



SHORT NOTES

Compact fluorescent lamps and electricity consumption trend in residential buildings in Ilorin, Nigeria

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Abstract

Purpose – The purpose of this study is to examine the electricity consumption trend in residential buildings using incandescent lamps and retrofitting with compact fluorescent lamps (CFLs).

Design/methodology/approach – Questionnaires were administered to capture the necessary data from three randomly selected residential estates in Ilorin, Nigeria. In total, 8,840 sampled incandescent lamps were retrofitted with CFLs. The electric energy in kilowatt hour (kWh) consumed prior to replacement for three months was compared with kWh consumption after retrofitting and analyzed employing *t*-tests.

Findings – The three-month average electricity consumption of ten households for the University of Ilorin GRA quarters and Lower Niger River Basin staff quarters pre- and post-installation were 20,259 and 13,010 kWh, and 46,891 and 29,588 kWh, respectively. Results show that there were significant differences between the observed and tabulated values for the pre- and post-installation of CFLs, respectively, at 5 per cent confidence level. About 40 per cent reduction in electricity consumption was achieved through deployment of CFLs in the residential households.

Originality/value – This paper demonstrates how retrofitting of incandescent lamps with CFLs can bring about possible reduction in electricity consumption in residential households in Nigeria.

Keywords Electricity, Energy consumption, Energy efficiency, Incandescent lamps, Compact fluorescent lamps, Retrofitting, Nigeria

Paper type Research paper



Nomenclature

$\bar{X}_1$	= pre-installation sample mean (kWh)	s_1^2	= pre-installation sample variance (kWh)
μ_1, μ_2	= values of the population means of null hypothesis	s_2^2	= post-installation sample variance (kWh)
$\bar{X}_2$	= post-installation sample mean (kWh)	n_1, n_2	= sample sizes for pre- and post-installation, respectively

1. Introduction

An analysis of Nigeria's electricity supply problems and prospects found that the electricity demand in Nigeria far outstrips the supply, which is epileptic in nature. The acute electricity supply hinders the country's development (Ajao *et al.*, 2009) and not only restricts socio-economic activities to basic human needs; it adversely affects quality of life (Ajao *et al.*, 2009; Sambo, 2008). The objective of the electric energy system is to provide the needed energy services. Energy services are the desired and useful products, processes or indeed services that result from the use of electricity, such as for lighting, provision of air-conditioned indoor climate, refrigerated storage, appropriate temperatures for cooking, etc. (Sambo, 1997). Presently, electric energy utilization in Nigeria is far from being efficient. The potential for efficient energy utilization or conservation in residential sector is substantial as it accounts for approximately one-third of overall delivered-energy use and carbon-dioxide emissions (Business, Enterprise and Regulatory Reform, 2008; Sambo, 2005). Key factors in the growth of household electricity consumption are the number of households with access to electricity supply, penetration rates of electric appliances, the size and efficiency of appliances (Dzioubinski and Chipman, 1999) and the use of traditional incandescent lighting (Sule *et al.*, 2010).

The use of compact fluorescent lamps (CFLs) that utilize up to 75 per cent less energy or electricity than incandescent light bulbs, can last up to ten times longer, cost little up front, and provide a quick return on investment (Energy Star, 2008; Powerline, 2005) is momentous. Thus, substantial savings can be made by simply switching from incandescent bulbs to CFLs, especially in the household sector. CFL is fluorescent lighting designed to be used in a standard (incandescent) light bulb socket. Fluorescent lighting works by passing a current through a gas-filled tube. CFLs incorporate the best features of fluorescents: high efficiency and long life and produce steady, quiet, white light (Duke Energy, 2007); which add to the aesthetics and usability of any home (Dioha *et al.*, 2010).

This study examines how a successful replacement of incandescent lamps with CFLs could bring about possible reduction in electricity consumption in residential households.

2. Method of study

A retrofitting exercise of incandescent lamps with CFLs in organized settlements was conducted as a pilot project under the Energy Commission of Nigeria energy-efficient programme. The commission supplied to states of the federation, CFLs for the replacement of incandescent lamps. In Kwara State, three organized residential estates were selected in Ilorin, the State capital. The tool employed for the data collection was a structured questionnaire administered through house-to-house surveys of selected residential estates to capture the needed data. These surveys were drafted to obtain information on the type of lighting and their respective wattages, consumption pattern, the distribution of incandescent lamps and CFLs in these estates, average monthly

electricity consumption (kWh) and average monthly bill paid (Naira). A total of 576 questionnaires were administered at the three estates visited.

For this study, electricity bills from Lower Niger River Basin quarters and University of Ilorin GRA quarters were collected and analyzed. The electric energy in kilowatt hour (kWh) consumed prior to replacement for three months were compared with kWh consumption three months after replacement using *t*-test.

