GLOBAL JOURNAL OF ADVANCED RESEARCH
(Scholarly Peer Review Publishing System)

ENERGY SAVING OF CFL AND LED LAMPS IN THE LIGHTING OF OFFICE BUILDINGS USING DIALUX LIGHTING DESIGN

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ABSTRACT

Environmental and occupancy changes in a building increase the complexity of control operations. Occupants not only impose control goals related to thermal comfort, visual comfort or indoor air quality but also influence the building processes affecting indirectly on the control functions of the different processes. Lighting in office buildings can account for approximately 30% of electrical use. This provides an opportunity for energy efficient technologies to be implemented to reduce this load. LED lamps are part of a growing industry, based on complex electronics and careful placing of light sensors. In an economy that is accepting the need for energy saving due to the realization of limited fossil fuels, it is important to maintain and enhance energy efficient systems. Research highlighted that previous studies would either use physical measuring approach, computer based software or an occupant survey to understand how well automated daylight control systems are working. This research combined all of these approaches to quantify how much energy automated daylight control systems are saving while ensuring that occupant satisfaction and comfort is maintained. CIBSE guide states that the average standard illuminance level for a seminar room is 300 lx, what is obtainable (base case) is 248 lx, which is below the standard illuminance required for proper function of the built space. Therefore, the strategy employed was first to change the lamps used in the seminar room, this gave an output of 306 lx which is above the optimum but not too much to cause glare.

Keywords: Energy, CFL lamps, LED lamps, Dialux lighting, Design

1. INTRODUCTION

A building can be compared to a system with a variety of physical processes interacting with each other and with the environment. From the control point of view, it is considered as having multivariant dynamic subsystems showing linear or non-linear behaviors. Environmental and occupancy changes in a building increase the complexity of control operations. Occupants not only impose control goals related to thermal comfort, visual comfort or indoor air quality but also influence the building processes impacting indirectly on the control functions of the different processes (HVAC, lighting, etc.).

Lighting or illumination is the deliberate use of light to achieve a practical or aesthetic effect. Lighting includes the use of both artificial light sources like lamps and light fixtures, as well as natural illumination by capturing daylight. Daylighting (using windows, skylights, or light shelves) is sometimes used as the main source of light during daytime in buildings. This can save energy in place of using artificial lighting, which represents a major component of energy consumption in buildings. Proper lighting can enhance task performance, improve the appearance of an area, or have positive psychological effects on occupants.

Lighting control systems reduce energy usage and cost by helping to provide light only when and where it is needed. Lighting control systems typically incorporate the use of time schedules, occupancy control, and photocell control (i.e. daylight). Some systems also support demand response and will automatically dim or turn off lights to take advantage of utility incentives. Lighting control systems are sometimes incorporated into larger building automation systems.

Many newer control systems are using wireless mesh open standards (such as ZigBee), which provides benefits including easier installation (no need to run control wires) and interoperability with other standards-based building control systems (e.g. security).

The first lighting controls level, also the most widely used, is the manual switch to put on or off an individual luminaries or a group of luminaries. This type of control is not robust enough with respect to energy efficiency as it relies solely on the behavior of the occupants who are not necessarily concerned by energy savings, especially in the tertiary sector buildings. Lighting control strategies provide additional cost-savings through real time pricing and load shedding. Reducing lighting power during electricity peak-use periods when energy rates are at the highest can also be achieved through a Lighting Management System (LMS). Lighting Management Systems allow building operators to integrated lighting systems with other building services such as heating, cooling, ventilation, in order to achieve a global energy approach for the whole building, in particular for green building or an energy-producing building.

The time scheduling control strategy enables switching on or off automatically based on time schedules and occupancy patterns for different zones. Twenty-four hour timers allow the occupants to set certain times for lighting. The timer is set to switch lighting on during occupancy. Measurements have shown that the best energy efficient solutions are combining the use of a cut off system with a manual switch on system; potential gains are between 10 and 15% (without daylighting) (Floyd et al. 1995, Rundquist et al. 1996). Note that the gain may be more than 50% in case of 24 hours lighting (Maniccia et al. 1999, NBI 2003). This strategy is used most widely in applications where building occupancy patterns are predictable and follow daily and weekly schedules like classrooms, meeting rooms and offices.

