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Energy Efficient Lighting: Luminance Assessments of CFLs and Incandescent Bulbs

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Abstract
Concerns about energy security, air pollution, and climate change the government of Nigeria is promoting policies that are focus on the need for energy conservation and clean energy promotion. This focus has resulted in a proliferation of high-level national initiatives on energy efficiency, renewable energy, energy security, and energy cooperation in the region. Of the many available technological options is the compact fluorescent lamp (CFL) which can directly replace a standard incandescent lamp. Increasing the efficiency of installed lighting lamps through the adoption of CFL efficient technology is an effective method to reduce peak demand and save wastage in residential section, where an estimated 15.3 million households lack access to grid electricity. The greatest advantage of the CFLs is its energy efficiency during use, with much less energy lost to heat. The CFLs typically convert about 45% of the electricity to visible light, whereas the incandescent bulbs only about 10%. This study attempts to evaluate and compare the Luminance of the CFLs acquired through ECN/ECOWAS/CUBA agreement, CFLs from other manufacturers and incandescent lamps.
Keywords: Compact fluorescent lamp (CFL, Energy efficiency, incandescent Lamps energy conservation

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1. Introduction

The provision of reliable, secure and affordable energy services are central to addressing the nation's development challenges, including poverty, inequality, climate change, food security, health and education. They are also required for wealth creation and economic development. The link between energy and the Millennium Development Goals (MDGs) has been discussed extensively in the literature and energy poverty is acknowledged as undermining achievement of the MDGs. Yet current actions to eliminate energy poverty are falling short both in terms of scale and pace. Study has shown that sub-Saharan Africa is in the midst of a power crisis marked by insufficient generating capacity, unreliable supplies, high prices, and low rates of popular access to the electricity grid. The region's capacity for generating power is lower than that of any other world region, and growth in that capacity has stagnated. The average price of power in Sub-Saharan Africa is double that of other developing regions, but supply is unreliable. Because new household connections in many countries are not keeping up with population growth, the electrification rate, already low, is actually declining (Eberhard et al. 2008).

Nigeria is faced with acute energy shortage in form of energy poverty. At the present it is estimated that 15.3 million households lack access to grid electricity; and for those connected to the national grid, supply is erratic at best (Eleri et al. 2012). Per capita electricity consumption has been less than 150KWh per annum and rural areas suffer the most electricity deprivation, making everyday functions hard and time consuming (NBS-CBN-NCC,2011), which in turn complicates the process of economic and social development. Thus, significant proportion of businesses and residential consumers generate their own electricity.

In the past, the government of Nigeria has made effort to extend electricity to over 70 per cent of Nigerian population especially in rural areas, through the National Rural Electrification Programme (Eleri et al. 2012). In spite of this significant stride, achieving universal access will no doubt be costly and perhaps slow.

Improving Nigeria's energy efficiency is however an essential stride out of energy deprivation. Internationally, energy efficiency is recognised as the most cost-effective means of reducing dependence on fossil fuels as well as an essential component of sustainable energy policy. One of the many available energy efficiency technological options, the compact fluorescent lamp (CFL) – which can directly replace a standard incandescent lamp, uses 75 percent less energy, and lasts six to ten times as long – has the potential to be an important, highly viable, and quickly implemented solution (USAID, 2007). Besides, increasing the efficiency of installed lighting lamps through the adoption of CFLs technology is an effective method to reduce peak demand and save wastage in residential section residential sector.

The greatest advantage of the CFLs is its energy efficiency during use, with much less energy lost to heat. The CFLs typically convert about 45% of the electricity to visible light, whereas the incandescent bulbs only about 10% (Tosenstock 2007). This study attempts to evaluate and compare the Luminance of the CFLs and incandescent lamp. The study is part of pilot projects of the National Centre for Energy and Environment on energy efficiency and best practices.

