LED Lighting:

Myths and Uses

by Tony Hansen

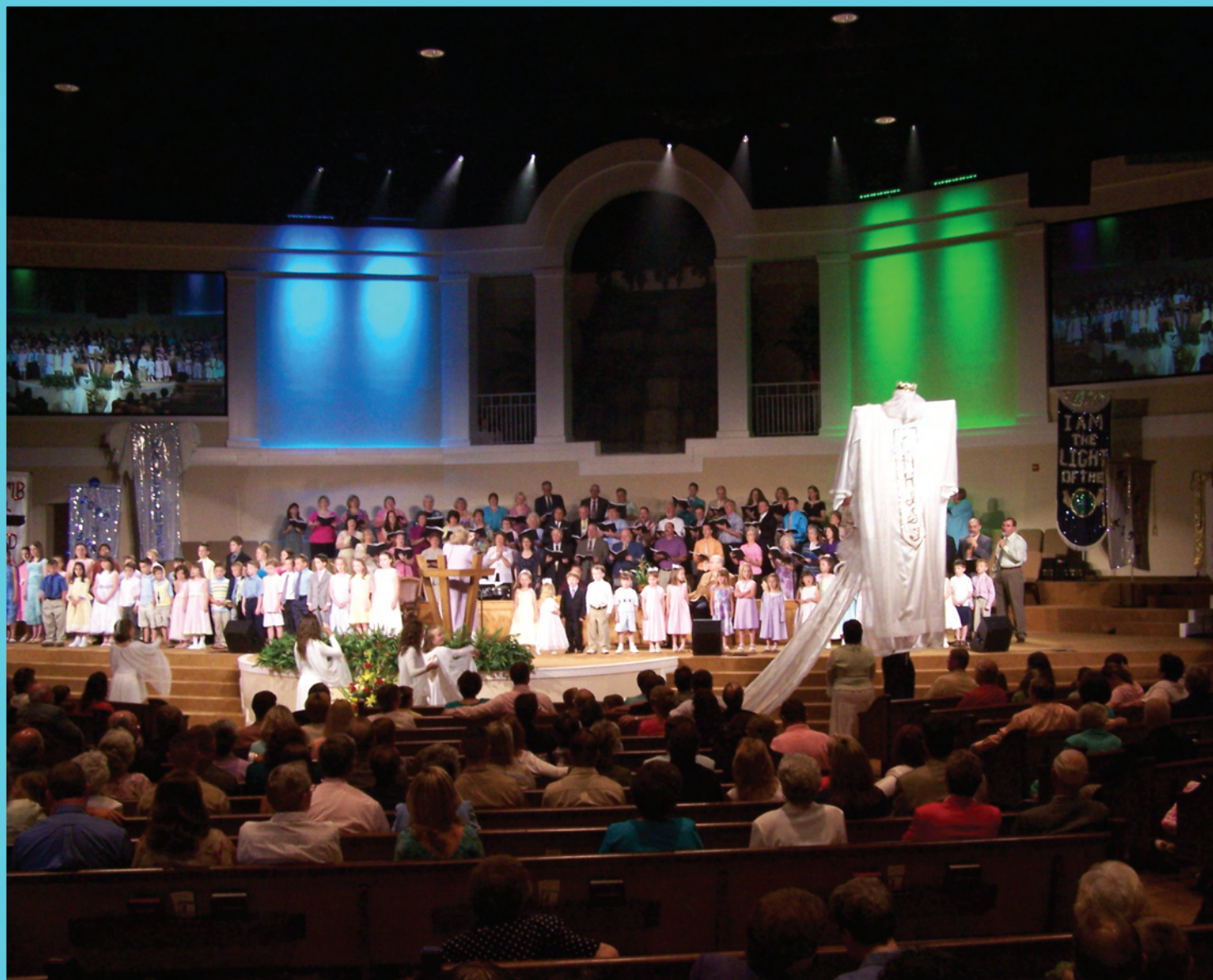
This article will most likely be outdated by the time it goes to print. LED technology is evolving so rapidly that it is a very difficult technology to address, and the amount of misinformation that has propagated over the years doesn't help. In this article I am going to try to address some of the complexities of LED lighting and also talk about where it has really made a name for itself.