The Dusk or Dawn control strategy is a type of predicted occupancy strategy based on sunrise and sunset which can be calculated for every building location. Light is switched on automatically when it gets dark, and off when there is enough daylight. This control type is not often applied for indoor lighting but is very efficient for atriums with good daylight availability or for glazed corridors linking buildings. This strategy is not necessarily achieved with an outdoor daylight sensor. The on and off hours can be provided by a scheduler.

The Daylight Harvesting Control Strategy (DHCS) allows facilities to reduce lighting energy consumption by using daylight, supplementing it with artificial lighting as needed to maintain the required lighting level. The Daylight harvesting control strategy uses a photocell to measure the lighting level within a space, on a surface or at a specific point. If the light level is too high, the system's controller reduces the lumen output of the light sources. If the light level is too low, the controller increases the lumen output of the light sources. Sensors are often used in large areas, each controlling a separate group of lights in order to maintain a uniform lighting level throughout the area. The result is a system that minimizes lighting energy use while maintaini ng uniform lighting levels. This system can also provide the constant luminance strategy.

Daylight harvesting systems are generally used in spaces that have relatively wide areas of windows or skylights. Typical applications include classrooms, high-rise office buildings and retail facilities. The savings potential varies from 20% (daylight-harvesting alone) to more than 50% (daylight harvesting plus real occupancy (NBI 2003). In office buildings, predicted occupancy control strategy (based on scheduler) allows 10% gain whereas real occupancy (based on presence detector) allows 20% gains. We can notice that Daylight-harvesting impact depends on the climatic zone. So, in office building potential gains vary from 30% (Paris) to 40% (Nice). Coupling of different strategies should result in more energy gains, for instance, daylight harvesting and real occupancy achieves up to 50% gains. These gains are function of the room and window sizes, building orientation and sensor(s) position(s).

2. LITERATURE REVIEW

Energy Conservation in Buildings

If the building envelope and building materials were adequately taken care of to allow for a longer time period for day lighting, and maximum indoor space cooling, this would reduce the time of need of electrical energy for both lighting and cooling devices. Consequently, this will promote energy conservation. Apart from the building envelope, a lot of opportunities also exist for energy conservation in the lighting and cooling devices subsectors. For instance, due to the high first cost of fluorescent bulbs, incandescent bulbs (40- and 60-W rating) are still the predominant electric lighting device in the country. Hence, approximately 34.3% of total electricity use in urban households goes to lighting (Adegbulugbe &Akinbami, 1995). The tropical climate of Nigeria definitely makes space cooling an essential energy service. This is provided by electric fans and air-conditioners. Fans have a much higher market share than air-conditioners in Nigerian households because of their lower investment costs and lower electricity consumption.

Energy usage in public buildings

According to the US Department of Energy, lighting ranks as the most significant use of electricity in commercial buildings. Lighting uses more power on average than cooling, ventilation and refrigeration combined. Whether in existing facilities or in new construction, the easiest route to energy savings is to shed lighting loads.

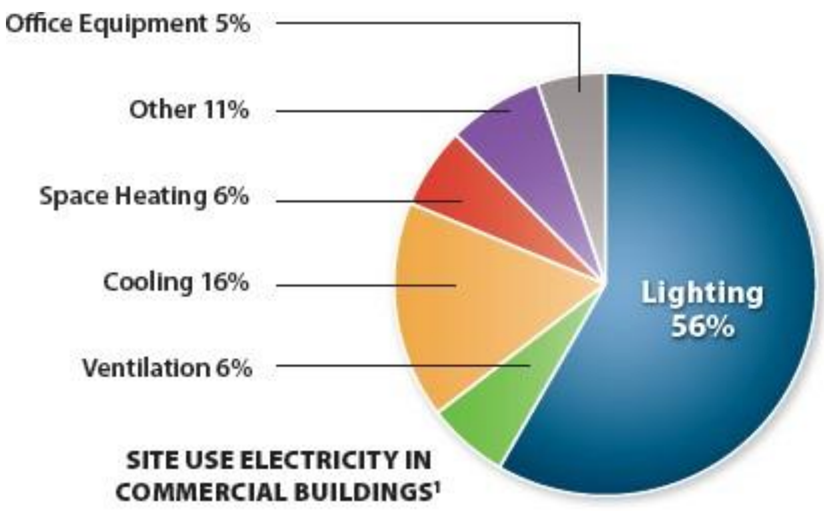

Figure 1: Energy usage in public buildings

Lighting

Possible energy saving measures through lighting in offices, homes, commercial centers, and industries in Nigeria include the following:

