

Introduction

Why we chose full spectrum lighting for Life University

In the Enrollment Management Project, we had to replace all of the lamps, as there were multiple colors of fluorescent bulbs. We also wanted to reduce the glare without adding fixtures, or decreasing the light level. This gave us the opportunity to introduce full spectrum lighting to Life University's campus, which we believe is a positive move toward creating a better learning and working environment for all of the University's occupants.

Our interest in full spectrum lighting did not come from the design or facility community; in fact, the information from those communities may negate it. Our inspiration to look into full spectrum lighting was the holistic health care community, mainly the up and coming, young chiropractors and their resources, along with testimonies and personal experience.

As designers, the focus is on creating the best environment for the people who will be exposed to the space and selecting the best lighting is one of these factors. I remember one of the first comments Dr. Riekeman made to me was, "fluorescent lights suck the life out of you". What our research has found is cool white fluorescents do "suck the life out of you".

In sustainable design there is a balance between what is good for the environment, the people, energy consumption, and cost. Originally, full spectrum bulbs were avoided because of the cost. The price of the bulbs was as much as ten times the cost of typical "cool white" bulbs. "Full Spectrum" bulbs were being marketed retail and charging more for the label. We were able to find a full spectrum bulb with the correct specs at wholesale prices making the higher cost no longer a factor.

This paper is not intended as a technical report. Instead, it is an overview of the research that brought us to the conclusion. We believe full spectrum lighting is the best resource in the market for artificial lighting for the benefit and well being of the people.

Full Spectrum Lighting: Benefits for People

The choice to specify full spectrum lighting is driven from the results of our research on available sources for artificial light. Our research concluded that full spectrum lighting is the best choice as it most closely simulates natural outdoor sunlight which is the healthiest light; and, as compared to the unhealthy, traditional, cool white fluorescent lighting, it has a higher return on investment due to the indirect cost savings of the health and well-being of those occupying the space.

It is well known and documented that sunlight promotes health and well-being. Unfortunately, as documented by the EPA, "On average, Americans spend about 90 percent or more of their time indoors"ⁱ and thus miss the benefits of this health source. To help counteract this, building designers are finding new ways to introduce daylight indoors. The US Green Building Council has included specific credits in the LEED rating system available by achieving a specified increased availability of daylight to occupants, citing that "Studies have demonstrated that productivity increases dramatically for those building occupants working in day lit areas."ⁱⁱ Although a noble direction, the majority of office and classroom spaces are still lit by artificial light.

There are vast amounts of documented case studies that support that the next best thing to natural outdoor light, when one has to be indoors, is the use of full spectrum lighting. Full spectrum lighting—also referred to as broad spectrum lighting—most closely emulates natural sunlight by mimicking the measurable light of the sun. As stated by Wasdyke in his explanation of an article in the CEE NEWS publication of January 1990, "[this is accomplished by] simulating the full spectral power distribution range (both visible and ultraviolet) of natural outdoor light. Spectral power distribution (quantity of light or power emitted at each wavelength) is used to determine color temperature, color rendering index, and lumen output of a particular lamp."ⁱⁱⁱ

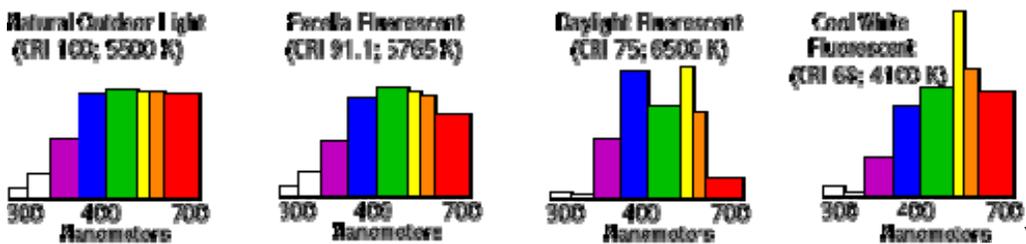
The color temperature, noted in Kelvin degrees, indicates how warm or cool a light source appears. “The color temperature of outdoor light varies between 5500K and 6800K depending on time of day, weather, season, and/or latitude”, with noon day sunlight measured at 5500K.^{iv}

There is also a numerical rating system known as the Color Rendering Index, or CRI. This rating further measures the ability of a light source to visually display the true appearance of an object’s color and compares it to an object’s color under natural daylight, which has a “perfect balance” of color and a CRI of 100.