3. Results and discussion

In total, 73 households comprising six duplexes, seven storey buildings having six flats each and six bungalows were visited at the University of Ilorin GRA quarters. Other households surveyed include, Mandate I & II Housing Estate comprising of 347 bungalows and the Lower Niger River Basin quarters having 155 households mainly bungalows and only one duplex. These houses were retrofitted with 8,840 CFLs.

Table I depicts the distribution of building types in the sample estates and the total number of households surveyed. Tables II and III are the distribution of incandescent lamps and CFLs in the selected estates while Table IV depicts the average kWh consumed pre- and post-installation of CFLs in the University of Ilorin GRA quarters and Lower

Table I.
Types of building

S. no.	Name of estate	Duplex	Bungalows	Storey building (No. of flats)	BQs	Household total
1	UL-GRAQ	6	6	7(42)	19	73
2	LNRBQ	1	155	Nil	Nil	156
3	MT-I & II	Nil	347	Nil	Nil	347
	Total	7	508	7(42)	19	576

Notes: UL-GRAQ: University of Ilorin, GRA quarters; LNRBQ: Lower Niger River Basin quarters; MT-I & II: Mandate I & II Housing estate

Table II.
Distribution of incandescent lamps in the selected estates

Wattage	No. of incandescent lamps			Total
	UL-GRAQ	LNRBQ	MT-I & II	
20	10	30	250	290
40	127	76	1,344	1,547
60	913	2,585	3,381	6,879
100	13	51	8	72
200	19	25	8	52
Total	1,082	2,767	4,991	8,840

Table III.
Distribution of CFLs in the selected estates before retrofitting

Wattage	No. of CFLs			Total
	UL-GRAQ	LNRBQ	MT-I & II	
5-8	Nil	Nil	Nil	Nil
9-12	Nil	1	1	2
13-16	33	5	Nil	35
17-20	3	2	4	9
20 and above	Nil	26	8	34
Total	36	34	13	80

Niger River Basin quarters, respectively. Figures 1 and 2 show the variation of incandescent lamps and CFLs in the selected estates while Figure 3 shows the average monthly electricity consumption in these quarters during the study period.

The objective is to determine whether the energy consumption of the sampled households differ before and after the installation of CFLs.

3.1 Hypothesis

H_0 . The energy consumption before the installation of CFLs is not significantly different from energy consumption after the installation of CFLs.

H_1 . The energy consumption before the installation of CFLs is significantly different from energy consumption after the installation of CFLs.

That is, $H_0: \mu_1 - \mu_2 = 0$ vs $H_1: \mu_1 - \mu_2 \neq 0$.

3.2 t-Tests analysis (Keller, 2009)

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{s_p^2((n_1 + n_2)/n_1 n_2)}} \sim t_{(\alpha/2), n_1 + n_2 - 2} \quad (1)$$

Estate	December 2009	Pre-installation			Average	Post-installation			Reduction	
		January 2010	February 2010			April 2010	May 2010	June 2010	kWh	%
UL-GRAQ Consumption (kWh)	17,398	23,652	19,728	20,259	15,525	13,359	10,147	13,010	7,249	36
LNRBQ Consumption (kWh)	36,972	56,784	46,917	46,891	34,216	28,184	26,364	29,588	17,303	37

Table IV.
Average monthly kWh of
electricity consumed in
University of Ilorin GRA
quarters and Lower Niger
River Basin quarters

