Utilization of busted CFL in developing cheap and efficient segmented compact LED bulbs

N S Andres$^1$ and R T Ponce$^1$

$^1$Electrical Engineering Department, Bataan Peninsula State University, 2100, Balanga City Bataan, Philippines

Abstract. Today’s generation will not survive a day without the help of lighting. In fact, someone’s productivity, particularly at night, depends on the presence of a good lighting and it seems that it is a daily necessity. Lighting takes a large part on the consumption of household electrical energy particularly in the Philippines. There are different type of lighting bulbs used at home can affect the overall lighting consumption. Nowadays, most commonly and widely used bulb in the household is the Compact Fluorescent Light (CFL). However, the main problem of CFL is the mercury they contain. In addition to this is the harmful effect of mercury such as Emission of UV Radiation. In response to the said problem, this project study gives solution to the problem of the society concerning environment, health and safety as well energy conservation, by developing a segmented compact light-emitting diode (SCLED) bulb from busted CFL that are efficient, economical, and does not contain toxic chemicals.

1. Introduction

Based on the results of the 2011 Household Energy Consumption Survey (HECS), electricity remains as the most common source of energy used by households particularly in the Philippines. About 87 percent of 21.0 million households used electricity from March to August 2011. As of 2016, the demand for electricity in the residential is leading among the different sectors. It is often grouped depending on its uses that are distributed for heating and cooling, lighting, operating appliances etc [1].

![Figure 1. January- June 2016 Philippine power demand](image)

Now that the world is in the age where lighting seems to be a daily necessity, typical homes as shown in figure 1, consume nearly 27 percent of the energy used today: making lighting as the major source of electricity consumption. Lighting plays a large part on the consumption of household electrical energy; it consumes about 18% of the total generated electricity of total energy consumption in residential sectors as shown in figure 2 [2].
One of the main factors in lighting energy consumption is the light bulb. The use of correct and appropriate type of light bulb improves the efficiency of energy usage. There are three general types of lighting that are widely used in the household nowadays: the (light-emitting diode) LED bulb, (compact fluorescent light) CFL bulb and the incandescent bulb. But each of them has their perks and perils [3]. Unfortunately, most of the time, people in the residential end up choosing a lamp based on it is price rather than its efficiency and this cause us to pay for our lighting more than necessary.

Today, CFLs are the most used lighting sources in the household. Using CFLs will allow people to decrease their energy consumption; also it is a good start to decrease greenhouse emissions. However, the main problem of CFLs is the mercury they contain. When products and wastes containing mercury are improperly disposed of, mercury is released into the air, ground or water. It is persistent in the environment; it never breaks down nor goes away.

In addition to the harmful effects of mercury is that it emits Ultraviolet (UV) Radiation. This UV radiation interacts with the chemicals on the inside of the bulb to generate light. The acute and chronic effects are the normal responses of the skin to UVR; acute reactions considered will be erythema (sunburn) and vitamin D production. Skin aging and skin cancer will be discussed as those reactions produced by prolonged or repeated UVR exposure [4].

In response to the aforementioned situation where the three types of lights are compared by their efficiency and effectiveness as light sources, the proponents conducted this study. Since the CFLs are the most commonly used light bulbs in the residential and has a great compatibility to LED in terms of design and materials, the proponents conducted a study about innovating and recycling CFL into a more efficient and environment friendly LED light bulb.

2. Materials and methodology
The following materials and methods were used in this study.

2.1. Investigation phase
Data about present average usage and disposal of CFL shall be gathered. The researchers chose CFL to use and recycle because of its still huge volume of sales [5] and great compatibility to LED case. Data and specifications of LEDs and CFLs should also be collected and recorded for future reference of test and comparisons.

2.2. Design phase
The proponents have developed a circuit and designed the layout for the power supply of the SCLED light bulb adapted from the different components recycled or salvage from the busted CFL. Figure 3 shows the developed PCB layout for the power supply. The proponents also designed the layout for the LED strips as shown in figure 4.
Figure 3. Printed circuit board (PCB) layout for power supply

Figure 4. PCB layout for LED strips

Figure 5. Schematic diagram
Figure 5 shows the schematic diagram of the circuit used and applied by the proponents in developing the SCLED bulb. The values and components are based on the availability in the busted CFL and the circuitry composition of LED lamps. The circuit values and components may vary because of the different circuitry and components used by different bulb manufacturers. The circuit flow and design for SCLED remains the same.

2.3. Construction phase
This part includes the actual design and position of power supply, the design and construction of the case of prototype, and the actual fabrication of the prototype. Figure 6 demonstrates the step by step procedure in constructing the prototype; from gathering the materials and recycling to fixing the parts and finalizing the prototype.

2.4. Testing using light meter
Light meter is an instrument used to measure illuminance. The measurements were recorded from one-meter vertical distance and one-meter horizontal distance. The researchers recorded and tabulated the data and measurements every hour for a whole day. The researchers also measured the illuminance of the bulbs from one-meter distance with the light bulbs being closed and open again every 5 minutes in a one-hour continuous operation.

2.5. Testing using infrared thermometer
Infrared thermometer is a device used to measure the temperature of a certain area using infrared. The researchers recorded and tabulated the data and measurements every one hour for a whole day. The data and measurements were compared in natural room temperature and the actual room temperature.

