Impact of Efficacy Deviation Using Rated Power and Measured Power Characteristics of Energy Efficient Lamps

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ABSTRACT

Clean modern energy is the most desirable standard power measured in Africa particularly Nigeria considering the present power crisis afflicting the nation. Unless the government adopts new technologies and policy interventions that can salvage the nation from economic and environmental degradation and desire to deliver consumer from the hands of the lamps manufacturer who at all time we not state the actual rating of the lamps for profit sake. It will be difficult to have a clean energy. The use of Tungsten Filament incandescent lamps for lighting is energy intensive. It is believed that only about 5% of total energy used by an incandescent bulb is converted to light energy while the remaining 95% is converted to heat energy. This is the reason why it has become necessary for a shift from the use of Tungsten Filament Incandescent lamps to energy efficient ones.In other to achieve this, there has to be a way that a Government regulator would be able to verify the quality of these lamps regarding their efficient use of energy, make comparisons and provide recommendation to the public with evidence backed up by results and as well come to conclusion in coming up with laws that will encourage low consumption rate which will reduce the national consumption rate and allow energy efficiency practice for the housing sector, and all other sectors at large. This has necessitated this research work.

Keywords: Impact, Efficacy Deviatio, Rated Power, Measured Power Characteristics and Energy Efficient Lamps

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1. INTRODUCTION

The electric lamp is one of the everyday conveniences that most affects our lives, was not “invented” in the traditional sense in 1879 by Thomas Alva Edison, although he could be said to have created the first commercially practical incandescent light. He was neither the first nor the only person trying to invent an incandescent light bulb. In fact, some historians claim there were over 20 inventors of incandescent lamps prior to Edison’s version. However, Edison is often credited with the invention because his version was able to outstrip the earlier versions because of a combination of three factors: an effective incandescent material, a higher vacuum than others were able to achieve and a high resistance that made power distribution from a centralized source economically viable. Today, the quest for energy efficient lamps has led to the invention of the compact fluorescent lamps and the light emitting diode lamps

2. LITERATURE REVIEW

Popular in Nigeria today are three types of lamps for general lighting and they are the tungsten filament incandescent lamps, the compact fluorescent lamps (CFLs) and the light emitting diode (LED) lamps. Among these three, the CFLs and the LEDs are the ones that are energy efficient and are known as Self Ballasted Lamps.

2.1. Types of Lamps for General Lighting

2.1.1. Tungsten Filament Lamps

A tungsten light bulb refers generally to incandescent light bulbs, which are lamps that generate light by heating a metal wire or filament with electricity until it becomes white hot and glows. Tungsten filament lamps are named from the metal tungsten, a gray material that has an extremely high melting point. Because of its high melting point and its strength, it makes for a good filament in light bulbs. A filament is a metal wire that glows when electricity is channeled into it. Light bulbs that use this method to generate light with heat are called incandescent lights. Tungsten light bulbs and other incandescent bulbs are often used in photography as an alternative to flash lights because the continuous light given off by tungsten bulbs allow photographers to see shadows cast by light.

2.1.2. Compact fluorescent lamps (CFLs)

The Compact Fluorescent Lamps are designed to replace incandescent lamps. Most types use the same fixtures as the older bulbs and come in similar sizes. Compared to an incandescent bulb offering the same amount of visible light, a CFL model uses only one-fifth to one-third of the electricity and can last from 6,000 hours to 15,000 hours of use. A CFL uses a curved or folded tube and a compact electronic ballast at the base. Moreover, CFLs are available in different color temperatures. Soft white bulbs, or warm bulbs, replicate the yellowish glow of older lamps. White varieties offer cooler light. All high-quality CFLs have a color rendering index (CRI) of 80 or better. Several, but not all, CFL models work with dimmer switches. These are the most common energy saving light bulbs.