1. Re-lamping. It means substituting one lamp for another to save energy. New fixtures are available which produces superior energy savings, reliability, and longevity compared with incandescent lamps. CFLs are generally considered best for replacement of lower incandescent lamps at homes, offices, and commercial and industrial outfits. These lamps have efficacy ranging from 55 to 65 lm/W. The average rated lamp life is 10,000 h, which is ten times longer than that of a normal incandescent. They offer excellent color-rendering properties in addition to the very high luminous efficiency. Also, they offer energy-saving potential.

2. Installing lighting control systems in bathrooms, stores, and bedrooms. Lighting controls are devices for turning lights on and off or for dimming them.

3. There is the need to install lighting control systems such as photocells, timers, occupancy sensors, and dimmers in bathrooms, stores, bedrooms, and other areas not frequently used. This is to avoid wastage of energy in these areas.

4. Street light control. Street lighting accounts for more than 50% of all electricity consumed inNigeria of this value, about 50% or more of the energy is wasted by obsolete equipment, inadequate maintenance, or inefficient use. Saving lighting energy requires either reducing electricity consumed by the light source or reducing the length of time.

In Nigeria, demonstration plants have been funded for technologies such as coal liquefaction and coal gasification, fluidized bed combustion of coal (Onyegbebu, 2002)and improvement of methods for extracting oil from shale. Other concepts being explored are the conversion of solid waste into methane gas, the extraction of natural gas from coal seams, the use of fuel cells, magneto hydrodynamics, wind energy, and ocean thermal energy.

Solar power research is being pursued in connection with efforts to design residential and commercial buildings that will use energy more efficiently. Some of the most promising devices are solar collectors (which employ water heated by the sun), solar mirrors, and photovoltaic cells capable of directly converting the energy of sunlight into electricity (Onyegbebu, 2002).

Energy savings using lighting control systems

Lighting controls reduce building operation costs. Properly operated lighting controls reduce lighting energy when lighting is unnecessary and reduce lighting demand when and where possible.

A survey of two groups of professionals describing themselves as electrical contractors and energy consultants, conducted by the Lighting Controls Association from its lighting control newsletter database, suggests automatic lighting controls are becoming more popular in lighting retrofits. Respondents reported lighting controls were considered in over 50 percent and installed in over 30 percent of their projects in 2012.

Numerous studies over the last 50 years attest to the importance of daylight in design. Research indicates that daylight can improve user satisfaction/performance and retail sales. These characteristics can make day lighted buildings more valuable and marketable. Daylighting also enables daylight harvesting, an innovative control strategy that can generate 35-60+% energy savings. A daylight harvesting system decreases electric light contribution as the daylight contribution increases. With a daylight harvesting control system, electric lighting is increased or decreased in direct or approximate proportion to the amount of natural light present, resulting in a minimum maintained illumination level in the controlled space. Daylight harvesting controls can be effective in virtually any type of facility where the lights operate much of the time and where a significant quantity of daylight is provided with windows and/or skylights.

We are living in an age where green energy is a well-known term, and energy savings are a hot topic. Artificial lighting is a big part of our daily routine, and is needed by many to carry out daily routines. This has led to lighting taking up roughly 12% of the world’s energy usage. So it has become of great interest to improve the energy performance of lighting – especially with the easy attainable energy sources becoming scarcer.

The lighting in a building is coming from two parties: artificial light and sunlight. Due to the big variation in sunlight during the day both parties plays a role in the interiors design. As a general rule of thumb a daylight factor of 2% should be achieved – 10k lux outside would result in 200lux inside, the 2% definition. However, this may not be achieved in every scenario due to different building designs eg. A room with a big depth compared to a small width hence the need for artificial lighting. Since this project is involving school lighting only those illuminance levels are listed. According to DS700, an illuminance level of 200lux is acceptable while EN12464-1 says 300lux is acceptable.

3. METHODOLOGY

Research Design

This research tries to analyzed data to show the importance of light sensors/detectors in the reduction of both energy use and cost incurred in the use of artificial lighting within an educational building environment. The research makes use of software (DIALux Evo) to run simulations, which provided basis for inferences and conclusions.