At this point in time, and as best as can be measured—with lumens and foot-candles not varying between possible options—for a lamp to be considered “full spectrum” it must meet both the following

- Kelvin: Over 5000K (with maximum benefit achieved at around 5500K)
- CRI: Over 90

The graph below shows a comparison of the spectrum of light of natural outdoor light and compares it to the full spectrum fluorescent recently specified, and other types of fluorescent light.



As stated by the US Green Building Council “...green buildings are intended to be environmentally responsible, economically profitable, and healthy places to live and work.”^{vi} Of all the resources available, the overriding proponent to full spectrum lighting is the health benefits, as compared to traditional cool white fluorescent lighting, showing consistently that full spectrum lighting promotes a healthier and better indoor environment experience for all.

Documented in numerous sources, full spectrum lighting has been found to support the following benefits:

Health Benefits:

- Improves mood/overall well-being
- Reduces stress/anxiety
- Improves mental awareness
- Increases oxygen intake
- Reduces heart rate
- Improves vitamin D synthesis in the body
- Reduces incidence of dental decay
- Improves results of light therapy in treating seasonal affective disorder (SAD)
- Improves results of light therapy for sleep disorders

Other Benefits:

- Improves productivity
- Improves scholastic performance of students
- Improves attendance among students and workers
- Improves color perception
- Improves visual clarity
- Improves plant growth
- Improves retail sales

In fact, although there are differing options on the degree of benefit, there was no documentation found that shows any negative human effects from full spectrum lighting. On the other hand, typical fluorescent lighting, also known as “cool white”, has been documented as having negative physical and mental health impacts, including hyperactivity in children and some adults, fatigue, irritability, and attention deficits.

This is not a new idea. In his 1974 article “Effects of Spectral Differences in Illumination on Fatigue”, published in the *Journal of Applied Psychology*, J. Mass is noted as concluding, “Natural sunlight makes people feel better than artificial light does. The more natural the light, the more comfort and better the performance. Statistically significant differences are proven for subjects in rooms lit by cool white lamps versus broad spectrum lamps. Subjects brought from outdoors into cool white rooms tended to become less lively or lethargic. The subjects exhibited no change when brought from outdoors into broad spectrum rooms. Visual accuracy and alertness were measurably better in the broad spectrum rooms versus the cool white rooms. (Maas, 1974)”^{vii}

Multiple sources referenced the studies of Dr. Fritz Hollwich, Professor Emeritus, Department of Ophthalmology at the University of Munster, Germany. Hollwich found high levels of stress hormones—specifically cortisol—in individuals under cool white fluorescent and found normal levels, in people working under full-spectrum.^{viii} Based on the research of Dr. Hollwich and others, the cool-white fluorescent bulb was legally banned in Germany in 1980^{ix}

A great deal of research has been conducted in the school environment. To follow are just a few examples that consistently conclude the same results.

Laurence D. Martel, Ph.D., President: National Academy of Integrative Learning, Inc., Hilton Head Island, S. C., in her article “Light: An Element in the Ergonomics of Learning” writes, ““Malillumination” is to “light” as “malnutrition” is to “food”. “Malillumination” is the term coined by pioneer light researcher, Dr. John Ott, to describe sunlight deficiency and the negative, harmful effects of artificial pink or cool-white fluorescent lighting on behavior, learning, health, hardiness and longevity”. She goes on to state “schools, classrooms and other work environments where people spend time learning and working under simulated sunlight (full spectrum lighting and color) experience less stress and anxiety, improved behavior and attitudes, improved health and attendance, and increased performance and academic achievement.”^x

Pediatrician Doris Rapp, M.D. states in her bestselling book, *Is This Your Child’s World?*, that “The best lighting for schools (and elsewhere) is natural light. But in many classrooms, students spend about six hours a day beneath (cool white) fluorescent lights. These ordinary fluorescent lights can emit X-rays, radiation and radio waves – emissions that can decrease productivity and cause fatigue, confusion, eyestrain, irritability, depression and hyperactivity in some sensitive children (and adults...).^{xi}

In addition to this case study research, we found policies supporting full spectrum lighting as a better choice for the indoor environment. The Office of Disability Employment Policy of The US Department of Labor states one of the modifications to improve productivity for employees with psychiatric disabilities includes increasing natural lighting or full spectrum lighting.^{xii} In their ADA Accommodations and Compliance series, Job Accommodation Network (JAN) —a service provided by the U.S. Department of Labor's Office of Disability Employment Policy (ODEP)—recommends the exclusive use of full-spectrum lighting in the workplace for conditions of lupus, fibromyalgia, chronic fatigue syndrome and bi-polar disorder.^{xiii}

In fact, the only negative against full spectrum is that in the past, full spectrum has been sold at as much as ten times the cost of standard cool white fluorescents. It seems that the name “full spectrum” has been used as a catch word to a target market and it came with higher costs. With the increase public awareness of full spectrum, the cost for such lighting on the wholesale market has come down to with-in pennies per lamp of the typical cool white lamp.