LEDs involve a great deal of science but I am going to try to keep this article to the basics. There is a lot of good information out there if you know to look for it.

A basic definition of an LED, as per Wikipedia: "A light-emitting diode (LED) is a semiconductor device that emits incoherent narrow-spectrum light when electrically biased in the forward direction of the p-n junction. This effect is a form of electroluminescence. An LED is usually a small area source, often with extra optics added to the chip that shapes its radiation pattern. The color of the emitted light depends on the composition and condition of the semiconducting material used, and can be infrared, visible, or near-ultraviolet."

I could not have said it better myself. So that essentially covers the science of it, now on to practical considerations.

To begin with, I have often said that LED Lighting has allowed us to place light in ways that we have never been able to before, but that it is not quite



LED fixtures in use on back wall of Forestville Baptist church in Greeneville, SC

ready to replace any existing light sources. LEDs as a light source are a relatively new concept. It has only been over the past five years that we have really seen LEDs as a viable source of light.

LEDs have of course been around for decades as indicator lights. You probably have them in your car stereo or on your dashboard. They also make great Jumbotrons and video screens. However, it has been the development of the lensing and power of LEDs that has allowed them to become a light source.

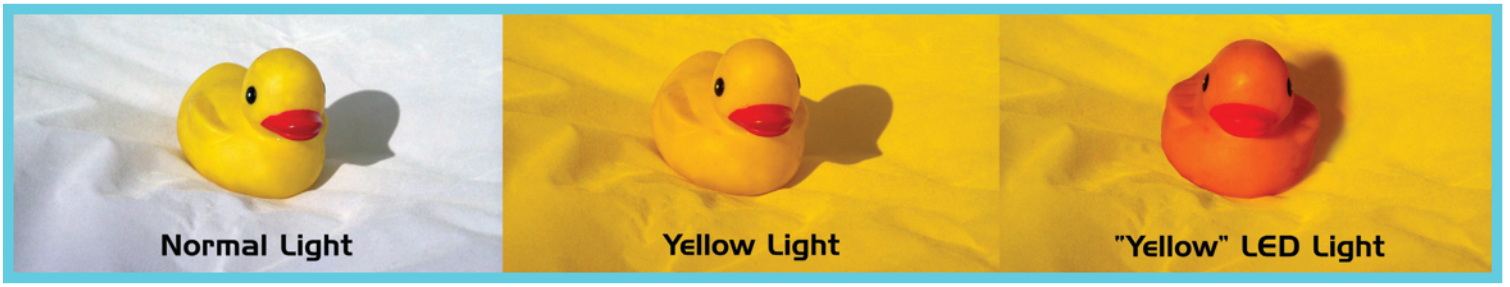
With any new technology comes new marketing and a few potentially misleading ideas. I have noticed that most of the reputable players have become very aware as to how to market LED, but there are still a lot of old ideas floating around.

#1 LEDS LAST FOREVER

A couple of years back, in the month of September, I went into one of those big box stores and they had the new LED holiday lights on display. They were nice and sparkly and they really caught my eye. Over the months leading up to Christmas I noticed that they didn't seem to have the luster they had in the beginning. By November they appeared to be unplugged but I noticed that they in fact were still energized. After I cupped my hand around a lamp, I noticed a faint glow. It was then that a friend pointed out the box with a prominent advertisement "Lifetime lights". The question may be: whose lifetime? A Mayfly, maybe.

