



## A collective approach to reducing carbon dioxide emission: A case study of four University of Lagos Halls of residence



S.M. Abolarin\*, A.O. Gbadegesin, M.B. Shitta, A. Yussuff, C.A. Eguma,  
L. Ehwerhemuepha, O. Adegbenro

National Centre for Energy Efficiency and Conservation, Faculty of Engineering, University of Lagos, Akoka, Yaba, Lagos, Nigeria

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### ABSTRACT

A major focus of existing literature on energy conservation is the modelling and quantification of energy savings and the corresponding carbon dioxide emissions from lightings. While many studies have established theoretical frameworks concerning these issues, very little documentation exists relating to energy savings and emission levels in students' hostels. This paper considers the lighting efficiency improvement of four University of Lagos halls of residence for the purpose of quantifying energy saving and the minimization of carbon dioxide that can be made. Compact fluorescent lamps are considered alternatives to the current primary usage of conventional fluorescent and incandescent bulbs. The existing electricity consumption data obtained from energy audit are used in combination with conversion factors to estimate the annual CO<sub>2</sub> contributed to the atmosphere by lighting in each of the buildings. The result of the study shows that over 45% reduction in carbon dioxide emission can be achieved. There is a lot individuals can do to reduce the emissions, for example, using energy saving appliances, turning off appliances when not in use, less use of fossil fuels, are simple measures that can be adopted to reduce annual carbon footprint, improve economic growth, enhance environment, health and save the planet.

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### 1. Introduction

The need to reduce carbon dioxide emission has now become everybody's concern. This is because its adverse effects are being experienced worldwide [1]. One very obvious way to contribute to the fight against green house gas emission is to employ energy efficiency and conservation practices.

Energy efficiency is the use of technology that requires less energy to perform the same function. Energy efficiency involves using technology to reduce the amount of energy used [2]. Examples include using more efficient lighting, better building management, more energy conserving windows, or more fuel efficient automobiles. A compact fluorescent light bulb that uses less energy to produce the same amount of light as an incandescent light bulb is an example of energy efficiency. Energy conservation is any behaviour that results in the use of less energy. Energy conservation involves behavioural changes, such as switching off lights, utilizing daylight to reduce the need for artificial lighting, turning down thermostats or switching off computers when not in use, to reduce energy consumption. The decision to replace an incandescent light

bulb and normal fluorescent tube with a compact fluorescent lamp is an example of both energy efficiency and conservation (technology may provide an option but it is up to society or individual to adopt it). The combination of energy efficiency and energy conservation offers the greatest energy saving, cost savings and CO<sub>2</sub> reduction in related energy consumption emission [3–11].

Efficiency and conservation are key components of energy sustainability [12]. Sustainability as a concept encourages every generation to meet its energy needs without compromising the energy needs of the future generations. It focuses on long term energy strategies and policies that ensure adequate energy to meet today's needs, as well as tomorrow's.

Some of the benefits attributed to energy efficiency and conservation include reduction in energy consumption, operating cost, duration of lighting fixture replacement, the heat generated by the incandescent lamps and improvement in energy performance of buildings [13–15]. Others include participation in the global energy sustainability and contribution to the fight against greenhouse gases [16].

Human activities like rise in the use of fossil fuels for electricity consumption, transportation, deforestation, industrialization, landfills, interference with the natural water or carbon cycles, have increased the amount of green house gases and thus the carbon footprint of individuals and organizations. Therefore every individual is contributing to the phenomenon of global warming caused by the

\* Corresponding author. Tel.: +234 8028114010.

E-mail addresses: [mayor2802001@yahoo.co.uk](mailto:mayor2802001@yahoo.co.uk), [sogoabolarin@gmail.com](mailto:sogoabolarin@gmail.com) (S.M. Abolarin).

### Nomenclature

CO <sub>2</sub>	carbon dioxide
TPD	total power demand (W)
SW	system wattage (W)
kWh	energy consumption
CFL	compact fluorescent lamps
DLI	distance learning institute
<i>n</i>	number of lamps
<i>F<sub>d</sub></i>	demand factor
TOE	tonnes of oil equivalent

### Subscript

<i>d</i>	demand
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green house effect. The effect is already being felt in many parts of the world [17,18].

A total carbon footprint/emission quantification would include energy related emissions from human activities – that is, from heat, light, power and refrigeration and all transport related emissions from cars, freight and distribution. By measuring the carbon footprint, the energy consumer gets a better sense of what impact and the lifestyle that deserve the greatest attention [19].

More than 40% of final energy consumption in developing countries is due to the residential and tertiary sector, the major part of which is buildings [20]. Worldwide, buildings account for almost a third of final energy consumption and are an equally important source of CO<sub>2</sub> emissions [21]. Inappropriate energy use and increasing concern for climate change calls for new and improved methods for the prediction of building energy consumption. This is especially important in design of new-built and refurbishment of low energy and net-zero energy buildings where there are high uncertainties in the estimation of collected energy and used energy [22].

