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Energy efficiency in buildings: Case of post graduate hostels at the University of Benin, Nigeria

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ABSTRACT

This paper examines the potential for energy savings in the post graduate hostels of the University of Benin and also other Nigerian higher institutions. Electricity consumption and cost profiles show a substantial difference between incandescent bulb usage and compact fluorescent lamp (CFL) usage due to the preponderant use of inefficient electrical appliances and increasing business activities within the community. A retrofitting exercise was carried out by the National Centre for Energy and Environment (NCEE), an agency of the Energy Commission of Nigeria (ECN) as part of the ECN/ECOWAS/Cuba Energy Efficiency Project. A total of 386 incandescent light bulbs with 40,140 watts were replaced with 386 CFLs of 5,404 watts with 34,736 watts as Total Energy Saved in the Keystone Postgraduate Hostel of the University of Benin, Benin City. In the Intercontinental Postgraduate Hostel, a total of 119 incandescent light bulbs with 10,020 watts were replaced with 128 CFLs of 1,792 watts. The total energy saved is 8,228 watts. Also, in the Erastus Akingbola Postgraduate Hostel, a total of 44 incandescent light bulbs with 3,600 watts were replaced with 49 CFLs of 689 watts with energy savings of 2,911 watts. This resulted in a total of 45,875 watts as Total Energy Saved from the three post graduate hostels of the University of Benin, Nigeria. Thus there can be an estimate electricity savings potential of 74.42% through well articulated and vigorously pursued energy efficiency.

Keywords: Energy savings, energy efficiency, retrofitting.

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INTRODUCTION

Energy is central to sustainable development and poverty reduction efforts. It affects all aspects of development-social, economic, and environmental-including livelihoods, access to water, agricultural productivity, health, population levels, education, and gender related issues. None of the Millennium Development Goals (MDGs) can be met without major improvements in the quality and quantity of energy services in developing countries. Energy is intrinsically linked with sustainable development at the local, national, and regional levels. At the local level, modern energy is required to improved the overall quality of life (especially, that of the poor) by enhancing productive activities and enterprise, which will result in increased incomes.

The electricity supply-demand gap in less developed countries is increasing rapidly as a result of the fast growing demand for electricity, increasing urbanization, generation capacity deficits and fuel supply issues. It has been estimated that more than half of the world's population lives in rural areas, almost 90% of them, approximately 3 billion, in developing countries. Out of these, nearly 1.6 billion are without access to energy (WEC, 1999, 2000; UN, 2004). As a result, the World Bank and other regional bodies including ECOWAS have increased its efforts to implement cost-effective supply and demand-side energy efficiency options that will reduce the need for electricity generation and peak capacities (GNESD, 2004, 2005, 2006). From a lens of demand-side, energy efficiency measures, energy efficiency technologies offer one of the most promising solutions to help close the supply-demand gap in many developing countries. Although the use of modern energy efficient lighting technologies has been increasing over the past several years, particularly in the commercial sector, most of the lighting in residential sector in developing countries continues to come in the form of the traditional incandescent bulbs, which are very energy inefficient when compared to linear fluorescent tube lights (FTLs) and newer lighting technologies such as the compact fluorescent lamps (CFLs) and light-emitting diodes (LED) based systems (Limaye et al., 2009).

Globally, incandescent lamps are estimated to have accounted for 970 TWh of final electricity consumption in 2005 and given rise to about 560 Mt of CO_2 emissions. About 61% of this demand was in the residential sector with the rest in commercial and public buildings. If current trends continue, incandescent lamps could use 1610 TWh of final electricity by 2030 (IEA, 2006).

In Nigeria, where the utility companies do not have enough energy to meet the needs of everybody at the same time, energy supply is alternated. With good energy management at the residential, public and private sector, there will be no need to alternate electricity supply (Community Research and Development Centre, 2009).