2. Material and Methods

Experiments were conducted to show the lighting efficiency of Compact Fluorescent Lamps as compared to Incandescent Light Bulbs and also show the lighting efficiency between CFL supplied by the Energy Commission of Nigeria ECN/ECOWAS/CUBA government (LIYA and Landlite Products) and other CFLs easily obtained in the open market e.g. Visicom, CAC, Tunsgam and Newsound. Samples of open market CFLs were obtained from the Faculty of Engineering, University of Benin.

2.1. Voltage Reading

Average daily voltage usage was taken using clamp meter at peak periods. This was done twice daily with readings taken for an average of 7.2 hours. Readings were taken for 30 days and data on KVA, KWH BILLING were generated using equation 1 below:

KWH= $Power\ factor \times 30days \times 7.2Hours \times Diversity\ Factor$ *(negligible)* (eqtn 1)

REVENUE = **KWH** $\times 11.7 + 2469 + 185 \times Vat(0.05)$

Where:

Power Factor = $\sqrt{3}.K.V.A$

KVA ("kilo-volts/ampere") = $V(\text{voltage}) \times I(\text{current})$

Energy saved was determined using energy *smart* saving calculator (*General Electric Model*).

2.2. Luminance comparison between CFLs/Incandescents/CFLs from Open Market

Setup 1: Three 14 watts "LandLite" CFLs supplied by the Energy Commission of Nigeria (ECN)/ECOWAS/CUBA government and Three 100 watts incandescent light bulbs were fitted into the "Luminance Comparison System/Unit, a locally fabricated lamp holder and switching system with the capacity of 6 points (plate 1). The Compact Fluorescent Lamps were switched on while the incandescent lights bulbs were switched off. The lux metre was used to measure the luminance of the CFLs at a one metre distance from the light sources (Plate 2). Next the CFLs were switched off and the 3 incandescent light bulbs switched on. Again the luminance was measured with the lux metre at a distance of one metre from source and recorded. This was repeated for three times to obtain the mean, standard deviation and error of estimation values, as shown in Table 1.

Plate 1: Luminance comparison unit

Plate 2: Digital Lux Meter (LX-101)

Setup II: using the same procedure in comparison of CFLs luminance in setup 1, the experiment was repeated for the comparison between three 8 watts "LIYA" CFLs supplied by the ECN and three 60 watts incandescent light bulbs retrieved from residential quarters of the university of Benin campus. The appropriate luminance values recorded. This was repeated for three times to obtain the mean, standard deviation and error of estimation values, as shown in table 2.

SetupIII: A comparison was done between two 18 watts of high quality CFL from the ECN and two 20 watts CFLs of "Tungsram" products supplied by the Faculty of Engineering of the University of Benin. Readings were repeated three times to obtain the mean, standard deviation and error of estimation values, as shown in table 3.

3. Results & Discussion

Table 1

TYPE	No. of Bulbs Used	Wattage	$Lumen_1$	$Lumen_2$	$Lumen_3$	Mean	SD	Error (+/-)
CFL (ECN)	3	14	241	243	243	242.3	1.15	0.66
Incandescent	3	100	214	214	215	214.33	0.57	0.33

With a "wattage" differential of 86 watts between the CFL and Incandescent bulb, the 14 watts CFL of 242.3 Lumen was brighter than the 100 watts incandescent bulb of 214.33 Lumen.

Table 2

TYPE	No. of Bulbs Used	Wattage	$Lumen_1$	$Lumen_2$	$Lumen_3$	Mean	SD	Error (+/-)
CFL (ECN - LIYA)	3	8	116	118	121	118.33	2.51	1.45
Incandescent	3	60	120	122	123	121.6	1.527	0.88

With a "wattage" differential of 52 watts between the CFL and Incandescent bulb, the 8 watts CFL of 118.33 Lumen was almost as bright as the 60 watts incandescent bulb of 121.6 Lumen.