LEDs will offer substantially more life than a regular filament light bulb, but in most cases not a lifetime to you and me. The death of LEDs is heat, and the problem with the light string I saw at the store is that there was no accommodation to dissipate heat. The LEDs basically cooked themselves. A properly cooled LED in the right environment may well last several hundred thousand hours, but the conditions need to be right. Additionally, LEDs will die by getting dimmer, not a sudden failure like a filament lamp.

In some cases a loss of only 10% of light may be unacceptable, in others you could stand to lose half of your output and still find the light useful. This is a decision you need to make but it is obviously going to be capitalized on by some marketing. After all, the lights I saw on display were technically still lit, they just didn't have a useful output. I will call an LED a long life lamp but not "lifetime".



In a yellow LED light, the ducky turns from yellow to red. Thus, "The Evil Duck"

#2 LEDS ARE HIGHLY EFFICIENT

Not really. Technically a lamp's efficiency is how well it converts its energy use into visible light. A scale that we use to determine efficiency, among other things, is the CRI (Color Rendering Index). In very simple terms, this is a rating from 1 to 100 as to how evenly and properly a source creates light into the human visible spectrum. A rating in the 90's is what we want for nice even light, great for video. The problem is that LEDs (at the time of writing) are generally in the 20's at best. So, they use a small amount of power to create a very limited amount of light. Thus they are technically not efficient, because they don't create a lot of usable light. Generally though, LED fixtures have a very low power draw. I have heard that a regular incandescent light bulb is actually more efficient than LED when put into perspective. A compact fluorescent lamp is still probably the current king of efficiency. I will call an LED low power, but not efficient.

LED Scenic highlighting at International Tabernacle in West Palm Beach, FL

#3 LEDS DO NOT CREATE HEAT

As we discussed in item #1, the death of LED is heat. Anything electronic creates some heat. I have burned my hand on poorly made LED fixtures, so believe me, they create heat. However, being a digital light and not incorporating a filament, they tend to make far less heat than some other sources. Generally a properly designed LED fixture will dissipate its heat and not feel nearly as warm as some other sources. In theory, if you could keep an LED comfortably cool, you will get a substantially longer life. For example LEDs could make a great fridge bulb (if you don't mind the color), but would make a poor oven light.

The environment will thus make a difference in the LEDs expected life. LEDs hung by my in-laws in Minnesota will have a better life with a fixture mounted outside than I will with one at my home in Orlando. However, I am very comfortable putting a decent LED fixture near people or soft goods without being too concerned with burns. So, LEDs are low heat in most cases.

#4 LEDS CAN MIX 16 MILLION COLORS

Maybe, if you can differentiate them all. This number comes from the DMX channels that drive the fixture. DMX is a standardized lighting protocol that provides 256 steps of intensity per channel. Most fixtures will use three channels: one for red, one blue and one green. If you do a simple multiplication of the available steps per channel (256*256*256) you will get over 16 million possible combinations. I cannot confirm that all of the fixtures make full use of all of the channels, but this is where the number comes from. LEDs will likely mix all the colors you need (with a caveat, see #5).

#5 LEDS CAN REPLACE ANY LIGHT SOURCE

Sure LEDs can make millions of colors, but you are forgetting about that CRI thing. Remember the Color Rendering Index that tells us how much of the spectrum we have to WORK with. The problem is that you will only get these colors on a NEUTRAL surface. This is where the critical CRI comes into play.

I do a seminar called "The Evil Duck", and it's all about LED. After going over some of the technical jargon, I'll take out a regular amber spotlight and shine it onto a white screen. I will then take an LED fixture and shine it onto the screen next to the other light and mix it to appear to be the same shade of amber to the naked eye. Basically, I have two yellow splotches of light on my screen that appear identical to most. Now I take a child's Rubber Ducky toy and hold it up in the standard yellow spotlight. He appears to be a yellow ducky in a yellow light. Next I'll move the ducky into the yellow LED light, where I often hear a gasp, because he turns dark red, thus the evil ducky, as seen on pg. 36.