Most of the energy we generate in Nigeria comes from the burning of fossil fuel (oil and gas). For every kilowatt of electricity we consume, there is an equivalent emission of greenhouse gases (GHGs). Energy efficiency can help to reduce the emission of GHGs and reduce the reliance on petroleum to drive our economy. The negative environmental impacts associated with the generation of energy will also be reduced if we use energy efficiently. Many people can be employed during intervention programmes to change the behaviour of people to use energy efficiently. For companies manufacturing electrical appliances, there will then be competition among them on who manufactures the most efficient appliances to capture the patronage of consumers (Community Research and Development Centre, 2009).

Nigeria faces the complex problems of climate change and energy poverty. It is estimated that currently, 15.3 million households lack access to grid electricity; and for those connected to the national grid, supply is erratic at best. Per capita electricity consumption has been less than 150 KWh per annum. Rural areas suffer the most electricity deprivation (Banwell and Kwartin, 2006). To ensure energy access, while at the same time safeguarding the ecosystem, energy efficiency initiatives targeted at large-scale implementation technologies will be apt. Compact Fluorescent Lamps (CFLs) are a direct substitute for Incandescent light bulbs which is widely used in Nigeria.

Energy efficiency is a way of managing and restraining the growth in energy consumption. It means using less energy to provide the same or even better service. For example, a compact fluorescent lamp (CFL) uses less energy than an incandescent bulb to produce same amount of light, the CFL is considered to be more energy efficient. The goal of energy efficiency is to reduce the amount of energy required to provide products and services. Improvements in energy efficiency are generally achieved by adopting a more efficient technology or production processes or by application of commonly acceptable methods to reduce energy losses. Reducing energy use is seen as a solution to the problem of reducing carbon dioxide emission. Efficient energy use is essential to slowing the energy demand growth so that rising clean energy supplies can make deep cuts in fossil fuel use. If energy use grows too rapidly, renewable energy development will chase a receding target. Likewise, unless clean energy supplies come online rapidly, slowing demand growth will only begin to reduce total carbon emissions; a reduction in the carbon content of energy sources is also needed. A sustainable energy economy thus requires major commitments to both efficiency and renewables. Energy efficiency thus has a lot of advantages: reduction in customer energy bills; customer control over energy costs; reduction in air pollution and greenhouse gases; creation of jobs and improvements in state economies; protection of national energy security. The aim of this study is therefore to examine the cost and energy emission implications of retrofitting CFLs in the Post Graduate residential Hostels within the University of Benin, Nigeria.

METHOLOGY

Study area

The study area is the University of Benin, Benin City, Nigeria. The selected areas were divided into 3 single project areas which included: Keystone P.G Hostel, Intercontinental Bank P.G Hostel and Erastus Akingbola P.G Hostel of the University of Benin, Ugbowo Camus. The projects are shown in Figures 1 to 3. Each project area has boundaries defined by the location of service transformers.

Pre-survey

On site survey was conducted for the 3 post graduate residential hostels, during which a structured questionnaire was administered to the beneficiaries to obtain information on:

1. Hostel type (that is, single bed space, double bed space, bunk bed spaces, etc)
2. Use area or room types (that is, living room, kitchen, bathroom, etc)
3. Lighting energy audit, that is, incandescent wattages, fixture and bulb types. Energy audit involved consultation with residents to define the retrofitting approach, date of exercise and its duration.

Initial information on use area or room types, existing lighting types and number of lighting points were determined using a structured questionnaire. This was complemented with field counts of the actual lighting points and types (pin type or screw type). A total of 156 questionnaires were administered in the selected post graduate hostels. The process lasted for four weeks and took place during the week days.

Retrieval of incandescent bulbs

At the commencement of the project, all the incandescent bulbs were retrieved. These bulbs were taken to the Energy

Figure 1. Keystone P.G hostel of the University of Benin.

Figure 2. Intercontinental Bank P.G hostel of the University of Benin.

Figure 3. Erastus Akingbola P.G hostel of the University of Benin.

