Lighting Considerations For The Modern Day School Environment:

Beyond energy efficiency and cost savings

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Prepared by: BENYA BURNETT CONSULTANCY
Davis CA. USA upon request of GO GREEN LIGHTING LLC.

For most school districts, selecting the best lighting systems for either new construction or retrofit of existing buildings requires a unique "read between lines" diligence. Today, there are two competing and yet equally complex technologies that must be fully understood before making an informed decision and like all products, marketing spin has a great influence on product claims. With robust scientific research now crediting built environmental light with biological influence, the final selection of a lighting system beyond energy saving potential must be considered[1] [2]. Today, a lighting decision resulting in a system which will realize the most economic benefit, as well as, address health safety concerns for occupant visual need AND biological impact will ensure a safe and visually stimulating environment for years to come [3].

Fluorescent Systems:
For most of the lighting in schools, fluorescent lighting has been the primary choice for decades, and for good reason. It is economical, energy efficient, and features long lamp life and requires little or no maintenance. However older systems with poor color quality and inefficient ballast systems have developed a bad reputation and are frequently cited as the suspected cause for student headaches and visual discomfort.

Modern day fluorescent lighting has improved steadily since its invention almost 80 years ago. With literally thousands of luminaire choices, today's energy efficient fluorescent lighting remains a common and excellent choice for color rendering and visual acuity without the problems associated with the past. The latest fluorescent lamps operate at over 100 mean lumens per watt, have excellent color rendering capability (CRI >85) and lamps can last as long as 65,000 hours. Flicker-free electronic ballasts permit dimming for energy savings as well as to accommodate teacher's needs. Modern lamps can be retrofitted into older luminaires producing a more efficient light distribution. Additionally, newer fluorescent systems offer an indirect component now demonstrated to provide enhanced visual comfort and perceived brightness. In many classrooms, replacing older cool white lamps and magnetic ballasts for the latest technology is a very cost effective retrofit.

LED Systems:
With the advent of advanced lighting technologies, LED lighting can now compete with fluorescent systems but it is by no means a slam-dunk. LED lighting is now available in both new luminaires, and, as retrofits for older fluorescent luminares. LED lamps can operate at up to 120 lumens per watt, with moderate color rendering considerations (CRI>80) and offer the same lamp color choices as fluorescent. LED lamp life is also very long, usually more than 50,000 hours, and LED lighting may require less maintenance over time than any other type of lighting system. It is also dimmable. From a health perspective however LED technologies are drawing debate as to the potential harm for ocular stress among children under the age of 18, as well as, a potential benefit for delivering circadian- correct blue rich white light in the absence of daylight [4] [5] [6]. Currently, the lines are blurred as to the clear cut winner between fluorescent and LED replacement systems both requiring additional research to independently validate claims, as well as, refute safety concerns and circulating misinformation.

From a performance perspective, choosing between fluorescent and LED is a read between the lines challenge. LED lighting systems have been heavily publicized, but for schools, most LED systems are no more efficient than modern fluorescent lighting. Even the best LED lighting systems are only 25% more efficient than the best fluorescent systems, but they often cost 50-100% more. Since many schools only operate lights 2000-2500 hours per year, it can take a decade or more to amortize the higher cost of LED.

Advanced Electronic Controls
Recommended as an integrated optimizer for both fluorescent and LED systems, lighting controls can make a large difference in energy use particularly in a sunny climate. Currently, light limiting shades are used to reduce glare and block heat transmission from the afternoon sun. This causes an overly darkened classroom totally dependent upon electric lighting for visual acuity. In a classroom with windows and automated glare control shades, daylight can be used to effectively illuminate without cost at least part of the classroom much of every day while selective commissioning will allow controls to timely reduce glare and heat transmission by lowing shades only when needed. This will produce a lighting energy savings of as much as 90% if lights are automatically dimmed or turned off when there is adequate daylight. In addition, utilizing controls with either a fluorescent or LED lighting system can extend lamp life by decades. Upon examination, most school districts opting for a high output fluorescent retrofit offering excellent color rendering and commissioned with daylighting controls often realize less upfront and overall cost than an LED system, as well as results in higher energy savings.

Cost Savings
In addition, consideration of controls for either lighting system has another 'bottom line' benefit. Many utility companies offer incentives (rebates) to customers who update their lighting systems. Some incentive programs favor controls; others favor fluorescent or LED replacement lamps or new energy efficient lighting systems. For the school district interesting in making the best investment, many times the advantage of one lighting approach will become apparent when a thorough study is

performed. When it comes to making the best choice for students, a wise decision between the two systems may best be rendered with a mindset of 'educators: be the first to educate yourselves"

Circadian Considerations

All life runs on a set timing pattern governed by the ever present light/ dark periods of a 24 hour day and the seasonal cycles found on Earth. A series of biological "clocks" are located within every cell of the body and brain for the purpose of aligning our physiological, biological and neurological processes to that of the changing Earth environmental conditions. The signals which entrain the cellular clocks to the environment are called Zeitgebers: the primary environmental cue is light.