2.1.3 Light emitting diode (LED) lamps

LED lamps are light bulbs featuring an assembly of LEDs. They resemble conventional lamps in shape and come with connections for most existing fixtures. These lamps are highly energy-efficient and offer several advantages over CFL lamps. For example, LED bulbs come to full brightness immediately, and their service life is significantly longer at 15,000 to 50,000 hours, depending on quality. They use 75 to 80 per cent less energy than incandescent options. However, they cost more than CFL lamps. Like CFLs, LED lamps come in different color temperatures. Besides bulbs, there are also LED tube lights that fit fluorescent tube light fixtures. These are the most expensive energy saving light bulbs. They are also the most energy efficient and the most durable.

2.2 Characteristics Of Self Ballasted Lamps For General Lighting

The following are characteristics of self-ballasted lamps that are measured:

2.2.1. Rated voltage

The voltage or voltage range marked on the lamp [3].

2.2.2. Rated wattage

The wattage marked on the lamp [3].

2.2.3. Rated Frequency

The frequency marked on the lamp or declared as such by the manufacturer or responsible vendor.

2.2.4. Rated Luminous Flux
The flux marked on the body of the lamp or declared by the manufacturer or responsible vendor

2.2.5. Initial Values
The photometric and electrical characteristics at the end of the 100h ageing period [3].

2.2.6. Life (of individual lamp)
The length of time during which a complete lamp operates to burn-out [3].

2.2.7. Starting time
The time needed, after the supply voltage is switched on, for the lamp to start fully and remain alight [3]. Halogen and LED bulbs, like incandescent light bulbs, light up immediately as soon as you switch them on. CFL bulbs may take some time to come on, and to get up to full brightness, though they have improved since the first CFL bulbs came out. There is a wide range in performance with the fastest bulbs reaching full brightness in around 30 seconds and others taking over 5 minutes.

2.2.8. Run-up time
The time needed, after the supply voltage is switched on, for the lamp to reach 80% of its final luminous flux.

2.2.9. Stabilization time
The burning time of the lamp required to obtain stable operating electrical and photometric characteristics].

2.2.10. Measured Power
It is the actual amount of power that flowed through the bulb.

2.2.11. Efficacy
Based on initial values, it is calculated as the ratio of the luminous flux of the lamp to the consumed power after 100-hour ageing period.

3. RESEARCH METHODOLOGY

Certain critical characteristics of energy efficient lamps can be determined using test equipment. These characteristics include luminous flux, efficacy, power factor, color and torsion e.t.c. In this research, lamp testing facility at the Electrical Electronics Laboratory of Standards Organisation of Nigeria (SON), Lekki was used to test thirty energy efficient lamps. This test facility has the following equipment and components:

1. SPEKTRON Coating Integrating Sphere: It is where the bulb is mounted for the performance test.
2. Digital Power Meter: This is used to take readings on electrical characteristics displayed by the lamp under test (LUT).
3. Digital CC & CV DC power Supply: It is used to supply power to DC lamps, and it is used for calibration of the equipment.
4. HAAS-1200 Accurate Array Spectrometer: It analyses the characteristics of the Bulb and sends the Information to the CPU and other meters.
5. AC Power Supply: It shows the frequency, Voltage, Current, Power and Power factor rating of the Bulb.
6. Rapid Recording Photometer: It shows the Efficacy, Luminous flux of the Bulb.
7. Computer: It shows the comprehensive analysis of all the test parameters fed from the Spectrometer

8. Digital Torque Meter: It is used to determine the mechanical strength of the joint between the lamp shell and the lamp cap.

3.1. Test Samples

For this research, the 30 test samples where used for the test. The lamp caps for the test samples where B22 and E27. The test was carried out under specific test conditions inside a Spektron coating Integrating Sphere at different times.

3.2. Lamp Testing Procedure

For this procedure, we shall limit ourselves to performance test. The Lamp Under Test (LUT) is first placed in a draught – proof chamber at an ambient temperature of (25± 1) °C and a relative humidity of 65% maximum and is switched on in that chamber for 100 hours before carrying out the steps listed below.

