

Design of a low-cost lighting system for the rural areas of Bangladesh

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Abstract—This study was conducted to find a solution to solve the problem of deprivation of light present in the rural society of Bangladesh. More than 50percent of our rural population are deprived of electricity. This in turns results in absence of light in houses. A device was designed using bottles, Light Emitting Diode, solar panel and battery for an alternative lighting system. This device is not so costly and can be reproduced very easily. Different variations of this device was tested using a light meter (Model-LX 1102). A brief overview of this newly proposed lighting system is discussed in the study.

Keywords—Light Emitting Diode; Solar energy; Rural society; Lighting;

I. INTRODUCTION

Bangladesh has a largely growing population and economic growth in South Asian subcontinent. There is a serious demand-supply gap of electricity in our country. Affordable energy for all has always been out of reach. Even today, Bangladesh is unable to provide ample production of energy. Meeting with the demand and supply of energy has been a hefty task for any government. The lighting is not taken seriously in many industrial countries and many developing countries. So, many don't even fathom passing their nights without proper lighting at flick of a switch. About 40% of the people in rural areas had access to the electricity in 2010[1]. Solar energy can be used to alleviate this problem. However, the usage of solar panel has its own demerits. The panel alone costs about 60Taka per watt capacity. Also the efficiency of locally available solar panels in Bangladesh is about 40 to 60 percent. Hence, even for the need of small amount of solar energy, installation becomes a problem. Thus, our research aims to decrease the load of energy necessary for lighting a household by designing an alternative lighting system.

Bangladesh is bestowed with plentiful supply of renewable energy sources. Bangladesh receives average daily solar radiation of 4-6.5 KWh/m² [2]. The average bright sunshine duration in Bangladesh in the dry season is about 7.6 hours a day and in the monsoon season it is about 4.6

hours [3]. Thus a system using LED, Photovoltaic cell and the refractory property of water, an alternative lighting system was designed. Using a light meter (Model- LX-1102) the light density at various distances were measured. Although the system generates a small amount of light, we hope to dramatically affect the lives of rural families who live with the deprivation of light [4].

II. EXPERIMENTAL MODEL

Nine soda bottles (clear, plastic, 3 two liter bottles, 3 one liter bottles, 3 half liter bottles) were cleaned with cold water. The outside of the bottle were wiped. Then the bottles were filled with water. An amount 15grams of bleach were added to each bottle for sterilizing the water. These 15 grams of bleach were added not only to sterilize the bottles but also so that algae doesn't form within the bottle over the passage of time. The formation of algae would hinder the proper refraction of light from the bottle.

A standard nail and hammer was used to make a hole into the cap of the bottle. Then three sets of following LED were prepared: one 1W LED, two 1W LED and four 0.25W LED lights. The LED's were immersed into the water and the wire was brought out by the hole made before. The side of the hole were insulated using locally available adhesive. The prototypes were connected to a 3.6V 5000mA-h battery which was charged using a 5W solar panel. A switch was inserted within the circuit to control the light.

The light was measured using a light meter (Model- LX-1102) at various distances. All of the lights in the area or in surrounding area were turned off. The switch to control the LED turned on and the amount of Lux indicated on the light meter was recorded. Each design were tested for the comparison of data and the improvement of design.

III. ARRAY DESIGN

In this study, the bottles can be arranged in a series connected grid. In this case the power necessary will be supplied by the use of a solar panel. The minimum capacity of the battery will need to be determined using the following

equation:

$$\text{Capacity} = \frac{p * t}{v} * 1000 \quad (1)$$

Where, p = Total power necessary for the array (Watt)

t = Time duration for giving light (Hour)

v = Voltage difference of the LED (Volt)

By calculating the total power and battery capacity, we can determine the necessary solar panel for our project. Power produced by any solar panel per day can be determined by the following equation:

$$\text{Minimum power of solar panel} = \frac{T * R}{1000} \quad (2)$$

Where, T = Average sunshine time (Hour)

R = Panel rating (Watt)

IV. RESULT

From the experiment, the light intensities regarding various distances were collected and stored for different designs. For this different sizes of bottles were used. These are shown as follows.