3. Results and discussion

3.1. Illumination tests

![Figure 7](image1)

**Figure 7.** Lux measurement from one meter direct vertical distance

![Figure 8](image2)

**Figure 8.** Lux measurement from one meter direct horizontal distance

Figure 7 shows the data gathered using a lux meter to measure the illuminance of SCLED versus the
illuminance of a commercial LED and CFL in a 24-hour operation. It is measured every hour from directly one meter below the light source. The data gathered using lux meter from one meter horizontal distance shows a great difference between SCLED and CFL as depicted in figure 8.

![Figure 8](image1.png)

**Figure 8.** Lux measurement from one meter direct horizontal distance

Figure 9 illustrates the data gathered using a lux meter to measure the consistency of the illuminance of SCLED versus the illuminance of a commercial LED and CFL in a one-hour operation. The light is switched on and off every five minutes then measured the illuminance using the lux meter.

**3.2. Temperature test**

![Figure 9](image2.png)

**Figure 9.** Lux measurement from one meter direct horizontal distance

Operating temperature as one of the factors affecting the quality of light bulbs was also observed in
this study. Figure 10 shows the temperature curve of SCLED versus the commercial LED and CFL. The data were recorded every hour for a whole day continuous operation.

3.3. Energy consumption test

![Figure 11. Current measurement](image)

Figure 11 depicts the current drawn by the prototype in a 230V, 60Hz line. It is recorded every five minutes in a one-hour continuous operation.

3.4. Data Analysis and Computation

\[ I_{\text{ave}} = \frac{\sum \text{current measurements}}{\text{total number of test points}} \quad (1) \]

\[ I_{\text{ave}} = \frac{2(21.7 \text{mA})+8(21.8 \text{mA})+3(21.9 \text{mA})}{13} = 21.8077 \text{ mA} \]

\[ P = VI \]

\[ P = (230 \text{V})(21.8077 \text{ mA}) = 5.01577 \text{ watts} \sim 5 \text{ watts} \]

| Table 1. Prototype savings vs. CFL |
|-------------------------------------|
|                                  | SCLED                     | CFL                     |
| Life Span                        | Approx. 25,000 -50,000 hours | 2,000-8,000 hours |
| Wattage                          | 5 watts                   | 15 watts                |
| Electric Rate                    | 8php/kwh                  | 8php/kwh                |
| Operating hours                  | 10 hours/day              | 10 hours/day            |
| Charge per day                   | 0.4php                    | 1.2php                  |
| Charge per month                 | 12php                     | 36php                   |
| Charge per year                  | 146php                    | 438php                  |
| Yearly Savings                   | 292php                    |                         |
The prototype is observed to be much more economical than the commercial CFL. Table 1 shows the advantages as well as the computed yearly savings in using the prototype compared to the commercial CFL. Considering the life span of the light bulbs, the prototype is at least three times as much as durable as the commercial CFL. Using same electric rate and number of hours operated in a day, the data were computed and noticed to have a great difference in terms of operating cost per year.

4. Conclusion
SCLEDs have a lot of advantages compared to CFL, incandescent and other lighting lamps in residential and other applications. The power consumption is lower than other bulbs, therefore allowing customers to pay little amount of money in lighting energy consumption. It has longer life span compared to others, thus, making it more economical in the long run. It has a segmented feature that makes it more economical. If the LED strips are damaged, you can easily remove it from the SCLED case and replace it with new one without changing the other parts. Same thing will be done if other parts of the SCLED are damaged; user does not need to replace the whole bulb, instead, just replace the damaged part. SCLED is composed of parts and components from busted CFL, making it cheaper compared to the commercial LED. On the other hand, commercial CFLs may be cheaper or almost at the same price. However, the power consumption throughout is lower compared to those CFLs. To sum it up, in the long run, SCLED is cheaper and has a higher efficiency. It can contribute to the aspect of power consumption in the whole world scenario. This project has proven that LED bulb can be made out of recycled CFL. It only uses recycled components and plastic casing from the busted CFLs that can contribute in the reduction of waste materials. In addition, SCLEDs do not contain harmful chemicals such as mercury that can pollute the environment.

5. Acknowledgment
Our grateful appreciation to Dr. Gregorio J. Rodis, the University President, for granting us the opportunity to work on this study and for his endless quest to enrich research culture in the university especially among the faculty members of BPSU. The study would not be completed without the help of BSEE-5 students especially those who helped in the construction of the prototype. Thank you to, Renee Jane San Pedro-Ponce, the proofreader, and Altroye Manlangit, Jon Francis Pagador, Mark Anthony Mayuyo, Mia Sharifa Mesina, and Monalie Pujante for aiding the proponents in carrying out this study. Most of all, we express our heartfelt gratitude to Almighty God for His unwavering goodness, guidance and wisdom that He had provided throughout this research.

6. References
[1] Philippine Statistic Authority (2013) Energy is the most common source of energy used by households.
[2] Gallachoir B, O'Leary F and Howley M (2008) Energy in the Residential Sector.
[3] Francisco K B (2015) Difference between Incandescent, Compact Fluorescent Light and LED.
[4] Havas M (2008) Health Concerns associated with Energy Efficient Lighting and their Electromagnetic Emissions
[5] Berkeley L (2011) Energy-Efficient Compact Fluorescent Table Lamp