Lighting up a campus with LED lights

By Ally Clark

Introduction:

The High school located in Fountain Hills Arizona has a need for security lights at night. The lights serve to give visitors in the area enough light to see areas such as lockers or enough visibility for cameras to see intruders. The school uses a minimum of eight high energy halogen lights at night which uses tremendous amounts of energy over a typical 8 – 10 hour period. The need we see is to construct a totally green energy system from photo panels on the roofs that regenerate batteries and during the night would emit enough light to give visitors enough visibility to see.

The typical spots or flood lights used on campus consumes 30 kilowatt hours per building per day. The commercial rates we experience from SRP are on average $0.175 dollars per kilowatt hour. This would average almost $1,800 per year just to light one building per year. By replacing eight out of ten halogen lamps with LED lighting we project a total usage of 5-8 kilowatts per day that will be completely supplied by batteries and recharged by day using solar panels.

The research group has been using an experimental system that has successfully been used for two years on the roof of Einstein Hall at the high school. The installation cost of a professional system has been done. Preliminary research work on what type of lights and what type of colors needed to be considered. This report looks at both colors and types of LED lighting that exists today to supply this project for next year. Preliminary studies and extensive research has been done on alternative LED light sources.

Question to be answered:

What type of LED lighting will give off the most light for the least amount of energy and for the least cost per foot of light? The types of LED lights were divided into two categories: by color and by manufactured type.

Equipment:

A project board hooked up to four 200 watt solar panels was connected to a voltage regulator and several deep cycle batteries. The energy could be used directly by some LCD lights. The alternative was to use an inverter to turn DC current into AC for purposes of testing various incandescent lights. In addition an LCD multicolor light source was tested to measure light output and the energy consumed was measured by the battery energy drop over night. A light meter was used to measure lumens and a chart was used as a guide by several researchers to decide on the clarity experienced by each color.

Procedure:

The research took place in two stages. The first stage was to examine a multicolored disk LED light purchased from IKEA. The lighting consumed between 20 and 100 watts per hour depending on the color that was engaged on the disks. The lights were selected to stay on over night for 10 hours during the winter. The batteries were recharged to capacity prior to each evening test. The 300 watts of solar energy used to recharge the panels was monitored by a weather system on the same roof. The days with comparative lighting were selected for the study. Time to fully recharge the solar batteries was used as the indicator of relative energy used over night. As a result the types of colors and comparative emission of the lights using a light meter were compared.

The second stage was a detailed study of various LED light suppliers and their reported specifications of energy consumed, lumens of light emitted and cost per foot of the lighting.

Data:

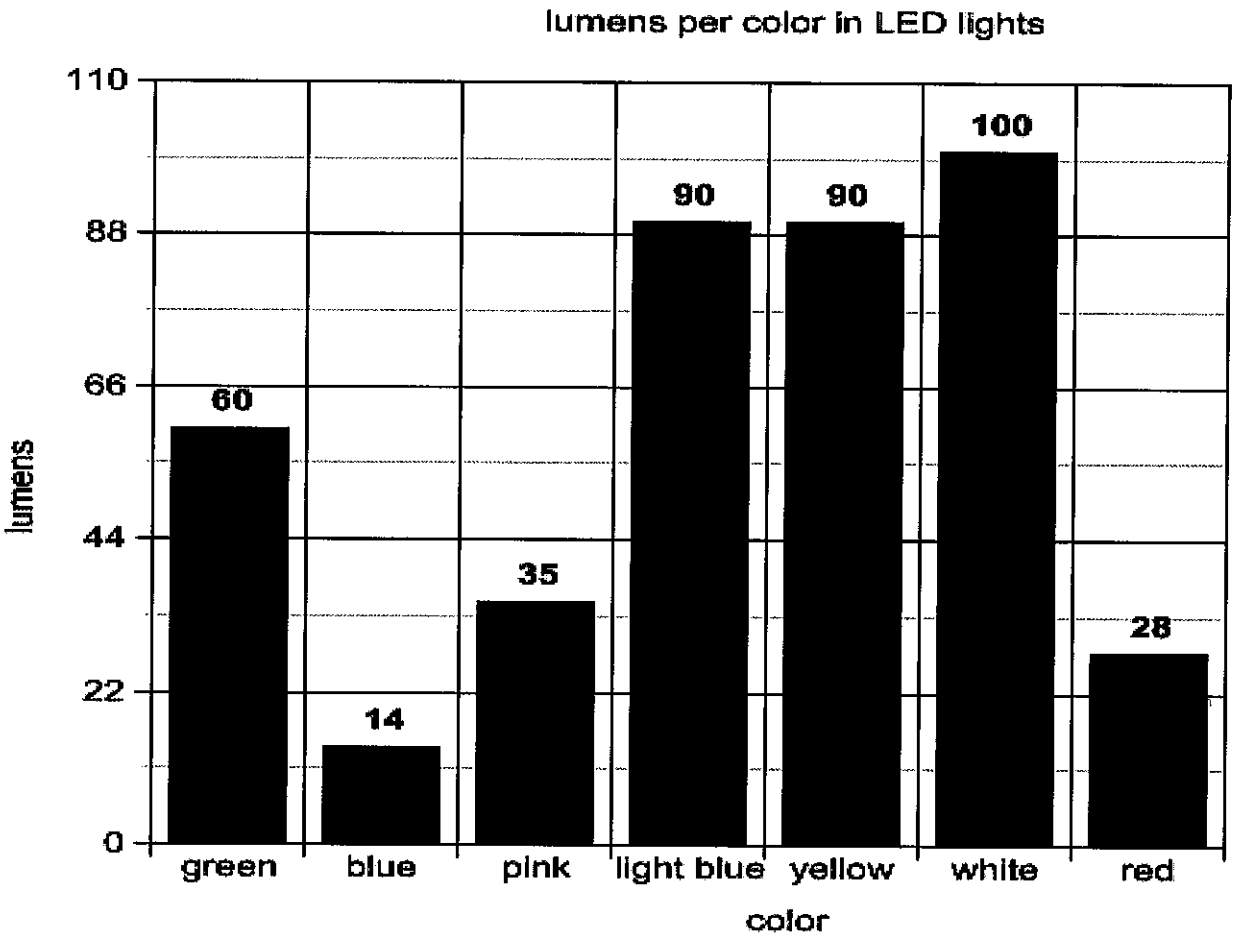
A composite of several on-line sources of light was created below to show what exists in the market place. As can be seen, the optimal color based on lumen output versus power consumption are the green, white and warm white(yellow).From a cost per yard stand point the green makes the most sense followed by white and warm white.