But the cost difference of the lamps is not the only cost comparison; the energy consumption is impacted as well. The typical full spectrum lamp has a higher wattage than the cool white so the cost should go up. But, it is also noted that the high rendition of color decreases the number of watts needed to create the ideal light level as compared to traditional cool fluorescents. Some research “show that light from a high color

rendering lamp, such as full spectrum light, provides equal visual acuity at 75% to 80% of the foot-candle level of a standard high lumen-output lamp such as cool white fluorescent light. In fact, lower wattage full spectrum light can be substituted for cool white lamps of higher foot-candles and actually improve visual acuity.”^{xiv}

Though the idea of full spectrum fluorescent light bulbs as the closest representation of natural outdoor light is not a new one, the benefits of the use of this lighting continues to be revealed. Studies have shown definite positive influences on mood, behavior, and health in human participants under full spectrum lighting, while they show negative impacts on the same factors under traditional cool white fluorescent lights. Combined with the understanding that the small lower direct cost difference for cool white fluorescent does not outweigh the indirect cost of the occupant’s well being, it just makes sense that the best option for interior lighting is the use of full spectrum lighting.

ⁱ “Buildings and their Impact on the Environment: A Statistical Summary”. EPA.gov. Revised April 22, 2009. <http://www.epa.gov/greenbuilding/pubs/gbstats.pdf>.

ⁱⁱ USGBC. *LEED for Commercial Interiors Reference Guide, version 2.0*. New Leaf Paper, 2006.

ⁱⁱⁱ Wasdyke, Ambrose Paul, Jr The Advantages of Full Spectrum Lighting, [naturallighting.com](http://www.naturallighting.com);
http://www.naturallighting.com/articles_advantages_full_spectrum_lighting.php.

^{iv} Weber, Larry “Choosing the Right Lamp”. [Naturallighting.com](http://www.naturallighting.com). 2003-2004.

^v Atlanta Light Bulbs.com. <http://www.atlantallightbulbs.com/excella.html>. Copyright © Atlanta Light Bulbs, Inc. 2008 : Privacy Policy.

^{vi} USGBC. *LEED for Commercial Interiors Reference Guide, version 2.0*. New Leaf Paper, 2006

^{vii} Mass, J., "Effects of Spectral Differences in Illumination on Fatigue"; *Journal of Applied Psychology*, Volume 59; 1974.
<http://www.fullspectrumlighting.com/durotest/Full%20Spectrum%20Lamps%20Essay.htm>.

^{viii} H.e.s.e. project, “Artificial Light in the Environment: Human Health Effects”. <http://www.hese-project.org/hese-uk/en/issues/cfl.php>.

^{ix} Hollwich, Fritz and Dieckhues, B., "The Effect of Natural and Artificial Light Via the Eye on the Hormonal and Metabolic Balance of Animal and Man," *Ophthalmologica*, 1980, vol. 180., no 4, pp. 188-197. <http://www.midwest-lighting.com/seeingthelight.htm>.

^x Martel, Laurence D., Ph.D, “Light: An Element in the Ergonomics of Learning”. <http://www.full-spectrum-lighting.com/durotest/Light%20Element%20Ergonomics%20Learning.htm>

^{xi} Full Spectrum Solutions.com. http://www.fullspectrumlighting.com/lighting_for_schools.shtm

^{xii} Office of Disability Employment Policy. “Maximizing Productivity: Accommodations for Employees with Psychiatric Disabilities”. March 2006, <http://www.dol.gov/odep/pubs/fact/psychiatric.htm>

^{xiii} <http://www.lupusmctd.com/index.php?action=search2>

^{xiv} Wasdyke, Ambrose Paul, Jr The Advantages of Full Spectrum Lighting, [naturallighting.com](http://www.naturallighting.com);
http://www.naturallighting.com/articles_advantages_full_spectrum_lighting.php.