TABLE I. MEASUREMENT OF LIGHT INTENSITY WITHOUT BOTTLE

Distance (m)	Measured light without bottle for various sources (Lux)		
	One 1W LED	Two 1W LED	Four 0.25W LED
0.2	102.4	144	134.97
0.5	24.42	29.68	27.37
1.0	6.55	8.47	8.66
1.5	2.97	4.03	4.1
2.0	1.53	2.41	2.4

The light intensity of various LED for various vertical distances are shown in table 1. From Table 1, it can be observed that with the increase of distances from the bottle, the intensity of light drops.

The light density in flux at different vertical distances are shown one 1W LED configuration is shown in figure 1. According to figure 1, for 0.2m away from the bottle, the measured light intensity is 138.5, 48.3 and 32 Lux for the bottles of 0.5L, 1L and 2L respectively. And for 2m away from the bottle, the measured light intensity is 3.68, 0.33 and 0.98 Lux for the bottles of 0.5L, 1L and 2L respectively.

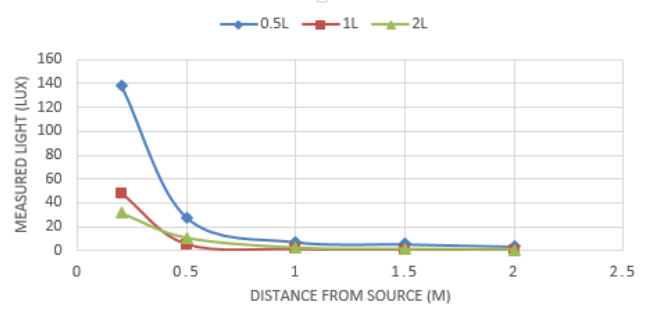


Fig.1 Measurement of light intensity for one 1W LED

The light density in flux at different vertical distances are shown two 1W LED configuration is shown in figure 2. According to figure 2, for 0.2m away from the bottle, the measured light intensity is 115.8, 60.88 and 55 Lux for the bottles of 0.5L, 1L and 2L respectively. And for 0.2m away from the bottle, the measured light intensity is 1.90, 0.68 and 0.62 Lux for the bottles of 0.5L, 1L and 2L respectively.

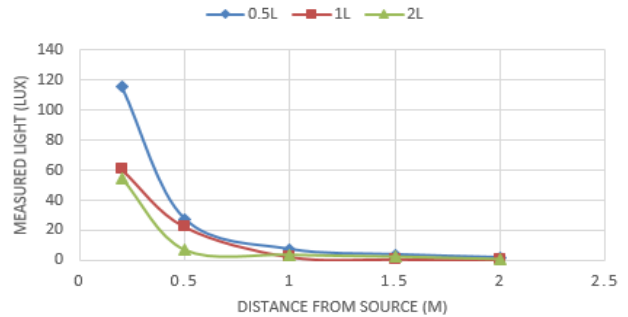


Fig.2 Measurement of light intensity for two 1W LED

The light density in flux at different vertical distances are shown four 0.25W LED configuration is shown in figure 3. According to figure 3, for 0.2m away from the bottle, the measured light intensity is 119.30, 58.85 and 46.5 Lux for the bottles of 0.5L, 1L and 2L respectively. And for 2m away from the bottle, the measured light intensity is 0.39, 0.36 and 0.22 Lux for the bottles of 0.5L, 1L and 2L respectively.

