WhitePaper

Five Questions To Answer About Sustainable School Lighting

Every school in the country has its own "colors" which can be found on everything from team jerseys to book covers. The colors are as varied as the students who attend the schools. Today, most schools have added another color to their palette: green.

More and more schools are embracing the sustainability movement in an effort to reduce their overall impact on the environment. This approach has begun to pervade all aspects of the school's operation, from its use of natural resources to its building materials. Within this eco-friendly approach, a specific area that is gaining significant momentum is sustainable school lighting.

What exactly is sustainable lighting? Two lighting associations, the Illuminating Engineering Society of North America (IESNA) and the International Association of Lighting Designers (IALD), have defined it by stating, "Sustainable lighting design meets the qualitative needs of the visual environment with the least impact on the physical environment." To be truly sustainable, school lighting must provide a high-quality visual environment that supports the learning needs of teachers and students. What makes sustainable lighting design today different from simplistic energy conservation movements of the past is the focus on human needs fulfilled by lighting.

Many assume that incorporating sustainable practices in a design, including lighting, is expensive. However, in a survey of 30 green schools (Greening America's Schools Costs & Benefits by Gregory Kats), the overall building costs were only 1-2% more than the building costs of a conventional school. This translates to about a $3 per square foot premium for going green. Further, the benefits of building a sustainable school significantly outweigh the $3 per square foot premium. In the schools studied, there was a 33% reduction in energy use and a 32% reduction in water use; along with other long-term savings in operational and health care costs. This translated to saving green schools about $12/square foot, four times the premium of going green. Sustainable lighting contributes to the overall sustainable design by helping to create a comfortable, productive environment in the school while reducing energy use and environmental impacts of the equipment.

Yet while the creation of sustainable school lighting is undoubtedly worthwhile, it does present a number of design and logistical concerns. To begin with, developing effective lighting is a daunting task in and of itself, aside from the sustainability concerns. The ultimate goal of school lighting, according to the IESNA Handbook, is "to provide a visual environment for both students and instructors that is supportive of the learning processes and is responsive to the psychological and emotional needs of learners." Given the plethora of lighting options available, as well as the scores of vendors to choose from, meeting this description alone can be a significant design and engineering challenge.

Once the decision to go green is deemed feasible, from a financial, environmental and human perspective, how does one go about the process of selecting a sustainable school lighting system? While the following list is by no means complete, the five questions below should all be considered carefully when conducting the search for a viable solution.

Question 1:
How can lighting help reduce our environmental impact?

Throughout their life cycle, the single largest environmental impact of lighting systems is their energy use. In many schools, lighting accounts for as much as 50% of the electricity used by the school. Minimizing the electrical energy used for lighting depends on four steps: 1) design the lighting for adequate light levels and lighting quality, 2) select highly efficient equipment, 3) implement daylight harvesting strategies to reduce electric lighting when daylighting is present, and 4) implement occupancy controls to reduce electric lighting in unoccupied spaces. Some details on efficient lamps, ballasts and fixtures are provided later in this article, along with ideas for daylight and occupancy controls. When these four steps are followed, energy savings of 25-50% can be realized over traditional school designs.

Beyond energy use, the environmental impacts of manufacturing and shipping can also be considered for your lighting system. A number of lighting manufacturers continue to operate factories in the U.S. with tight environmental regulations and shorter shipping distances, while some manufacturers provide lighting equipment manufactured in other parts of the world. International factories may not meet the same environmental standards as those in the U.S., and the environmental impacts of the additional transportation should be considered. Further, some lighting companies provide certifications such as Cradle to Cradle and Carbon Neutral to document the sustainability of their practices.

Question 2:

How can lighting help create a comfortable, productive school learning environment?

Creating a comfortable, productive learning environment depends on an evaluation of the human needs of a

school space. To do this effectively, it is important to consider the profile of the occupants. Classrooms, by and large, are filled with teachers young and old, as well as students. All will be in this space for about six to eight hours a day, with one or two breaks, similar to the duration of a worker in a work place. Some of the tasks in a classroom are the traditional ones such as reading and writing, but today's classroom often has additional tasks, like computer work and audio-visual presentations. Additional and more complex factors, such as color quality and facial modelling, better explained as the unspoken communication found through reading the face and lips of another, are also important, especially with today's changing learning styles and teaching techniques that involve more group interaction.

Consideration of these human needs in classroom lighting can lead to different conclusions about the best type of lighting system. For the traditional classroom, recessed lighting that provided uniform, high light levels throughout the room worked well, and could often be controlled by a single switch. In the contemporary classroom, though, recessed lighting can produce harsh shadows for group interactions and may not produce adequate light levels on the walls, where graphic information is often displayed. Instead, pendant lighting fixtures with some indirect light (uplight) combined with direct light provide a better atmosphere. And more sophisticated control schemes can help the teacher to easily transition from whiteboard lecture mode to AV presentation mode, while still providing enough light for students to take notes.