Table 3

TYPE	No. of Bulbs Used	Wattage	$Lumen_1$	$Lumen_2$	$Lumen_3$	Mean	SD	Error (+/-)
CFL (ECN - LIYA)	2	18	238	240	240	239.3	1.15	0.66
CFLs of open market	2	20	71	72	75	72.66	2.0	1.2

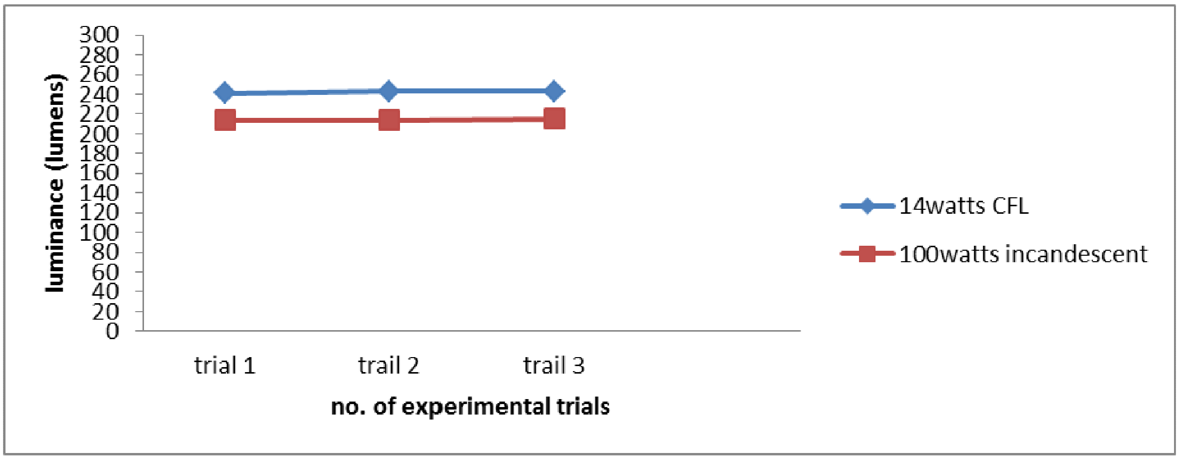

Fig 1: Results of luminance assessments for 14watts CFL and 100watts incandescent bulbs

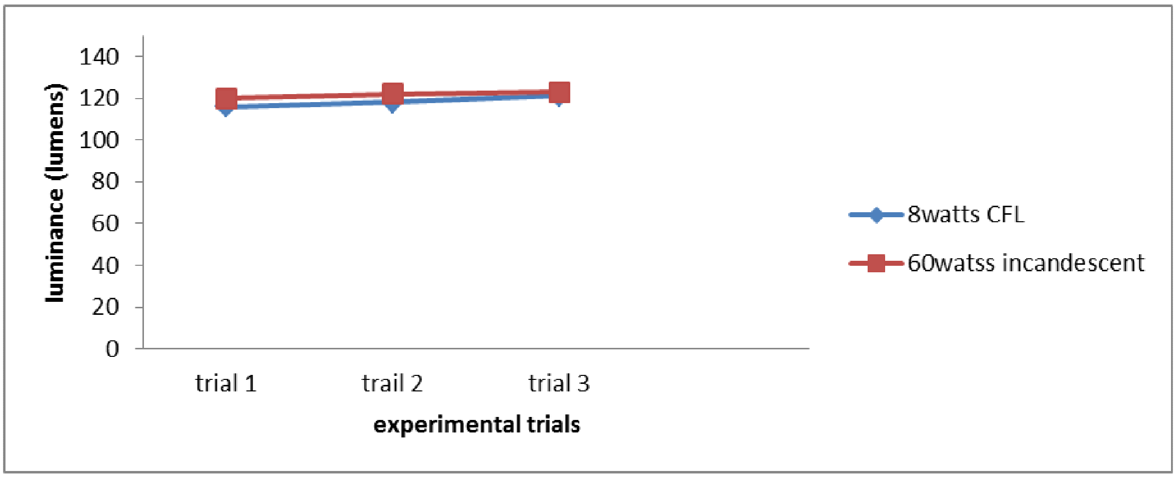

Fig 2: Results of luminance assessments for 8watts CFL and 60watts incandescent bulbs

