Replacing Common Household Lighting with Fiber Optics

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Abstract

The main purpose of this project is to find a more environmentally friendly lighting source for houses and office buildings. To do this an environmentally friendly light source will be combined with fiber-optics to create optimum lighting. In order to determine which lighting source will be the brightest, most eco-friendly light, a lux test was done. Through testing results, a solar collector was shown to be energy efficient in the amount of lux that it was able to put into the fiber-optics. This project will have to be expanded to accommodate the need for lighting when the sun is not available.

Category: Engineering

Introduction

To be able to change the way a home or building is lit, the first thing to understand is light and its properties. According to the Merriam-Webster Dictionary light is, “1 noun a: something that makes vision possible,” or another way to put it would be “Light is all we really see.” (Freudenrich, 2000. How Light Works)

Light has two ways of traveling. Light can travel in waves or in particles known as photons. Since the time of the ancient Greeks, light was thought to have traveled in particles until the late 1600’s when Christian Huygens proposed a new theory of light traveling in waves. Later, in 1807, showing the effects of light passing through a small opening, spreading out, and interfering with light passing through another opening, Thomas Young backed Huygen’s theory. Many physicists today believe that light travels as both a wave and particle. One thing to remember is that both theories are a simple explanation for something deeper and more complex. (Freudenrich, 2000. How Light Works)

To understand how being able to “see” the colors and fascinating things in this world happens having knowledge of light frequencies is beneficial. Light frequency is the number of waves that pass through a given point in space during the duration of one second. This is important to know because the light people are able to see is in a range of “430 trillion Hz, light waves per second seen in the color red, to 750 trillion Hz seen in the color violet.” (Freudenrich, 2000. How Light Works) This range of the light waves that are visible to people is one small window of light compared to the other types of light that people cannot see.

Having a basic knowledge of light and how light works, in simple terms, comes into play in trying to create a lighting method that is pleasing to the people purchasing the product. There have been studies, such as the Department of Psychiatry at The University of North Carolina’s

study of the efficacy of light therapy in the treatment of mood disorders that have shown that light can affect people's moods. So being able to create a lighting source that not only creates light but reflects people's moods may become useful. (Psychiastry. 2005)

The actual lighting of the room is the next big topic of interest. Obviously fiber optics are going to be involved, but what is going to light the fiber optics? There are two more eco-friendly options that should be considered. The first lighting source is the sun. The pros of using the sun are that it is a natural resource, natural lighting has been proven to affect people's moods in a positive way, and more than likely it will not ever run out. Some of the cons would be that a device has to be made to collect the light, on a cloudy day the light will not be able to be collected, and the light from the sun cannot be accessed at night. The alternative eco-friendly lighting sources are L.E.D's, light emitting diodes. Some pros to L.E.D's are that they run on less electricity that a common household light bulb, they last longer than light bulbs, and they can be used during the night after the sun has gone down. The cons to L.E.D's are that they are normally soldered into the rest of the circuit, they are slightly more expensive than light bulbs, and they are extremely picky and use only an exact amount of electricity. The one last option is a combination of both the sun and the L.E.D's which may be even more eco-friendly than using just one type of lighting source.

A fiber optic is a thin glass fiber that is able to transmit light far distances. The advantage of using fiber optics to light a house is that being so thin, the fibers are flexible and can be altered to direct light to a certain area. If a home is being lit with fiber optics the laws and properties of how they work will be a good thing to know. As stated earlier, fiber optics are thin pieces of glass. Now here thin means that it is as thin as a human hair, which is pretty thin. They do come in a few different diameters including 3mm, 2mm, 1mm, 0.75 mm, 0.50mm, and the

width of the diameter continues to get smaller from there. Each one of these different sizes of fiber can transmit a certain amount of light. Within these sizes are different types of fibers as well. There are single mode fibers and there are multimode fibers. Single mode fibers are fibers that have only one mode of transmission, single line of data or light, per fiber. Multimode fibers allow many modes of transmission per fiber optic. (ARC Electronics. Fiber Optics) To figure out which mode will transmit the most light, testing will have to be done.