Efficiency/Audit and Environmental Forensic Laboratory, National Centre for Energy and Environment (NCEE), Energy Commission of Nigeria (ECN) for analysis and computation of the amounts of energy and billing cost savings (Table 1).

Replacement of CFLs

The replacement exercise lasted for one month, between 4 to 7 pm daily. This was to allow for the full participation and availability of

Table 1. Compositions of the hostels and statistics of retrieved incandescent bulbs.

Composition of hostels	Keystone P.G Hostel	Intercontinental Bank P.G Hostel	Erastus Akingbola P.G Hostel
No. of floors	3	2	3
No. of rooms	107	24	30
Lighting points per room	3	5	2
No. of lighting points	351	120	36 (107)*

*Erastus Akingbola P.G Hostel had 107 fluorescent tube light point, so these were not part of the exercise.

the hostel occupants. No CFL was given to any occupant for personal installation. This is to ensure that all light points were installed to avert possible re-installation of incandescent bulbs. Efforts were made to ensure that replaced CFLs were equal to the number of retrieved incandescent light bulbs. However, there were hostel rooms in which retrofitted CFLs were either less or more due to technical reasons resulting from the lighting point(s).

Voltage reading

Average daily voltage usage estimated in each of the post graduate hostel was taken using a clamp meter at peak periods when hostel occupants were home and appliances switched on. This exercise was done twice daily with readings taken between the hours of 6 am and 8 pm. Readings were taken from the post graduate hostel service transformers for two weeks and data on KVA, KWH revenue billing were collected and generated. Energy saved was determined using the energy smart saving calculator (General Electric Model). The formulas used are as follows:

$$KVA = \sqrt{3} \times V \times I$$

Where,
KVA is "kilo-volts/ampere"
V is voltage
I is current

$$KWH = KVA \times \text{power factor} \times 30 \text{ days} \times 24 \text{ h} \times \text{diversity factor}$$

Where,
Power factor = 0.85
Diversity factor = 0.6

Revenue = KWH × average daily use × 1 month × BEDC cost per unit

RESULTS AND DISCUSSION

A total of 386 (three hundred and eighty six) incandescent light bulbs with 40,140 watts were replaced with 386 (three hundred and eighty six) Compact Fluorescent lamps (CFLs) of 5,404 watts with 34,736 watts as Total Energy Saved in the Keystone Postgraduate Hostel of the University of Benin, Nigeria (Figures 4 and 5). From the calculation above, energy saved from keystone hostel after replacement of incandescent bulbs with CFLs was 34,736 Wh (76.3%) while money saved was ₦85,308.84 in one month. If there is no replacement of CFLs with incandescent bulb for one year a total of 416,832 Wh and ₦1,023,706 are estimated to be saved (Table 2).

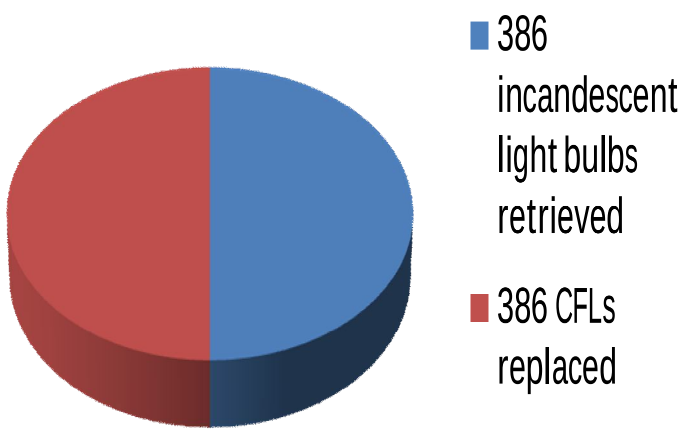

Figure 4. Variation between nos. of incandescent bulbs replaced with CFLs in Keystone Hostel.