Question 3:

How do we verify and validate the sustainable aspects of our school?

School designers, managers and decision makers can validate their sustainable designs through the various sustainability certifications and accreditations available today. Some of these are rating systems for the building design, while others are certifications for the building products. A few of these are summarized below.

LEED for Schools: The Leadership in Energy & Environmental Design (LEED) ratings systems from the U. S. Green Building Council (USGBC) are the nationally accepted benchmark for the design, construction and operation of high-performance green buildings. LEED ratings give building owners and operators the tools they need to have an immediate and measurable impact on their buildings' performance. LEED also promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality.

Many of the design criteria used in LEED for Schools are similar to those in LEED NC, but LEED for Schools does get very specific about the lighting systems in classrooms. The lighting criteria presented by LEED for Schools specifically for classroom lighting include:

- Providing a lighting system that operates in two modes: general and AV
- The general mode must provide an average light level of 35-50 footcandles on the desks
- The AV mode must provide an average light level of 10-20 footcandles on the desks
- The AV mode must provide no more than 7 vertical footcandles on the projection area

CHPS: The Collaborative for High Performance Schools (CHPS) rating system also outlines various sustainable lighting criteria for school lighting:

- Using photocontrols to automatically turn off or dim the electric lights when daylighting is available.
- Using multi-scene classroom lighting systems with general and AV modes, similar to the LEED for Schools requirements.

C2C: Cradle to Cradle^{CM} (C2C), is the leading "green" product certification program using a multi-criteria approach to address product design, manufacturing process and practice. The Cradle to Cradle^{CM} philosophy of designing and manufacturing products is based on natural cycles, seeking to minimize harmful material and practices and replace them with closed-loop processes that create benefits for mankind and the environment. C2C is the brainchild of renowned architect William McDonough and pioneering chemist Dr. Michael Braungart who formed McDonough Braungart Design Chemistry (MBDC). MBDC administers the Cradle to Cradle program evaluating products and awarding C2C certification.

Much like LEED, C2C provides different levels of certification depending on the points awarded for each criterion. Within the C2C program, five criteria are fully evaluated and points are awarded. The criteria include the use of environmentally safe and healthy materials, design for material reutilization and recycling, energy efficiency and the use of renewable energy in producing the product, water stewardship practices in the factories that produce the product, and the

social responsibility shown in the overall corporate policies of the manufacturer. Designers can also qualify for an "Innovation in Design" credit in the LEED rating program for using C2C Certified products.

One major feature of the C2C Certification is that it emphasizes continuous improvement by the product manufacturer. The C2C certification is annual and must be renewed each year. So, the manufacturer must continually assess each product decision as to its impact on the sustainability of the product, in order to maintain the C2C certification. The certification process helps to ensure that manufacturers and their products will continue to improve in the five criteria assessed as the re-certification moves forward.

By combining the building rating systems such as LEED for Schools and CHPS with product certification programs such as C2C, school designers can ensure that their buildings address all aspects of sustainability.

Question 4:

Which types of lighting equipment are best for our school?

Classrooms. Most sustainable classrooms today use a lighting system with linear pendant fixtures with an indirect/direct light distribution that have T8 or T5 fluorescent lamps and electronic ballasts. This type of lighting produces clear, diffuse light in the space. The quality of light from the pendants aids in facial modelling, making it easier for students and teachers to interact, promoting good communication. It also provides a uniform light to the desk for ease in reading and writing, and it provides good light levels onto the walls for displays. In some cases, the general room fixtures provide adequate lighting levels on the whiteboard, while some designers prefer using an additional "whiteboard" light. This can be a recessed wall-wash fixture or another pendant fixture designed to direct its light onto the whiteboard.

Sustainable lighting also considers the materials used in the lighting equipment. Historically, most school lighting fixtures have been made of steel or aluminium. These metals are both considered sustainable materials, since they can be recycled when removed from the school. And some manufacturers include recycled steel and aluminum in their products, although using post-consumer material has proven difficult because of the high-grade quality needed for the fixtures. Another material concern has been the use of PVC in the electrical wiring and feed cord materials. Non-PVC materials are now available and at least one manufacturer has successfully eliminated PVC from their lighting fixtures.

Daylighting is an important element in sustainable schools; however, it's best to try to minimize direct sunlight in the space. Use exterior or interior window treatments, like shades inside or fins outside, to reduce direct glare from the sun. For versatility in teaching methods, it is important to be able to completely shut out daylight when needed. That being said, for all occupants that are in a space for more than two hours, a view of the outdoors is a must, as it reduces eye fatigue and provides a mental break from being in a confined space.