General Specifications for a 1 Meter Length, 60 LEDs per Meter
for Waterproof or Non-Waterproof Flexible LED Strips

Color Range	[redacted]	Amber*	[redacted]	[redacted]	White*	Warm White*
Lumens	50-60	70-80	48	110-120	140	120
Wavelength	625-630 nM	590-595 nM	465-470 nM	515-520nM	Broad	550nM
Current Consumption	400mA	400mA	400mA	400mA	400mA	400mA
Power Consumption	4.76W	4.76W	4.80W	4.80W	5.80W	5.80W

Color	Price Per yard
Red	$7.47
Yellow	$7.80
Lime Green	$8.91
Blue	$12.02
Green	$14.95
Cool White	$14.95
Warm White	$14.95

Our own studies of different LED lights show much the same results as the published studies. As can be seen the white and green dominates. The light blue we feel has mostly white in it.



Battery Drain Test by varied light colors*

Color	Green	Light blue	Yellow	White
Battery power	11.83	11.62	11.65	11.61
Amps	.61	.71	.70	.67

Each night the batteries were charged to an optimal maximum of 13.1 volts. The battery potential tabulated was left after 10 hours of battery drain of the LED. The amps were the typical amps during battery discharge. As can be seen all colors yielded the same relative power drain. The color appears to be independent of the power drain over all. The actual differences come from the type of LEDs used.

Analysis:

It was found that there would need to be some testing one different led light to see if they could run on an eight hour period. There are three different styles that would work to do this testing on. Rope light are pretty good, there lumen out put is between 50 to 80 lumens/ft. there price ranges between 2 to 5 dollars a foot but in order to get them this cheep you usually have to by them in long strands about 150 to175 feet long. The energy that they use is about 1 to 6 watts/ft. They have a life span between 75,000 to 100,000 hours. The best one that was found cost 2.50 dollars/foot and had a low wattage of 2 watts a foot comes in 150 feet. The next type of LED light would be the light strip. LED light strip are also good they can get as bright as rope lights but generally they use less energy. They usually cost a little more than rope light, there cost per foot is about 3 to 7 dollars/foot. There life span is the same as rope lights about 100,000 hours. The positive part of getting light strips is that they come in smaller sections and that is what we want for this project. There are a few light strip that are considered the

best the they have different good qualities about them it would be imposable to tell at this stage which one could be better with out further testing. There are many different types of light fixtures there prices rang from 20 to 120 dollars per unit but the positive part is you don't have to get as many. There lumens out put is pretty high usually between 70 to 150 lumens/unit. There life span is the same as the rope lights. The best one found is light fixture that is 23 dollars/unit has a 100,000 hour life spans, power consumption 6 watts, and lumens 550Lm/unit.

Conclusion:

The recommendation from these studies is to choose the following types of lights:

a. Color: green, soft white or white

They give off the most lumens for the energy consumed.

b. Type of LED lights recommended: Spot LED's, Strip LED's, and rope lights

These choices will give the widest variety for the maximum output and the least cost per meter of light.

It appears that the China sourced rope lighting is the least expensive for the results we desire. Local experts tend to play down the China lights from a quality and lifetime argument stating that the products from china vary widely in quality control and have actual lifetimes on less then half the 100,000 hours the LED spots demonstrate. This will be one of the aspects we will look at next year.

Future Research

The nest step of this project is to purchase the LED lights and test them individually for a month at a time. This will give us enough data to decide which one is the most efficient, lowest wattage, highest lumens, and low in cost.

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