#5A COLOR SYSTEMS

This is where CRI and some high school science come back into play. We need to remember that in order for any pigment to appear as the color that we see, the color needs to also be available in the light reflecting off of it. Pigments are amazing things, they're light suckers. A pigment will take all of the light in the air and only reflect back to us the light it wants to create. All the other available light gets filtered out by the pigments.

If you walk into a room lit only in pure red light wearing blue clothes, your clothing will appear black because there is no blue light for it to reflect. Light is the only entity in the known universe to use the additive color system, absence of all light is black, but by adding colors of light we will work our way towards white.

Simple light color blend example

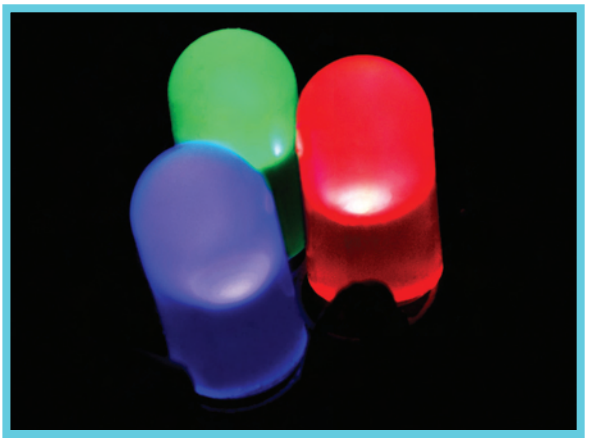
Pigments use subtractive color by filtering reflected light to only appear as the color they are. There is an interaction between the two systems to make any object appear the color that it does. Grocery stores know this and use very high CRI fixtures in the produce section so the vegetables appear at their best. This is why they may appear dull by the time they get to your kitchen.

Color theory is a very intense subject that can warrant an article on its own, so this is the condensed version. Let's go back to the duck. The reason he turned red under the LED fixture is because no amber light was available for him to reflect. The amber appearance was made by using the additive color system to mix red and green LED light onto a surface that would evenly reflect both. To our eyes these two colors combined to make

amber. However, that does not make the light purely amber, it is a bit of an illusion. The duck reflected red because that is the closest pigment it had to something that the LED provided.

Remember that LEDs have a low CRI so there is not a whole lot of available color spectrum to work with. LEDs are digital light and have the property of being a very specific frequency of color. We mix three of these frequencies to get the rough form of white light. Red, green and blue are the primary colors of the subtractive system and thus the basis for our lights. The issue with LED is that they are so pure, there is no fill between the colors to help illuminate all pigments.

On a neutral surface such as a white screen, I can get most colors because there is no additional filtering by the pigments. However, in the case of the duck, his pigment filtered out the green and made him appear red.



Close-up of 3 primary color LED's

LEDs will not do well lighting artwork, colored surfaces or people because they are so limited in their available color rendering. They are great for big white drops or lightly colored walls to make a color wash though. The reason that this is not as much of an issue with a traditional light source is because they start with a higher CRI and are filtered down to a color.

The thing is that most conventional light sources use Gel, Dichro, glass or other means to filter out the colors that we don't want. Often light colors are called filters for this reason. If you look at a traditional light source's created color on a chart it will be a nice smooth hill peaking at the intended color. LEDs on the other hand, will be one to three distinct spikes with nothing in the valleys. It has been suggested to just add more LEDs such as Amber. The problem is that each of the LEDs is very narrow even within its own color so it would require hundreds or thousands of additional LEDs to even begin to address all colors.

The highest quality TVs and computer monitors work on three colors and this is the basis for all light. These colors will just need to become more encompassing with LED. I believe this to be the most misunderstood area of LED light but also the fastest changing. At this point I will not use LED lights as a primary light on talent or scenery, but I will use it as an accent, color fill or eye candy all day (video cameras love to look at them).

