the daylighting performance and energy issues for an open plan office. Artificial lighting energy consumption, internal illuminance and daylight availability are systematically recorded and analysed. The actual energy savings under various outdoor illuminances are reported and the design implications discussed.

2. Background information

A fully air conditioned open plan office at the City University of Hong Kong facing northwest (320°) was selected for the study. The office is located in the 5th floor of the seven story Academic Building with the dimensions of 5.88 m (depth) × 10.29 m (along the window façade) × 2.39 m (height). The monitored room is the working space for the teaching staff members. A total of 14 ceiling mounted recessed fluorescent luminaries with standard diffusers are installed in four rows parallel to the window facades. Fig. 1 shows the luminaire layout plan for the office. Each luminaire consists of two 36 W fluorescent tubes (T5) with a dimmable electronic ballast, which can dim the lamp output smoothly and uniformly. The maximum lighting load is 1008 W plus the electronic ballast load, giving the lighting power density of about 16.7 W/m^2 for the interior