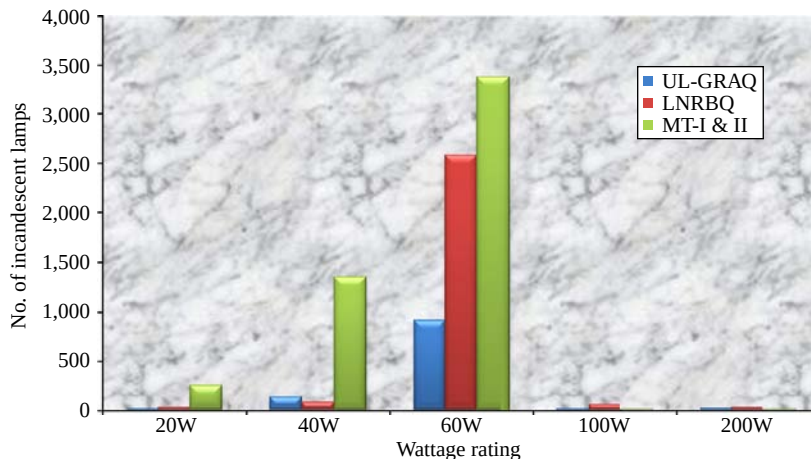


Figure 1.
Graph of distribution
of incandescent lamps
in selected estates

Figure 2.
Graph of distribution
of CFLs selected estates
before retrofitting

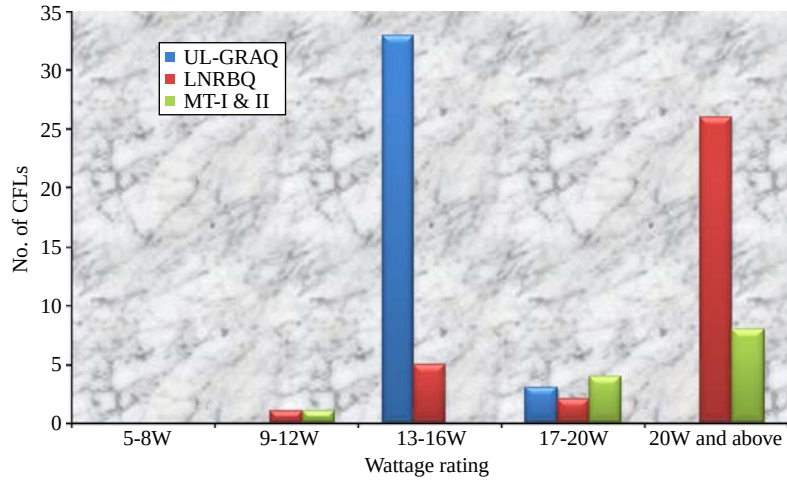
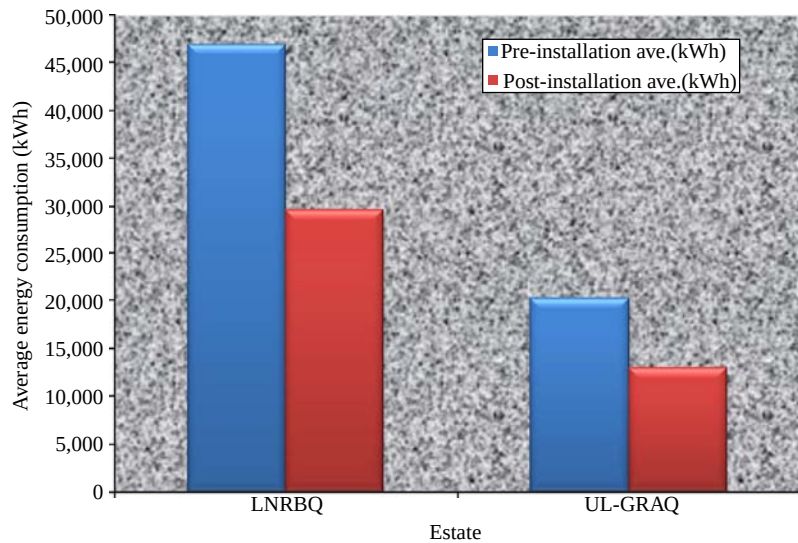


Figure 3.
Graph of average
monthly kWh of electricity
consumed in University
of Ilorin GRA quarters
and Lower Niger River
Basin quarters



Where:

$$s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$$

3.2.1 For University of Ilorin GRA quarters.

$$\bar{X}_1 = 525.92, \bar{X}_2 = 328.81, s_1^2 = 5,806.04, s_2^2 = 5,339.84, n_1 = n_2 = 73.$$

Therefore:

$$s_p^2 = \frac{(72 \times 5,806.04) + (72 \times 5,339.84)}{73 + 73 - 2} = 5,572.94$$

and thus:

$$t = \frac{(525.92 - 328.81) - 0}{\sqrt{5,572.94((73 + 73)/(73 \times 73))}} = 15.9519$$

The tabulated t -value at 5 per cent significance level:

$$t_{(\alpha/2), n_1 + n_2 - 2} \Rightarrow t_{(0.05/2), 310} = 1.960$$

3.2.2 For Lower Niger River Basin quarters.

$$\bar{X}_1 = 474.95, \bar{X}_2 = 317.08, s_1^2 = 7,988.69, s_2^2 = 5,205.36, n_1 = n_2 = 156.$$

Therefore:

$$s_p^2 = \frac{(155 \times 7,988.69) + (155 \times 5,205.36)}{156 + 156 - 2} = 6,597.025$$

and thus:

$$t = \frac{(474.95 - 317.08) - 0}{\sqrt{6,597.025((156 + 156)/(156 \times 156))}} = 17.1661$$

The tabulated t -value at 5 per cent significance level:

$$t_{\alpha/2, n_1 + n_2 - 2} \Rightarrow t_{(0.05/2), 310} = 1.960$$

Since the calculated values (15.9519 and 17.1661) are greater than the tabulated respective values (1.977 and 1.960), the null hypothesis is rejected. Consequently, there exists a significant difference in the energy consumption after retrofitting with CFLs in the sampled households.

4. Conclusion

In total, 8,840 sampled incandescent lamps were retrofitted with CFLs in three randomly selected residential estates in Ilorin, Nigeria. The electric energy in kWh consumed prior to retrofitting for three months were compared with kWh consumption after retrofitting for three months. About 40 per cent reduction in electricity consumption was achieved after the deployment of CFLs which depicts that efficient house lighting with CFLs will conserve significant electric energy for other purposes. The employment of CFLs in place of incandescent bulbs will not only reduce the quantity of electricity consumed but also a measure for mitigation of climate change by reducing the amount of carbon dioxide emissions.

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Further reading

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