Study Area

My case study area is located at the School Of Information and Communication Technology (ICT); the boardroom is the area of concentration, it is at the top floor of the entire building.

Walk Through Survey

The reconnaissance survey was carried out to get a firsthand description and characteristics of the boardroom; the survey was carried out over a period of four weeks to ensure the appropriateness of the chosen area of survey.

The board room is polygonal in shape with two concrete pillars located at the far end of the east and west side of the room, 15 no of lamps, wall surface is painted off-white, with cherry maroon colored wood table, black cushioned chairs and a swirl office chair at the end of the table, and a sand colored rug.

Plate 1: Picture showing the ICT seminar room

Model Description

The model started with drawing the plan on AutoCAD and importing it into the dialux software, and then the model was developed by adding the appropriate furniture types, windows and doors, with their respective colors, and importing lamps and luminaries.

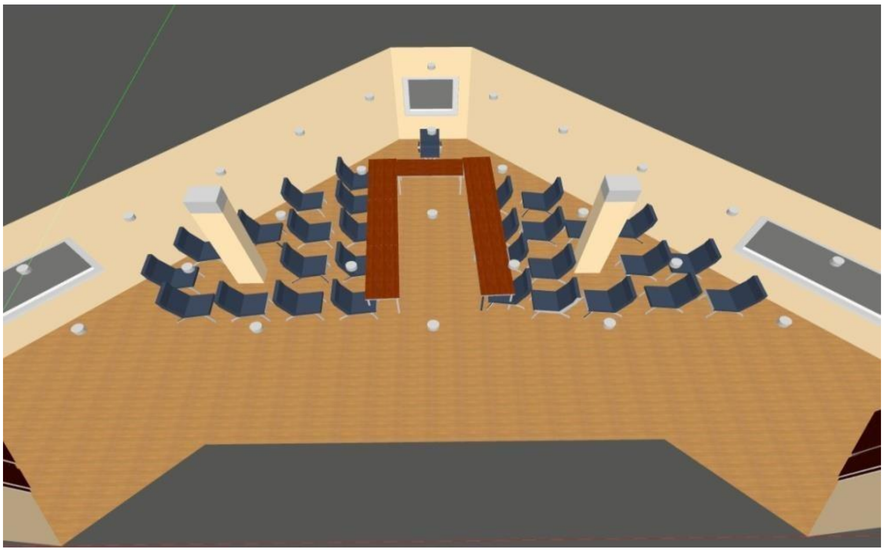

Figure 2: A model of ICT Board Room using Dialux-Evo

4. FINDINGS AND DISCUSSIONS

In this research study, light sensors with automatic dimming and on control abilities were introduced to help minimize the amount of artificial light used in the seminar room. The various data gotten from the simulated environment of the seminar room using Dialux Evo lighting design software with different case scenarios will be analyzed using charts and tables gotten as results from the software in this chapter