Building energy performance assessment is crucial to ascertain the efficiency of energy use in buildings and is the basis to make any decision for enhancing energy efficiency. In order to assess the energy performance of existing buildings quantitatively, the energy use of the assessed buildings should be quantified first. The quantified energy use will be then used to compare with the assessment criteria to determine the energy performance quantitatively [23].

The Kyoto protocol (an international agreement adopted in 1997 in Kyoto, Japan) of United Nations Framework Convention on Climate Change aims at globally and collectively reduce greenhouse gas emissions by 63.9% of the 1990 levels by 2012. Nigeria emitted a total of 77.75 million tonnes of carbon dioxide in 2009 compared with the 100.16 million tonnes emitted in 2008, thus ranks the 46th in world carbon dioxide emission list. Energy efficiency is essential in addressing the future management of climate change adaptation strategies [10,24].

University of Lagos electrical services are supplied by Power Holding Company of Nigeria (PHCN) with a peak power demand of some 6MW and average daily energy consumption of 74,726.63 kWh from incoming feeders. Two sets of 1 MW diesel generating sets consuming 140l/h generate standby power when the PHCN supply fails. The consumption on PHCN and each of generating sets supply contribute 93.41 tonnes of CO<sub>2</sub> daily and 0.3752 tonnes of CO<sub>2</sub> per hour respectively.

The University community is flooded with conventional light bulbs (incandescent and fluorescent) installed to provide illumination. There is therefore, a need to gradually move away from the present inefficient practices towards achieving green society – environmental friendly and less harmful in its energy production and usage. Unconsciously to the users, many of these light bulbs are left on in class rooms, outdoor lighting, and apartment building

hallways. In Nigeria, the majority of these light bulbs are powered by burning fossil fuels in electric generators.

According to University of Lagos Students Information Handbook 2009–2011 [25], 9031 students are currently accommodated in the University's 15 halls of residence. The capacities in the Halls under study are Erastus Akingbola 108, Mariere 450, King Jaja 630 and Moremi 885. The halls are also of different ages; the latest Erastus Akingbola was built in 2006, King Jaja 1974, while Mariere and Moremi were built in the early/late 60s. Energy efficiency and Sustainability were not critical issues at the time these buildings were constructed for use. It is therefore necessary to consider how they can be retrofitted to be in line with present ideas of energy conservation [26].

The occupants of these buildings have a high degree of control over electricity use with the choice of switching off appliances when not in use, even though they do not have an immediate economic incentive for conservation, they do not pay for electricity. However, with sufficient level of awareness on this subject through jingles, research publications, hand bills, wall bills on energy saving tips, regular monitoring and display of energy consumption data and charts on bill boards, they are likely to make decisions that are beneficial to the environment, by letting them know their current resource use and the associated problems, thus motivating and empowering them morally or ethically to conserve these resources [27,28].

The paper focuses on reducing the carbon dioxide emission in the atmosphere and uses a survey of four buildings within University of Lagos, Nigeria as a test case. It compares the present electricity consumption of four halls of residence within University of Lagos with proposed efficient measures and illustrates how consumers can estimate the carbon footprint in tonnes of oil equivalent on the kilowatts of energy consumed. Light bulb/lamp is the only energy consuming device considered. This work compares the present carbon dioxide contribution of the inefficient status of these buildings and proposes carbon emission saving strategies the University could adopt to minimize greenhouse gases. This study will help students and other members of the University community to understand how small, daily activities have a big impact on the environment.

Lighting is a large and rapidly growing source of energy demand and greenhouse gas emissions. In 2005 grid-based electricity consumption for lighting was 2650 TWh worldwide, which was about 19% of the total global electricity consumption [13]. Global electricity consumption for lighting is distributed approximately 28% to the residential sector, 48% to the service sector, 16% to the industrial sector, and 8% to street and other lighting. In the industrialized countries, national electricity consumption for lighting ranges from 5% to 15%, on the other hand, in developing countries the value can be as high as 86% of the total electricity use [29].

Switching from traditional light bulbs (called incandescent) to CFLs is an effective, simple change that everyone can make right now. Efficient lighting has been found in several studies to be a cost effective way to reduce CO<sub>2</sub> emissions [30,31]. Making this change will help in using less electricity at home and prevent greenhouse gas emissions that lead to global climate change. A companion paper titled Energy (Lighting) Audit of four University of Lagos Halls of Residence [32] has discussed the cost implication of this retrofitting.

## 2. Methodology

Data for the study was collected through library research including surfing Internet, the use of questionnaires and personal interviews on students (occupants), management of the halls' facilities, shop owners and daily energy consumption data from the

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