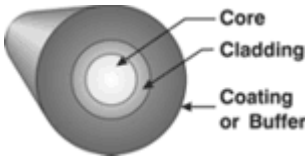


Figure 1

Fiber optics are made up of two main parts, the core and the cladding. The core is the interior of the fiber in which the light is transmitted. The cladding surrounds the core and has reflective properties so that the light stays in the core and is not lost. Also shown in Figure 1 is a coating or buffer; this contains the cladding and the core on some types of fiber optics, so that the fiber optic does not get damaged. The light enters one side of the fiber optic and is reflected back and forth through the core until it comes out the other end. (Alwayn, 2004)

Using fiber optics to transport the light from the light source to the room that is being lit will be more energy efficient than using copper because copper wiring loses electrons over distances and is not as flexible. When using fiber optics, the fibers are flexible enough to go where most copper wires cannot. Plus it takes a greater distance for fiber optic to start losing light through the fiber itself.

With more people in this world trying to go green, this is a great way for those people to be able to help out the environment. Since fiber optics and L.E.D's last for long periods of time and hardly ever need to be replaced, less waste from common household lighting would not end up in the landfills. Also, it takes much less energy to power an L.E.D than it does to light a light bulb, which means that less fossil fuels will be wasted trying to light common electrical lighting

systems. The big pay off of adding this possible new system of lighting into a home is that over the long run the homeowner who owns the system will wind up paying less compared to common household electrical systems. This is possible because the fiber optics and L.E.D's, though more expensive to install, will not have to be maintained as much and do not use anything close to the amount of energy used by conventional lighting. (Using fiber optics as the main source of lighting, over an extended period of time will leave homeowner with more money in their pocket.)

Engineering Goal

Is there a way to create a cleaner, more environmentally friendly lighting source for homes besides the common household light bulb?

Engineering Statement

In order to replace common household lighting, a new lighting source is needed to be used in a more efficient manner. Combining fiber optics with another, more eco-friendly lighting source is one way to replace the conventional way of lighting a home.

Methods

In order to determine which light source to use, a lux test will be done. First, make a box and paint the interior black. Then, make a hole, five mm in diameter, in the back wall of the box. Now, insert the L.E.D. in the hole. Connect a power source, and using a lux meter, record the lux count for the next thirty minutes. Record the data. After recording the data, take out the L.E.D. and replace it with an incandescent light bulb. Connect it to a power source and record the lux count for the next thirty minutes. Record the data. Next, record the lux count of a room that is lit with natural lighting for thirty minutes. Record the data. After that, record the lux count from direct sunlight for thirty minutes. Record the data. Last, make a light catcher out of a flashlight mirror and run fiber-optics from the hole, to the box made earlier. Record the lux count for thirty minutes. Record the data. After recording all the data, find the light source with the lux on average. This will be your light source that you will use to figure out how to light a building.