Step 1: Put on the mains, then the automatic voltage regulator and uninterruptible power supply allowing at least one minute for stabilization and surge removal.
Step 2: The power supply of the HAASUITE -1200 test facility is put on using the power button.
Step 3: The adjoining meters are also switched on.
Step 4: The whole equipment when switched on is allowed for about 15 minutes to warm up and stabilize.
Step 5: The sample (test-piece) is then removed from the pack and examined physically for defects, loose cap, broken filament (florescent) and broken pin (for Bayonet Caps or B22)
Step 6: When Certified Ok. The sample is mounted in the lamp holder inside the integrating sphere.
Step 7: Having ensured that the sample is properly fitted, the sphere is closed and locked.
Step 8: The lamp is run by pressing the "Output/Reset" button on the AC power supply.
Step 9: The display on the meter shows the flux with adjoining multiple (Sub multiple).
Step 10: The initial photo parameter (color, flux, efficacy) is run on the PC, noted and recorded.
Step 11: The electrical parameters (power, voltage, current, power factor, frequency) are also noted from the Meter and recorded.
Step 12: The initial efficacy (flux/power) lumen/watt is also analyzed and displayed on the computer.
Step 13: The test is run for several other values say up to ten times and the obtained values are noted and recorded.
Step 14: The values recorded is compared with the standard requirements for conformity.
Step 15: The output/reset button on the meter is pressed once to end the test.
Step 16: The sphere is opened and the sample is removed

The following should be noted:

1. The lamp holder in the sphere has no contact resistances or defects that could interfere with the test result (outcome)
2. The integrating sphere has a seal that prevents leakage of light of the smallest luminosity by design.
3. The inside of the sphere is sealed with pure white metal to minimize reasonably absorption of the light output from the test piece

All these to reduce potential errors to the barest minimum.

4. MATHEMATICAL MODEL AND RESULT

The mathematical model for Efficacy (E) and as Power (P) is developed using a curve fitting technique. The method of at least squares is used in this research work to develop the method. This is because it provides the best possible fit of all the data in a certain global sense.

Efficacy, E (in Lumens per watt) is a function of AC Power, P (in watts); that is,

Since the curve to be fitted is a straight line, then for a two-termed case,
Where a and b are constants;

Using curve fitting formula:

$$= \frac{\sum - \sum}{} \quad (3)$$

$$= \frac{\sum . - \sum \sum}{\sum . - \sum \sum} \quad (4)$$

Once a and b are known, then = + can be obtained.

5. RESULTS

Table 1: Table of Values for 30 Samples Tested

S/NO	R (W)	P (W)	E (LM/W)	E*P	P*P	E' (LM/W)
1	26	19.32	58.00	**1120.56**	**373.2624**	58.26448
2	85	44.10	62.00	**2734.2**	**1944.81**	71.78964
3	26	10.83	42.96	**465.2568**	**117.2889**	58.26448
4	20	7.95	39.53	**314.2635**	**63.2025**	56.88904
5	26	24.80	50.89	**1262.072**	**615.04**	58.26448
6	45	46.00	63.70	**2930.2**	**2116**	62.62004
7	20	19.60	55.51	**1087.996**	**384.16**	56.88904
8	85	25.77	49.00	**1262.73**	**664.0929**	71.78964
9	36	10.74	38.08	**408.9792**	**115.3476**	60.55688
10	40	20.61	61.00	**1257.21**	**424.7721**	61.47384
11	85	51.11	63.00	**3219.93**	**2612.232**	71.78964
12	18	15.71	56.00	**879.76**	**246.8041**	56.43056
13	26	23.52	56.00	**1317.12**	**553.1904**	58.26448
14	18	8.59	12.35	**106.0865**	**73.7881**	56.43056
15	36	10.74	38.08	**408.9792**	**115.3476**	60.55688
16	40	24.4	60.00	**1464**	**595.36**	61.47384
17	26	9.55	39.27	**375.0285**	**91.2025**	58.26448
18	20	9.00	38.18	**343.62**	**81**	56.88904
19	40	27.14	58.00	**1574.12**	**736.5796**	61.47384
20	26	9.41	41.77	**393.0557**	**88.5481**	58.26448
21	26	10.52	11.20	**117.824**	**110.6704**	58.26448
22	18	10.97	41.00	**449.77**	**120.3409**	56.43056
23	20	9.06	40.50	**366.93**	**82.0836**	56.88904
24	26	20.99	57.00	**1196.43**	**440.5801**	58.26448
25	85	29.37	40.14	**1178.912**	**862.5969**	71.78964
26	18	10.97	41.00	**449.77**	**120.3409**	56.43056
27	85	28.73	38.60	**1108.978**	**825.4129**	71.78964
28	105	34.96	49.00	**1713.04**	**1222.202**	76.37444
29	24	26.24	65.00	**1705.6**	**688.5376**	57.806
30	20	20.34	60.00	**1220.4**	**413.7156**	56.88904

R:Rated power(Watts); P is measured power (Watts); E is efficacy from measured power(LM/W); E' is expected efficacy from rated power(LM/W).