#6 LEDS ARE LOW MAINTENANCE

I can somewhat agree with this. LEDs do not have lamps to replace and since they make their color electronically, there is never a gel or color medium to replace. They are also very durable and are not affected by vibration or extreme cold. The only problems I have seen have been bird droppings and heavy snowfall (which the LED wouldn't melt), so I guess there can be some maintenance. LEDs also don't use large ballasts or cooling fans so they tend to be very quiet.

#7 ALL LEDS ARE THE SAME

LEDs used in entertainment lighting are graded based on the targeted color they are to produce. The manufacturers of the fixture can buy at a grade level similar to that of lumber or meat. Obviously the higher grade you buy, the more expensive the component. However, the higher the grade, the more consistent the color.

When you buy a fixture two or five or ten years from now, you will want it to match the one you bought today. This is where cost, quality and quality control come into play. I have seen fixtures from one manufacturer that have completely different colors side by side right on the shelf. This is the difference in LEDs. Another consideration is the difference in color choices from one manufacturer to the next. As was stated before, the death of LED is heat, and if there is no accommodation to remove the heat from the LED within the fixture, it may die prematurely. Lastly, the quality of the control electronics will affect the current going to the LEDs. With LEDs as with anything, you pay for what you get.

Okay, so with all of the myths aside, what can we actually use LED for? They are great for water rides. There are many low voltage versions available and with low maintenance they are perfect around pools. Not too many Houses of Worship have waterslides yet though. However there are a lot of pretty hard to reach places where LED lights would be great in churches. I will use LED fixtures in places that I don't want the customer to have to get a lift or scaffold to access every few months. I can put

LED's in use as a dramatic color highlight

TO SUMMARIZE:

LED PROS:

1. Low energy consumption
2. Low heat, safe around people and scenery
3. Minimal maintenance and parts
4. Very durable
5. Long life
6. Many color options when used properly
7. Silent
8. Very camera friendly as eye candy

LED CONS:

1. Cost
2. Low color rendition for pigmented surfaces
3. Limited lensing options
4. No cross brand standards
5. Limited quality control standards

a good quality fixture up and not have to worry about it for a couple of years at least. I also put them behind performers or choirs so I don't worry about anyone getting burned or starting a choir robe on fire that they let fall across the light.

As I mentioned earlier, the camera loves these things. I can put LED fixtures all over the stage pointing at the camera, and the performers can't hurt them or get hurt by them and the camera thinks they are as bright as sunshine. They are also great where I don't have a lot of power to work with.

My company was asked to design a lighting system for a youth room that could also be used as a club. Problem was, they had virtually no power left to spare. To add power for a lighting rig would have meant getting a new drop from the power company and all of the associated infrastructure. Even though it cost a bit more, we were able to design an entire system in LED and the whole room ran off of one outlet.

As an accent light, they can't be beat. I can put LED in coves, built into scenery, under counters, just about anywhere I want some colored accent lighting. We have had entire sanctuaries built for LED accent, as long as what is being accented is a light color. I love to highlight the walls behind the choir or either side of a baptistery with LED; it gives a wonderful splash of color as an accent.

LED is also a great seller down south because I can put a ton of them in a facility and not have to add more air conditioning, seeing as they put out virtually no heat.

In the end, I don't want to in any way imply that LED is not usable. Heck it's one of my favorite tools now. There does need to be some caution though to the claims of the "miraculous LED". It is showing great promise as a very viable source of light, but it's still a little early in its development. It may replace everything one day, just not yet.

LED's are a rapidly evolving and changing technology that will have transformed greatly, just in the time it takes for this article to go to press. Many reputable companies are designing new and innovative solutions to address color, heat and life issues. This article addresses the majority of the 3 color RGB units that are now on the market and how they are being advertised and represented, use this article as a primer to learn and discuss intelligently the many advances of LED technology. As always, knowledge is power and you should always ask questions and be comfortable with the products you buy. ◆

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