Data

Chart 1

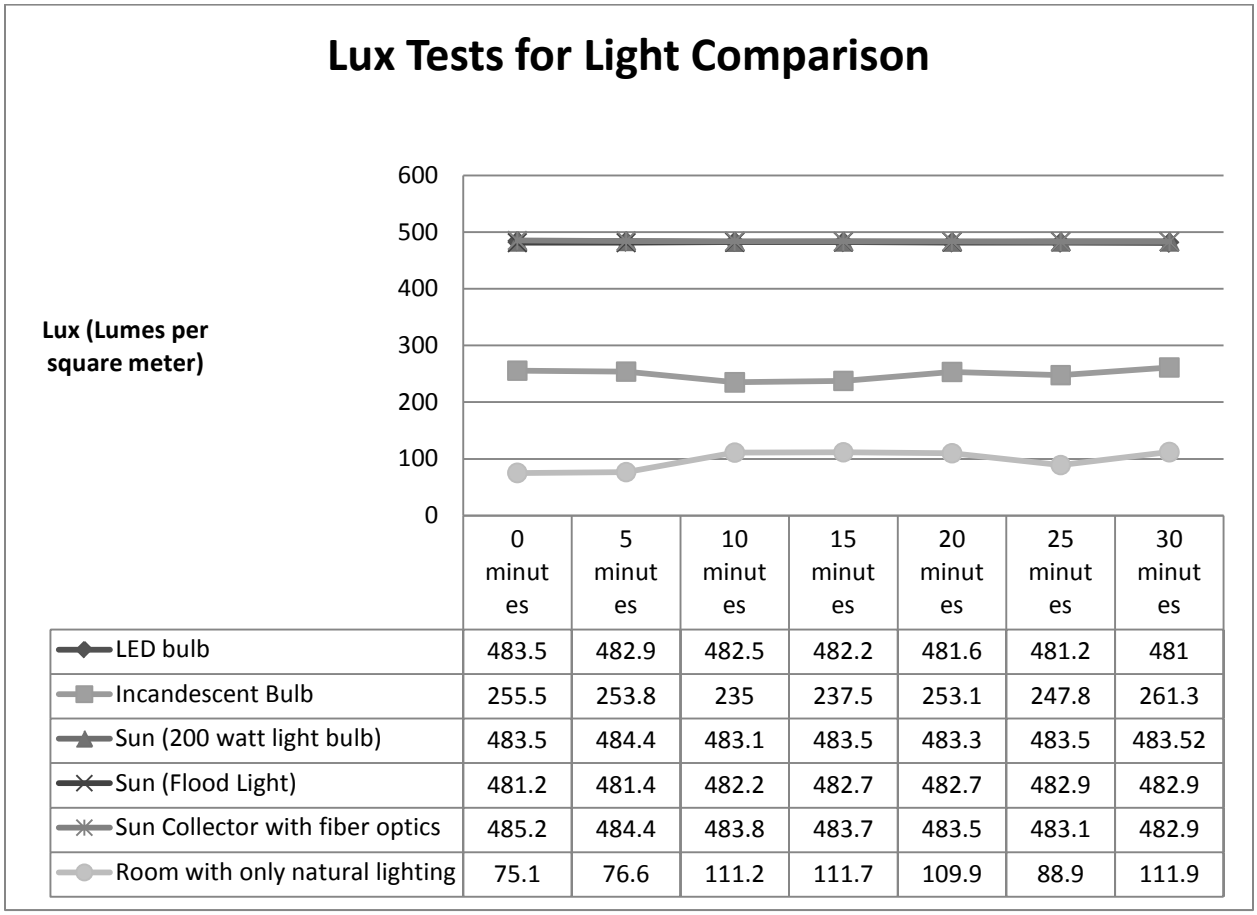
Comparison Between L.E.D's, Incandescent, and Compact Fluorescent Lighting			
	Incandecent Light	C.F. Light	L.E.D. Light
Lifespan of Light Source on Average(hours)	1,200	9,000	50,000
Watts of Electricity Used (equivalent to 60 watt bulb)	60 watts	13-15watts	6 - 8 watts
Kilo-watts of Electricity used (30 Incandescent Bulbs per year equivalent)	3,285	767	329
Annual Operating Cost (30 Incandescent Bulbs per year equivalent)	$ 328.59	$ 76.65	$ 32.85
Cost of Bulb (average)	$ 1.25	$ 3.63	$ 4.95 - $ 59.95
Total Cost for Bulbs per Year plus Cost of Electricity (30 Incandescent Bulbs per year equivalent)	$ 366.09	$ 185.20	$ 181.35 - $ 1,831.35
Savings per household per Year	$ -	$ 180.89	$ 184.74 - $ -1,465.26
Taken From:			
Comparison Chart LED Lights vs. Incandescent Light Bulbs vs. CFLs			
http://www.designrecycleinc.com/led%20comp%20chart.html			

Chart 2

Lux Tests for Light Comparison Lux (lumens per square meter)							
	0 minutes	5 minutes	10 minutes	15 minutes	20 minutes	25 minutes	30 minutes
LED bulb	483.5	482.9	482.5	482.2	481.6	481.2	481
Incandescent Bulb	255.5	253.8	235	237.5	253.1	247.8	261.3
Sun (200 watt light bulb)	483.5	484.4	483.1	483.5	483.3	483.5	483.52
Sun (Flood Light)	481.2	481.4	482.2	482.7	482.7	482.9	482.9
Sun Collector with fiber optics	485.2	484.4	483.8	483.7	483.5	483.1	482.9
Room with only natural lighting	75.1	76.6	111.2	111.7	109.9	88.9	111.9

	Mean	Median
LED bulb	482.1	482.2
Incandescent Bulb	249.1	253.1
Sun (200 watt light bulb)	483.5	483.5
Sun (Flood Light)	482.3	482.7
Sun Collector with fiber optics	483.8	483.7
Room with only natural lighting	97.9	109.9