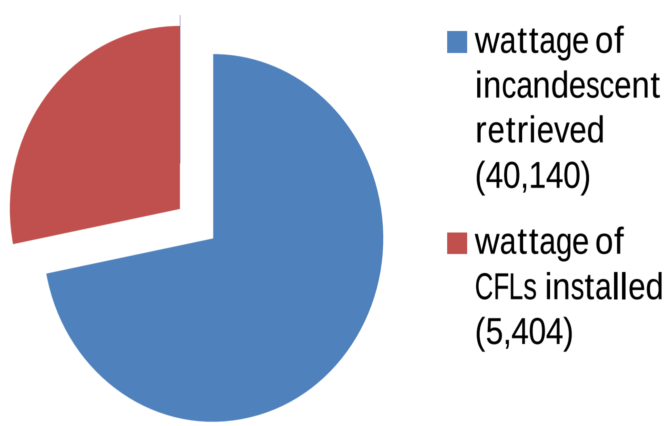

Figure 5. Variation in energy wattage between CFLs and incandescent bulbs in Keystone Hostel.

From Figures 6 and 7 and Table 3, energy saved from Intercontinental Hostel after replacement of incandescent bulbs with CFLs was 8,228 Wh (69.7%) while money saved was ₦20,207.31 in one month. If there is no replacement of CFLs with incandescent bulb for one year a total of 98,736 Wh and ₦242,487.72 are estimated to be saved.

Figures 8 and 9 show that from the Erastus Akingbola Postgraduate Hostel, a total of 46 incandescent light

Table 2. Monthly energy savings in Keystone Post Graduate Hostel.

Incandescent light bulbs				Compact fluorescent lamps
Watts	60	100	200	14
Pieces	79	260	47	386
Total watts	4,740	26,000	9,400	5,404
Total wattages: 40,140 Wh				Total wattages: 5,404 kWh
40,140/ 1000 kWh = 40.14 kWh = 40.14 x 7.2 h (Ave. daily use) = 298.008 kWh/day = 298.008 × 30 days = 8,670.24 kWh (monthly) = 8,670.24 × 11.37				5,404 /1000 kWh = 5.404 kWh = 5.404 × 7.2 h (Ave. daily use) = 38.9088 kWh/day = 38.9088 × 30 days = 1,167.264 kWh (monthly) = 1,167.264 × 11.37
Est. lighting bill per month = ₦98, 580.63				Est. lighting bill per month = ₦13, 271.79
Energy saved: 34,736 Wh (76.3%) Money saved: ₦85,308.84				

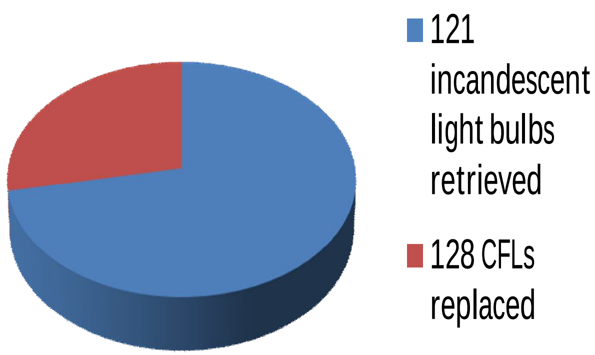

Figure 6. Variation btw nos. of incandescent bulbs replaced with CFLs in Intercontinental Hostel.

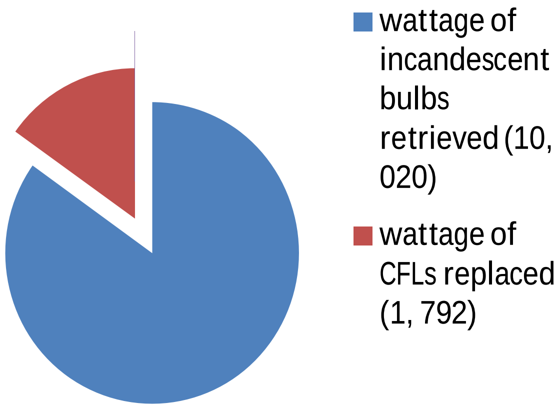

Figure 7. Variation in energy wattage between incandescent bulbs and CFLs in Intercontinental Hostel.