Coordinating the cellular timing patterns with environmental changes is a unique life function called the CIRCADIAN SYSTEM. Science has now determined that the human **circadian system is involved with all biologically active processes and functions including the regulation of blood pressure, heart rate, digestion and urine production.** It also has governance over the immune system, metabolic system and the endocrine system. It is a major system comprised of the **Circadian Rhythm and the Sleep /Wake Cycle** and is controlled by a small master pacemaker located in the brain. The eyes and the skin are major input receptors for delivering environmental cues to the master pacemaker, which in turn, then signal the peripheral clocks located in major organs including the liver, heart, and kidneys. Credible peer review research has demonstrated the ability of built environmental light /dark conditions to bring about the signaling conditions necessary to impact the circadian system including the expression or silencing of specific genes necessary for human health, wellbeing, reproduction, disease formation and survival [7]. The relevance of ambient lighting conditions is now considered by most scientific research to be that necessitating a dosing protocol for effective delivery.

As with all drug protocols, timing, intensity, duration, location, spectral power and exposure to ambient lighting conditions are the metrics which all light will be specified in the coming years ahead. Additionally, as with modern day pharmaceuticals, dosages are dependent on user age and in some cases gender. Recently scientific discovery has demonstrated the same to be true for the delivery and selective withholding of light for adolescents under the age of 18. This work has been predicated on the fact that the human brain and circadian system develops at different stages based on age and reproductive ability. This interprets to mean that the same exposure to light levels, the timing of the light, the spectral (color) distribution of light source and the intensity of the light will be different when specified for primary classrooms versus spaces where high school students spend the majority of their time. Simply stated, the older student requires an early morning avoidance of light versus the needs of primary school children who require high light levels immediately upon early morning awakening and continuing into the afternoon hours[8].

Those school districts where a separate middle school system is the norm face a more challenging situation: how to accurately deliver circadian correct lighting, as well as, visual acuity light levels for a neurologically and biologically diverse group of kids between the ages of 10 – 14.

The most dramatic example of how the delivery of light specific to the ages of children can be of the most profound benefit is that of 2 studies involving high school students in Virginia. Here simply by adjusting early morning light exposure based on the unique biological and circadian system needs of this age group had the results of a significant reduction in early morning traffic accidents and enhanced performance on scholastic standardized tests. Because of these studies and numerous others, the value of an age specific circadian light dosing protocol for high school students is now the basis for 19 US school districts initiating later start times thus enabling students a longer sleep period and a reduction of early morning light exposure.

LIGHT Concerns

Medical and scientific discovery is now establishing the relevance of a **desynchronized circadian system in the initiation, formation and progression of disease[9].** Recent policy declarations by the AMA (American Medical Association) and numerous world governments and health organizations have established the relevance of built environmental lighting conditions as a contributing factor in the ongoing battle against cancer, diabetes, heart disease and other major health-related conditions[10 11]. And most recently a new Vanderbilt University (USA) study demonstrates how an out- of- synch circadian rhythm for insulin action enhances the risk of metabolic syndrome, obesity and type 2 diabetes[12].

WHERE to Go From Here

As with any significant lighting upgrade, one must first assess the existing conditions and identify the performance requirements. Once the visual and biological requirements are identified then lighting project scope, layout and product selection can begin. This will include:

- Assay of existing system energy and visual performance conditions
- Lamp selection, recommended fixture upgrades, replacements, relocations, and additions
- Selection of lighting control and energy management systems for daylight and electric lighting optimization
- Development of commissioning protocols
- Documentation of all systems to support proper ongoing operation, and maintenance
- Benchmarking of initial optimized system for energy, visual, and biological performance to quantify energy savings, improvements in visual performance, and as a reference for future calibration of ongoing system operation.

- Training of staff and facilities personnel in the proper maintenance and operation of all systems for optimal performance and ROI
- Education of parents and school personal as to the expected benefits the new lighting system will impart and the minor behavior modifications needed at home for continued circadian support

The professionals at BENYA BURNETT CONSULTANCY stand ready to render these services providing your school district with the most energy efficient and human centered lighting system possible while in full consideration of your budgetary constraints.

Design Service Inc. dba
BENYA BURNETT CONSULTANCY
1612 Olympic Drive
Davis CA. 95616
USA

+1 (615) 351 8337
http://www.denyaburnett.com

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