Graph 1



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Graph 2

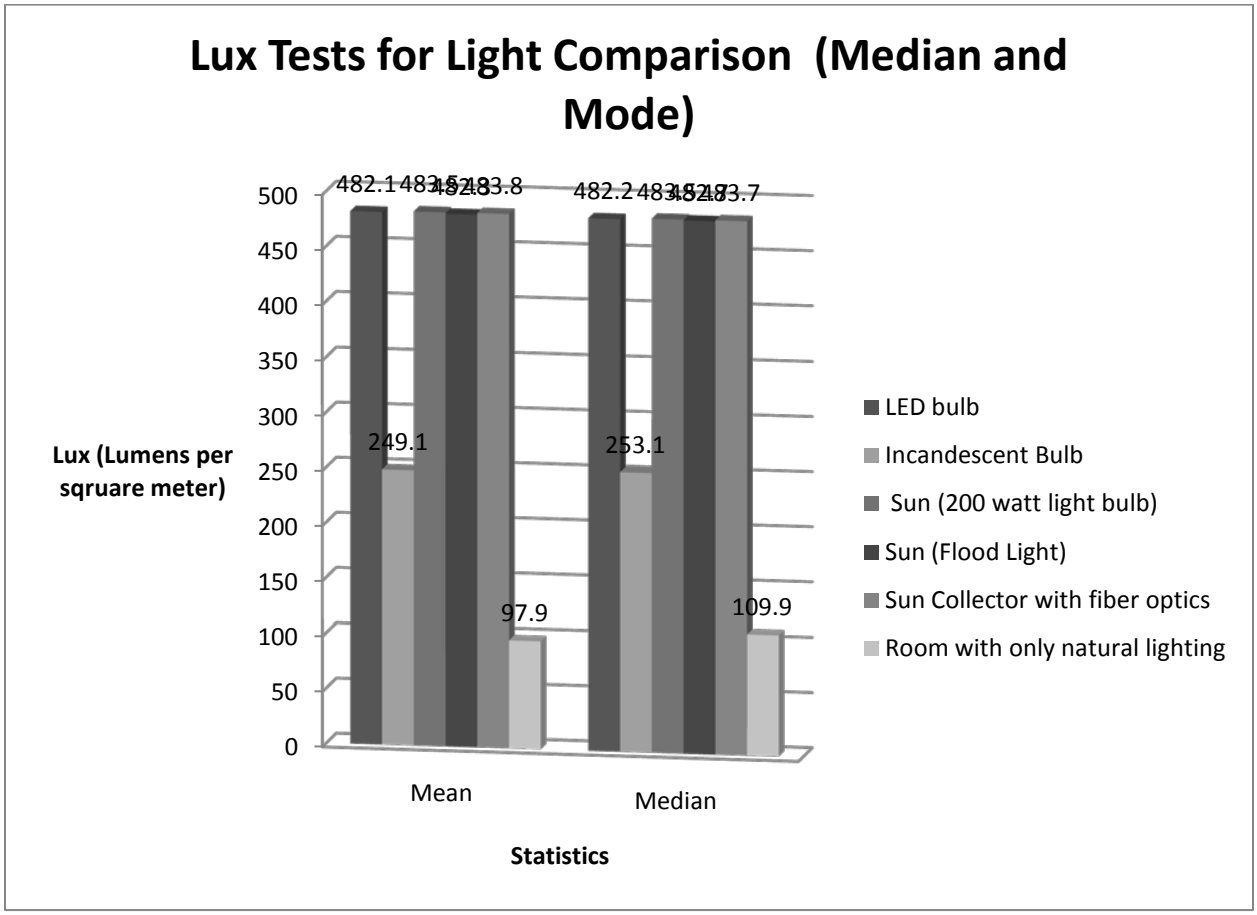
Lux Tests for Light Comparison (Median and Mode)
Lux (Lumens per sqruare meter)
500
450
400
350
300
250
200
150
100
50
0
249.1
97.9
253.1
109.9
Mean
Median
Statistics
LED bulb
Incandescent Bulb
Sun (200 watt light bulb)
Sun (Flood Light)
Sun Collector with fiber optics
Room with only natural lighting

Image 1 - room lit by natural lighting only (Joshua Marino)

Image 2 - box with interior painted black (Joshua Marino)