Libraries. Whether it's a simple reading room or a full reference library with book stacks, the school library requires high-quality lighting. For the basic reading room, the same lighting used in the classrooms will often suffice. But a more sophisticated solution is needed for book stack areas, which require a lighting system that can deliver light to the vertical planes on either side of the aisle. Specially-designed fluorescent fixtures are very effective for stack lighting, and an infrared motion sensor built into the fixture can turn the lights off or at least dim them down whenever the aisle is vacant, saving valuable energy.

Cafeterias. The school cafeteria provides an area for students and teachers to interact and recharge. For the lighting system to support this vital social area, designers usually want a distinctly different look than in the classrooms. Often, this means using individual suspended fixtures rather than the continuous rows used in the classrooms. These fixtures, which can be round or linear, add to the visual interest and appeal of the space, enhancing the cafeteria's atmosphere.

Question 5:

How can lighting controls help meet our sustainable design goals?

Modern controls technology provides greater flexibility than ever to adapt lighting conditions to the needs of a space at any given time. In sustainable schools, lighting controls can help reduce energy use through occupancy-based controls and through daylight harvesting techniques. Lighting controls are also important for the multi-modal teaching and learning that occurs in today's classrooms.

Multi-modal Environment: The contemporary classroom may have whiteboards, smart boards, computers, and LCD projectors. Classroom lighting systems must provide the right amount of flexibility and control to enhance this sort of multi-modal teaching and learning. For general lecture and classroom discussions, high light levels are needed, along with high quality light that sets the right tone for taking notes and interacting. During audio visual presentations, lighting levels must be reduced in order to see the visuals being presented. However, students might be taking notes during the presentation, and therefore still need the proper amount of light to write.

AV control systems allow teachers to easily switch between the general classroom lighting mode and the controlled lighting distribution needed for AV presentations. For example, a classroom using three-lamp indirect-direct fixtures can have a switch that allows the teacher to easily transition from two lamps on for general lighting to just one lamp on for AV presentations. Another switch can allow the teacher to turn off the fixtures that are closest to the presentation area, further enhancing the visibility of the presentation while still providing adequate lighting for note taking in the classroom. And, this can all be done from switches that are located right at the front of the room for the teacher's convenience. More sophisticated systems provide dimming capabilities for even more flexibility, although at higher cost. The photos on this page show a classroom with a general lighting mode scheme and with an AV mode switching scheme that is switched to one lamp with the front fixtures off.

Occupancy controls. Some of the greatest energy saving opportunities for lighting come from automatically turning lights off when rooms are vacant. Today's dual-technology occupancy or motion detectors combine infrared and ultrasonic techniques to address concerns with older technologies. These devices help prevent the problems with classroom lights turning off even when the room is occupied, which can occur with just an infrared sensor. Matching the coverage area and pattern of the sensors with the room configuration is an important step

General Lighting Mode

AV Lighting Mode

in classrooms, along with locating the sensor properly. In many classrooms, two occupancy sensors mounted in upper corners of the room will provide better performance than simply placing one in the middle of the room.

In libraries, the fixtures lighting the stacks are often left on all day, even when there is very little activity. Newer stack lighting fixtures incorporate an occupancy sensor right in the fixture, so that the lighting will automatically turn off or be reduced when no one is in the aisle. Whenever someone enters the aisle, the lights automatically turn on. Although the cost of these fixtures is higher because of the sensor, the potential energy savings quickly offsets the additional investment.

Daylight Harvesting. School designers today work hard to maximize daylighting and views for students and teachers in the school. And rating systems such as LEED for Schools and CHPS help to promote these design strategies. But, architectural solutions for daylighting do not save energy in and of themselves. Daylight must be properly integrated with the electric lighting system for its energy-savings potential to be realized. Daylight harvesting is a strategy that uses automatic lighting controls to reduce the electric lighting power in response to available daylight.

While daylight harvesting lighting controls have been available for years, the additional cost and complication of installing and commissioning the control systems often has proven prohibitive. Recent developments make it possible to mount the daylight sensor right in the light fixtures, with all the control wiring and power devices self-contained in the fixture. This means that the electrician simply installs the fixture in the normal way, with no special wiring required at the job site. Wireless remote control devices allow the electrician to adjust the daylight sensor easily while standing below the fixture, without the need to be up on a ladder to access the sensor. These fixtures then dim automatically in response to available daylighting, providing great potential for energy savings. The photo shows a typical classroom lighting fixture with a daylight sensor integrated into the fixture.

Today's emphasis on sustainable schools moves us well beyond the energy conservation days of the 1970s to a much broader view of schools and their environmental impacts. The five questions addressed in this article show how your school lighting systems can be an important part of an overall sustainability program. Sustainable school lighting balances concerns about environmental impacts with the need for comfortable, productive learning environments, and it considers how selecting proper lighting equipment and control solutions supports those goals. Addressing these five questions during your design phase will go a long way to ensuring a sustainable design that will please teachers, students and administrators.

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