Table 3. Monthly energy savings in Intercontinental Bank Post Graduate Hostel.

Incandescent light bulbs				**Compact fluorescent lamps**
Watts	40	60	100	14
Pieces	8	35	76	128
Total watts	320	2,100	7,600	1,792
Total wattages: 10,020 Wh				Total wattages: 1,792 KWh
10,020/ 1000 kWh = 10.020 kWh = 10.020 × 7.2 h (Ave. daily use) = 72.144 kWh/day = 72.144 × 30 days = 2,146.32 kWh (monthly) = 2,146.32 × 11.37				1,792/1000 kWh = 1.792 kWh = 1.792 × 7.2 h (Ave. daily use) = 12.9024 kWh/day = 12.9024 × 30 days = 387.07 kWh (monthly) = 387.07 × 11.37
Est. lighting bill per month = ₦24,608.32				Est. lighting bill per month = ₦4,401.01
Energy saved: 8,228 Wh (69.7%) Money saved: ₦20,207.31				

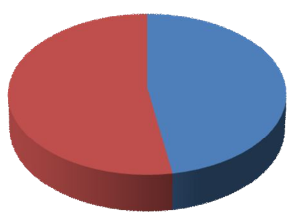

Figure 8. Variation btw nos. of incandescent bulbs replaced with CFLs in Akingbola Hostel.

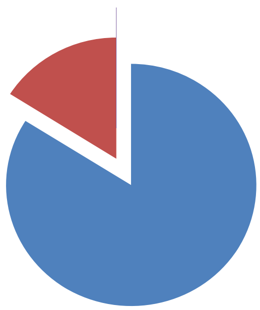

Figure 9. Variation in energy wattage between CFLs and incandescent bulbs in Akingbola Hostel.

bulbs with 3,636 watts were replaced with 49 CFLs of 686 watts. From Table 4, energy saved after replacement of incandescent bulbs with CFLs was 2,911 Wh (67.9%) while money saved was ₦7,149.18 in one month. If there is no replacement of CFLs with incandescent bulb for one year a total of 34,932 Wh and ₦85,790.16 are estimated

Table 4. Monthly energy savings in Erastus Akingbola Post Graduate Hostel.

Incandescent light bulbs			**Compact fluorescent lamps**
Watts	60	100	14
Pieces	20	24	49
Total watts	1,200	2,400	689
Total wattages: 3,600 Wh			Total wattages: 689 kWh
3,600/ 1000 kWh = 3.6 kWh = 3.6 × 7.2 h (Ave. daily use) = 25.92 kWh/day = 25.92 × 30 days = 777.6KWh (monthly) = 777.6 × 11.37			689/1000 kWh = 0.689 kWh = 0.689 × 7.2 h (Ave. daily use) = 4.9608 kWh/ day = 4.9608 × 30 days = 148.824 kWh (monthly) = 148.824 × 11.37
Est. lighting bill per month = ₦8, 841.31			Est. lighting bill per month = ₦1,692.13
Energy saved: 2,911 Wh (67.9%) Money saved: ₦7,149.18			