Image 3 - black box with L.E.D. lit inside (Joshua Marino)

Image 4 - how the L.E.D. was lit for testing (Joshua Marino)

Image 5 - meter used for testing (Joshua Marino)

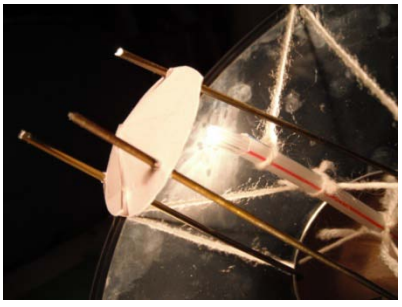

Image 6 - solar collector collecting light (Joshua Marino)

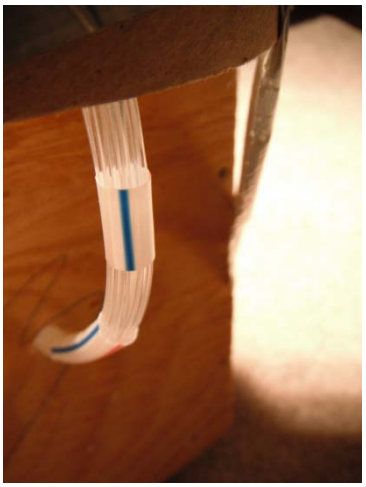

Image 7 - Fiber-Optics going into back of box for testing (Joshua Marino)

Image 8 - Solar collector collecting light for testing (Joshua Marino)

Image 9 - Back view of solar collector (Joshua Marino)

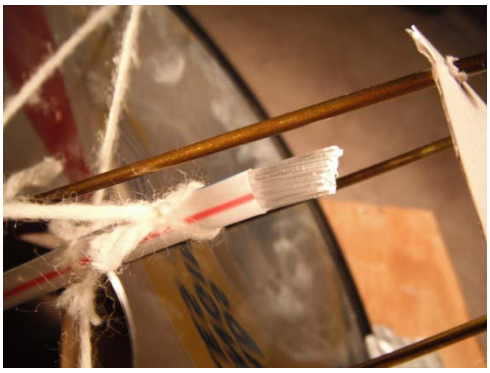

Image 10 - Fiber-Optics being filled with light from solar collector (Joshua Marino)

Results

From the data taken from these experiments the following results were determined. Of the main lighting sources tested, the three that produced the most amount of lux were the L.E.D. bulb, the 200 watt light bulb, and the flood lamp. Also tested were the incandescent bulb and a room with natural lighting coming through the window. The three problems with incandescent lighting is that it uses more energy, is not very environmentally friendly, and it lasts for a shorter period of time than the other light sources. The L.E.D. bulb, on the other hand, is another option for lighting a home. It costs less over time than incandescent bulbs, and uses less electricity, saving the homeowner more money. Also, they last up to forty-one times longer than incandescent bulbs. The one problem with L.E.D.'s is that they use electricity made by fossil fuels.

The 200 watt bulb and flood light were tested to determine a light source that could be used to replace the sun under testing conditions. Using the data taken from the experiment both bulbs could have been used for testing purposes. The flood lamp was chosen to represent the sun so the solar collector could be tested. In the test of the flood lamp, on average, the lux count was 482.3 L. The test done with the solar collector was 483.8 L on average. This mean the solar collector is extremely efficient and can be made into a full size prototype for further testing.

When the solar collector is built to accommodate the size a small home, more testing will be done to see if it is truly possible to replace common lighting with fiber-optics.

Conclusions and Recommendations

At this time it is possible to replace common household lighting with fiber-optics. Testing showed the solar collector was extremely efficient and that it actually worked. Now with a small prototype made and tested, a larger, full-size prototype may be made for further testing to truly see if the fiber-optics are capable of replacing common household lighting. In future projects another component to be added is the storage of this light when there is not any sunlight for the solar collector to collect, such as during the night. This project will be continued and modified to find the most eco-friendly way of lighting a home.

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Meter used for testing (Joshua Marino)

Fiber-Optics going into back of box for testing (Joshua Marino)

Solar collector collecting light (Joshua Marino)

Solar collector collecting light for testing (Joshua Marino)

Fiber-Optics being filled with light from solar collector (Joshua Marino)

Back view of solar collector (Joshua Marino)

Light source being tested (Joshua Marino)