WORK PLANE RESULT OVERVIEW

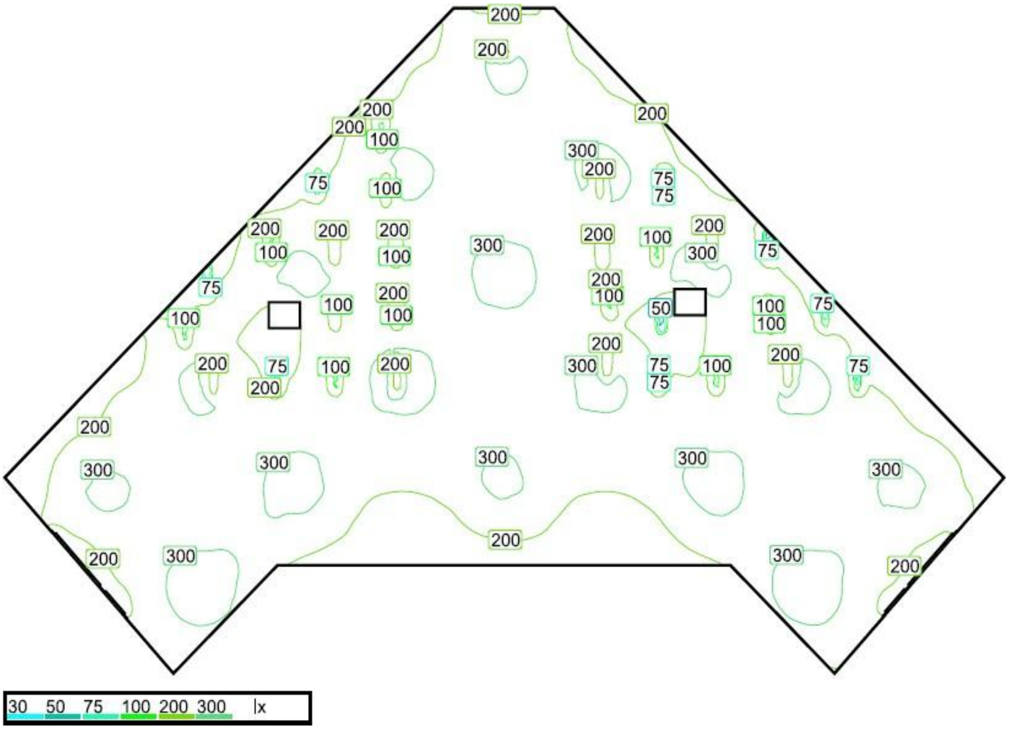

Figure 3: ISO shape for base case with CFL lamps

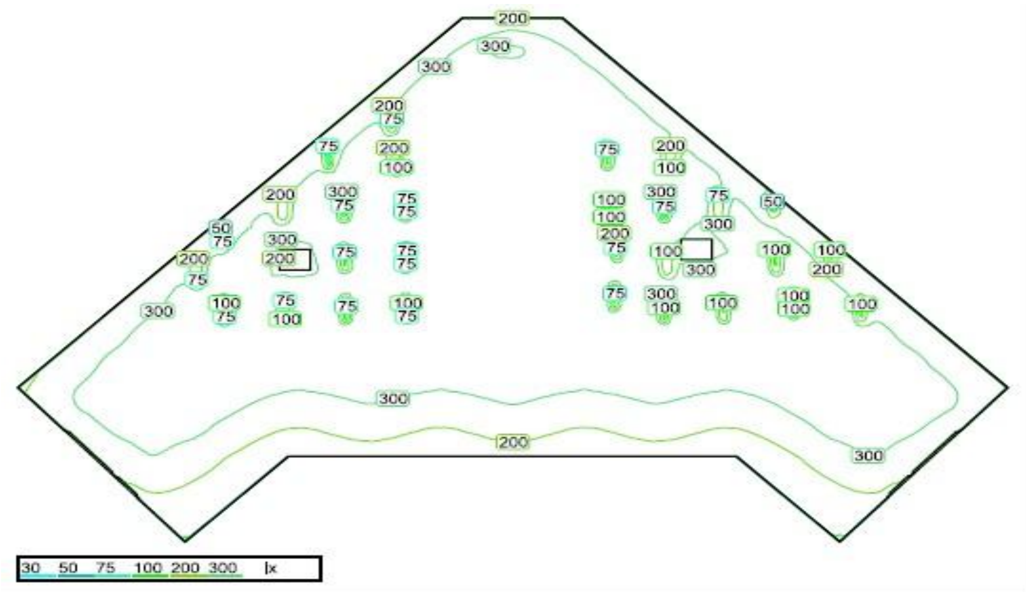

Figure 4: ISO shape for strategy using LED lamps

Table 1; Table showing luminous flux

Result type	Average perpendicular illuminance (lx)
Standard	**300**
Base case	**248**
Strategy	**306**

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5. CONCLUSIONS AND RECOMMENDATIONS

This section strives to expose the intrinsic factors that will aid the implementation of sustainable and efficient energy saving strategy using LED bulbs and sensors as control in a seminar room, overcoming all the obstacles and establishing largely its importance. This chapter brings to light the various conclusions drawn because of this research work, the findings and possible recommendations that when taken into severe consideration which led to implementation of sustainable energy saving strategies.

In relation to the simulations run and the data gotten from the entire research work, here are a few listed re-modifications advised/ recommended that can be applied to the already existing building, and can also be used in the construction of any new building. They include

1. Use of LED lamp instead of the normal/ existing compact florescent lamps which are presently in play
2. The introduction of more daylight into the building, since the case study area is located at the top floor of the building, the application of skylight and light tubes will go a long way to saving energy and cost use.

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