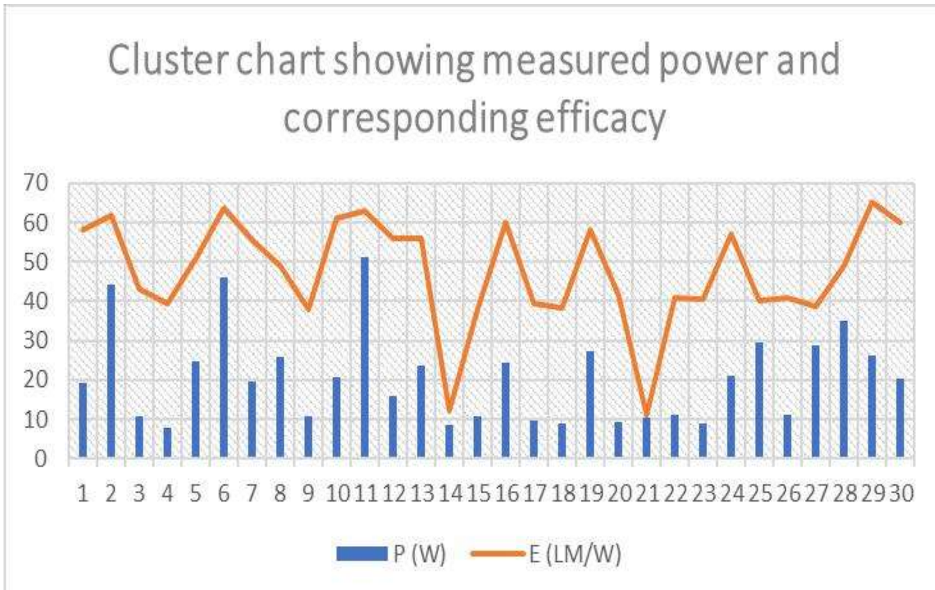

Fig. 3.0: Cluster chart showing measured power and corresponding efficacy

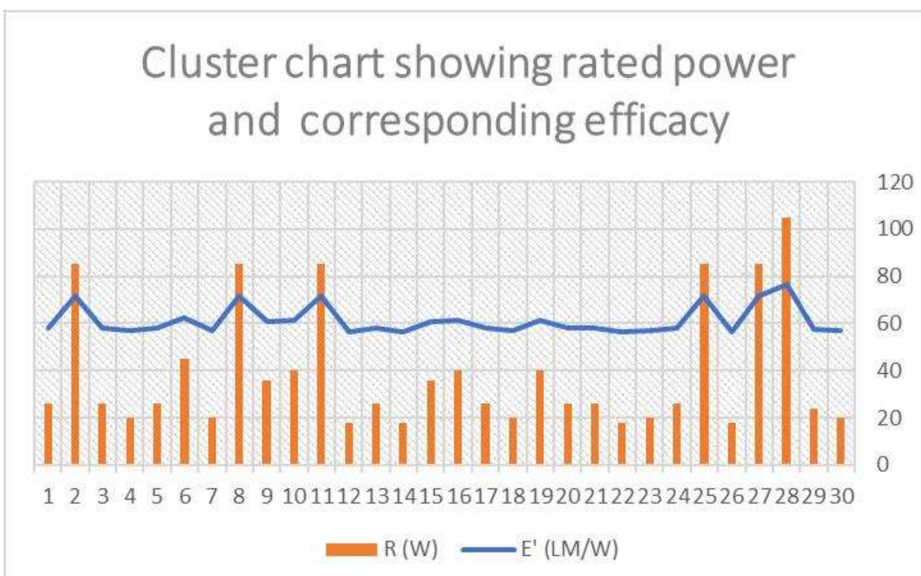

Fig. 3.1: Cluster chart showing rated power and corresponding efficacy

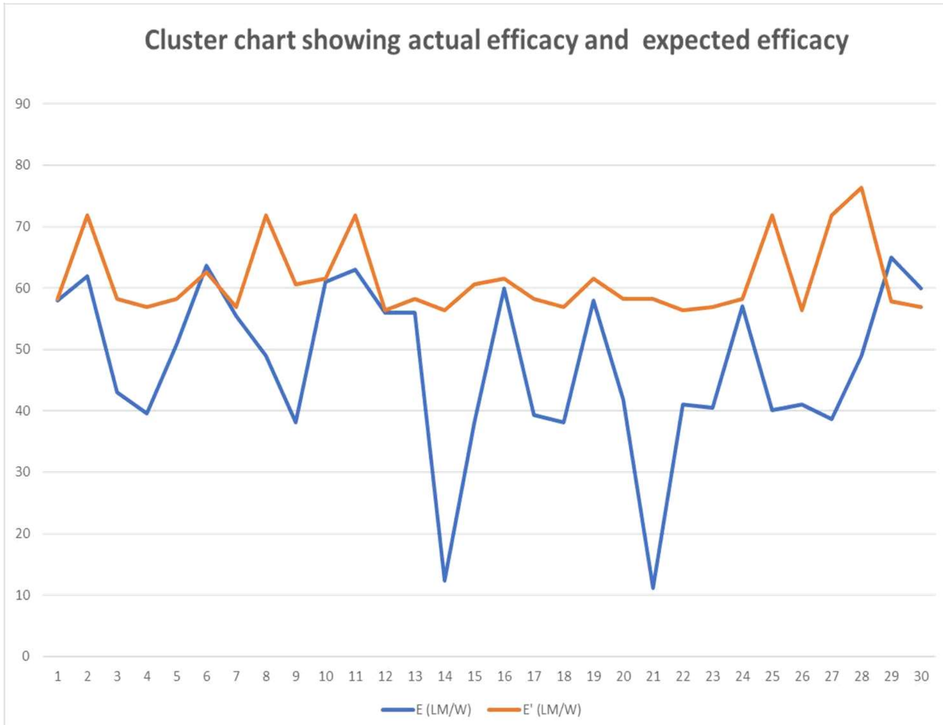

Fig. 3.2. Cluster chart showing actual efficacy and expected efficacy

6. DISCUSSION OF RESULTS

The table above shows the results of tests carried out on 30 samples of energy efficient lamps. The rated power R (as stated by the manufacturer), the measured power P, and the corresponding efficacy results are presented. In fig. 3.0, the measured power and corresponding efficacy are also presented while in fig. 3.1, the rated power and expected efficacy are presented. Fig. 3.2 compares the measured efficacy and the expected efficacy. There is a clear difference between the expected efficacy and the measured efficacy. The expected efficacy would have been obtained from tests if the rated power declared by the manufacturer was equal to the measured power, this in turn would have pushed about 60% of the samples into the pass or success zone of minimum of 60lm/W efficacy as specified by NIS 747 standard.

7. RECOMMENDATION AND CONCLUSION

This work has presented comparative analysis of efficacy on measured power and rated power of energy efficient lamps.The results obtained shows that the success rate in terms of Efficacy can improve if manufacturers specify rated power that is close to power measurements obtained from tests as this will reduce retail cost ensuring that customers get real value for money.

7.1 RECOMMENDATION

In order to achieve the above conclusion, I hereby recommend that:

1. There be massive awareness on the part of Customers as to what they are buying.
2. A sensitization workshop should be organized for manufacturers to enable them get it right.
3. All bulbs should be recycled rather than disposed of in the general waste. CFL bulbs in particular need to be treated carefully as they contain mercury, which could be dangerous.
4. Many manufacturers give a 'watts equivalent' figure on their packaging to indicate the brightness level. However, all packaging should now give brightness in lumens.

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