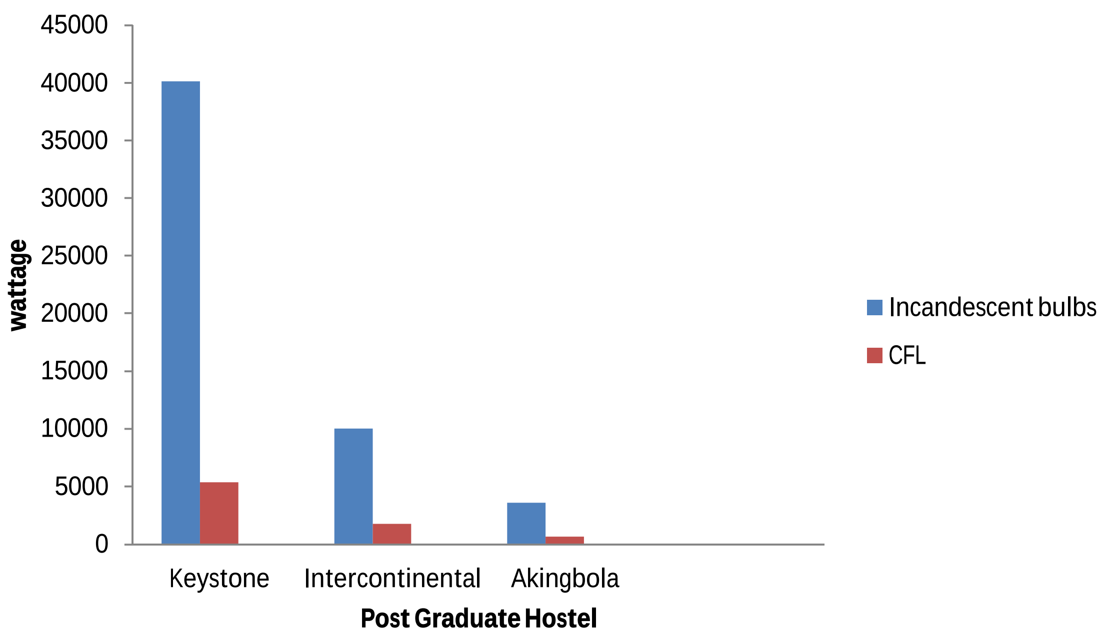

Figure 10. Variation between incandescent bulbs and CFL wattages of the 3 post graduate hostels.

to be saved (Figures 10 and 11).

CONCLUSION

There is great potential for minimizing energy wastages and improving residential lighting energy efficiency through retrofitting of incandescent light bulbs with CFLs. More importantly, using CFLs in place of incandescent bulbs has the potential to reduce system load and cost as shown in the study results. Energy efficient production process should be seen as a quick and cheaper source of new energy supply as the cost of providing energy can be several times the cost of saving it. Increasingly energy efficiency is considered to include not only the physical efficiency of the technical equipment and facilities but

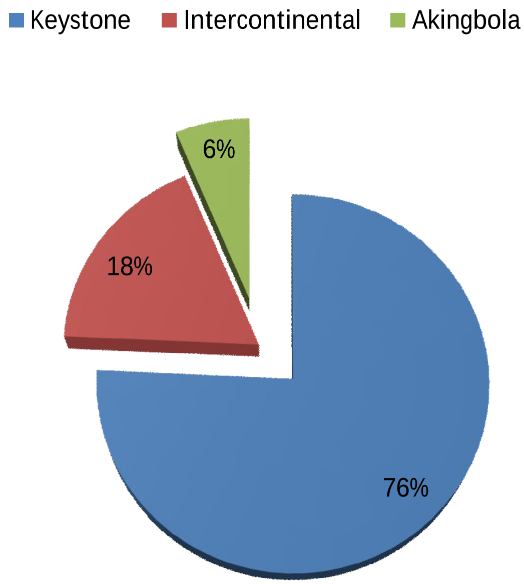

Figure 11. Percentage of energy saved from respective hostels.

also the overall economic efficiency of the energy system. Hence the adoption of energy efficiency measures in the major economic sectors (household, industrial and transport) in Nigeria will enhance profitability, reduce greenhouse gas emissions, promote sustainable development, and improve corporate social responsibility.

This paper analyzed energy efficiency through different Post Graduate Hostels (Keystone, Intercontinental Bank and Erastus Akingbola) at the University of Benin, Nigeria. The study established Compact Fluorescent Lamps as the better option as against Incandescent Light Bulbs for building energy efficiency. To ensure that the benefits of CFLs are sustained, there is need for awareness and adequate sensitization of the public on the environmental and economic importance of CFLS and energy efficient practises through implementation of policies and energy efficiency programmes.

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