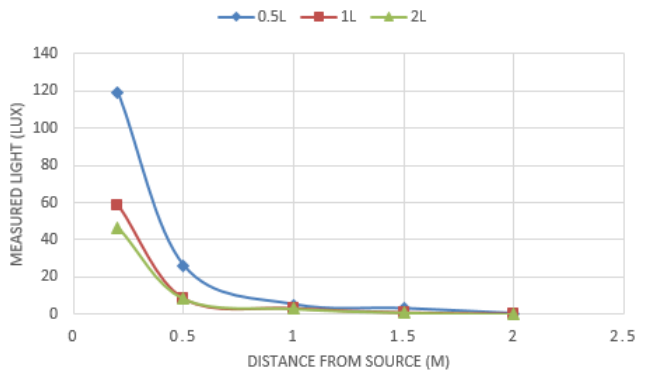


Fig.3 Measurement of light intensity for four 0.25W LED

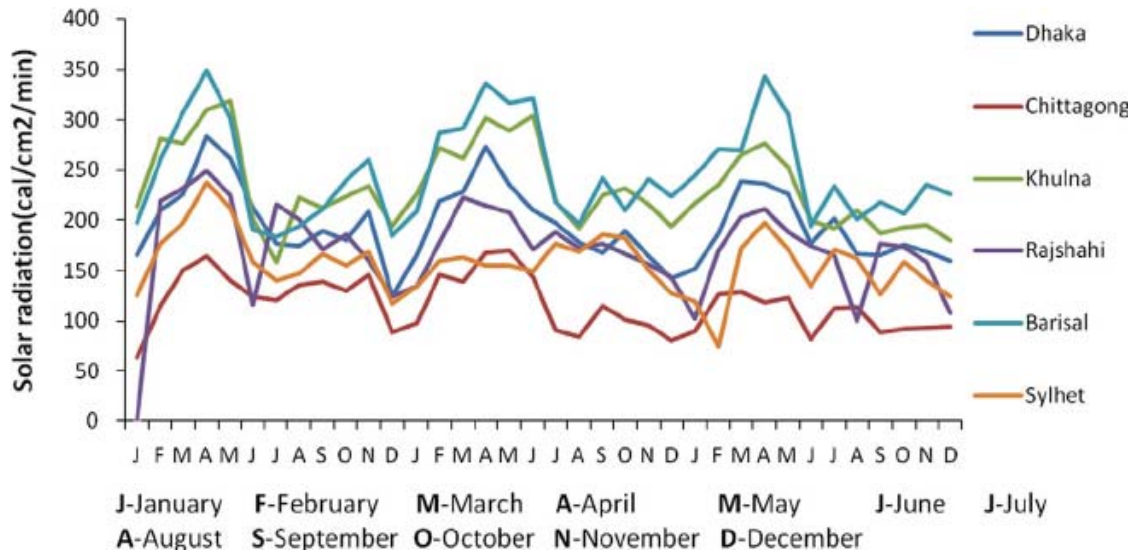


Fig.4 Solar radiation in various districts of Bangladesh [6]

The light density in flux at different vertical distances are shown above for four 0.25W LED. It can be seen that without bottle the measured lux amount is higher than with the bottle.

TABLE II. MEASUREMENT OF RADIAL DISTANCE FOR DIFFERENT LIGHT AND BOTTLE CONFIGURATION

Light Source	Measured highest distance for various bottles (cm)		
	0.5L	1L	2L
1W(1)	305	378	430
1W(2)	221	248	270
0.25W(4)	183	190	213

For different configuration of LED and bottles, the highest radial distance where the lux meter showed the value of 0.1Lux, was determined. From figure 1, 2 and 3, it can be determined that the intensity of light decreases with the increase of distance. It suggests that the bigger the bottle, the more area will be illuminated.

V. ANALYSIS

The sun emits at a rate of 3.8×10^{23} KW per second and the solar radiation reaching the earth surface in a year is approximate to 3400000EJ (Exa-Joule) which is 7500 times worlds total annual primary energy consumption of 450EJ.[5] Bangladesh is endowed with plentiful supply of renewable source of energy. The average solar radiation in different parts of the country is shown in figure 4.

We have experimented nine different variation of light sources. From the data we can see that due to light diffraction, the intensity of light reduces for same distance. However, the energy of light is dissipated radially. As seen from the results, the use of smaller bottle and one high-powered LED can give the best solution to our problem.

VI. CONCLUSION

More than 50% of the rural areas of Bangladesh are not connected to the national electricity grid. Their lives almost come to a standstill after sunset due to lack of energy. Our paper stands to use the abundant resources of solar energy of Bangladesh for illuminating the rural areas. This may not seem much, in the sense that much light intensity is not generated. But we hope that this would provide a significant change in the lifestyle of people where the electricity is yet to reach. To alleviate the problem of lighting, we have devised a system for the illumination of rural areas of Bangladesh. For our design, not much investment is necessary as parts used in our device comes from re-usable products. It can also be easily replaced. For our study, we suggest this system to be implemented in a medium scale. However, further research is required to optimize among costs, power and light intensity of the developed system.

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