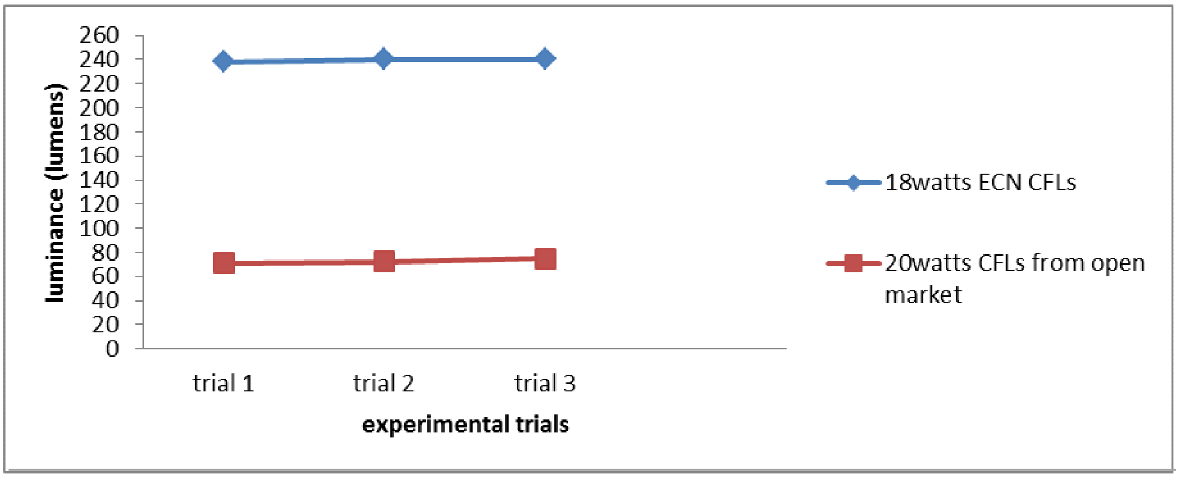

Fig 3: Results of luminance assessments for 18watts ECN CFL and 20watts CFL from open market

In comparing luminance between CFLs from different manufactures, setup 3 and fig: 3 showed that 18 watts CFLs from ECN with a luminance value of 239.3 is far brighter than that produced by "Tungsram" from open market with a value of 72.66 Lumen, even with a difference of 2 watts between both types of CFL.

Setup	Wattage of ECN CFLs	Wattage of open market CFLs	Wattage of incandescent Bulbs	Energy saved in wattage	Cost implication of energy saved (₦)
1	8	-	60	52	11, 513. 52
II	14	-	100	86	18, 954. 83
III	18	20	-	2	5 70. 42

Conclusion

The basic operational make up of incandescent light bulbs is that they produce heat and light with a resistant filament, while compact fluorescent light bulbs produce light by using electrons to produce and control the voltage and current which in turn produces light with very little heat. This report has compared and analysed the luminance of compact fluorescent lamps and incandescent light bulbs and from the results obtained, showed that the compact fluorescent lamps offer better and brighter luminance than incandescent bulbs with little heat given off, and at the same time conserving energy due to their lower wattage values. The study also showed that the high quality Compact Fluorescent Lamps from the ECN/ECOWAS/CUBA are of better quality and offer better luminance (brightness) that those of lesser grade from the Faculty of Engineering, University of Benin. The increased adoption of high-quality, energy-saving CFLs can provide the nation with an important opportunity for mitigating climate change, while also enhancing international collaboration on common clean energy challenges. The high-level political commitments worldwide to phase out incandescent lamps, without adequate planning for production and quality issues, have the makings of a large-scale policy failure. The report recommends that governments and private sector lighting suppliers should develop and implement a viable, national quality control scheme within to avoid losing consumer confidence due to the proliferation of substandard CFL products. Existing international standards and specifications are available. A number of regional and international initiatives addressing CFLs are planned or in place. The challenge is for governments and suppliers to seize the initiative by working together to develop a common, harmonized approach to the problem of CFL quality.

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