LEED, GREEN and CPTED
The Challenge in Creating Compatible Lighting Goals
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Two aspects of development that are advancing as priorities for property owners are Crime Prevention Through Environmental Design (CPTED) and the Leadership in Energy and Environmental Design (LEED) rating system. Both of these design approaches have considerable merit, but do CPTED and LEED share compatible goals? An underlying concept in LEED standards is that a sustainable building should minimize light pollution from exterior light sources. CPTED concepts typically require exterior environments to be generously lit in order to maintain a safe and secure environment at night. With such conflicting goals, is there a way to approach both LEED and CPTED requirements so that they agree with one another? This paper will discuss the process to find compatibility between LEED and CPTED, examine the LEED rating system in respect to lighting, describe the benefits of CPTED, and introduce lighting options that can satisfy the needs of both. If addressed properly, the goals of both LEED and CPTED can be compatible with each other.

The process to find compatibility

The key to making CPTED compatible with LEED standards is to balance energy consumption with security needs. With properly planned lighting, building owners can adhere to light pollution ordinances while maintaining uniformity on the site, thus creating a safe environment. Finding a balance between CPTED and LEED requires the application of a simple process outlined below.

First, identify the energy efficiency goals for the building or development. This may include: what level of LEED certification the owner would like to achieve, what type of energy conserving technologies, and what cost efficiencies the owner would like to see in the building. Footcandle levels at the property site boundaries should be addressed according to the function of the property: Parks & rural settings are to be extremely low; Residential zones shall be moderately higher; and commercial and entertainment districts are to have a somewhat higher footcandle level. The lighting design and selection of lighting products are critical to achieving these goals. To guarantee a successful exterior lighting plan, some suggestions from the U.S. Department of Energy are: choose full cut-off lumninaires and low-angle spotlights, use low-reflectance exterior surfaces, and restrict lighting to critical areas.

Next, identify the level of protection needed and the security goals of the project. Security practitioners need to communicate the benefits of security lighting to building owners, for this can hinder the cost savings related to energy efficiency goals. Although costs for energy can be great, one must not underestimate the costs associated with premises liability. LEED goals do not take into account security considerations. Therefore, the identification of these

goals is extremely important to ensure that product selection does not make the property more vulnerable to criminal acts.

Third, explore the multitude of options made available through preplanning. The most effective way to balance the goals of energy consumption and security is to address the identified energy efficiency goals and security goals during the preplanning phase. CPTED and LEED are alike in the fact that they both become extremely costly when implementing either concept as a retrofit. Exterior lighting should only include such illumination as needed for safety and security. Lighting power densities should be designed lower than permitted under American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE) and/or Illuminating Engineering Society of North America standards (IESNA). LEED goals do not take into account security considerations. Likewise, CPTED does not take into account energy efficiency goals. Therefore, the identification of these goals is extremely important to ensure that product selection does not make the property more vulnerable to criminal acts.

The LEED rating system

The LEED rating system has become the driving force behind the green building movement in America. This program is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings. The originators of this standard, The United States Green Building Council, or USGBC, describe LEED as "a national standard that aims to improve environmental, health and economic performance of buildings using established and / or advanced industry principals, practices, materials and standards". The overall LEED program promotes a whole-building approach by recognizing performance in five key areas of human and environmental health. These areas include: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality.

There are numerous LEED rating systems for almost every type of construction: New Construction; Existing Buildings, Commercial Interiors, Core and Shell, Schools, Retail, Healthcare, Homes, and Neighborhood Development. Currently there are four LEED rating systems that address commercial construction: LEED-NC 2.1 for new construction and major renovation projects; LEED-EB for existing buildings operations and maintenance; LEED-CI for commercial interiors projects; and LEED-CS for core and shell development projects. Within each of these systems, there are four levels of certification that can be achieved, (in order from lowest to most prestigious): certified, silver, gold, and platinum. LEED-NC 2.1, the original and most prevalent certification, outlines 64 potential credits than can be granted. A project gains a higher level of certification according to how many credits are granted.

Potential LEED credits for lighting.

While lighting is a relatively small component of the LEED system, it can be instrumental in achieving at least 8 to 22 points in several different areas of the

system. Exterior lighting is especially susceptible to achieving the identified energy efficiency goal. Many of the light trespass and skyglow criteria are very similar to light pollution standards put forth by the International Dark Sky Association. The potential LEED credits gained from lighting are as follows:

1) **Section SS: Sustainable Sites**

Credit 8: Light Pollution Reduction

Possible point value: 1 Point

"Eliminate light trespass from the building and site, improve night sky access and reduce development impact on nocturnal environments." Credit 8, known as the "Light Pollution Reduction" credit, deals with exterior nighttime lighting requirements and strives to: eliminate light, trespass, reduce light pollution, and reduce impacts on nocturnal environments. There are five requirements that must be met before being considered eligible for this credit. The first is: "Meet or provide lower light levels and uniformity ratios than those recommended by the IESNA Recommended Practice Manual: Lighting for Exterior Environments (RP-33-99)". The second requirement is for Exterior Luminaires: "Design exterior lighting such that all exterior luminaires with more than 1000 initial lamp lumens are shielded and all luminaires with more than 3500 initial lamp lumens meet the Full Cutoff IESNA Classification". The third requirement only pertains to interior lighting: "The maximum candela value of all interior lighting shall fall within the building", (not out through windows). The fourth requirement is: "The maximum candela value of all exterior lighting shall fall within the property". The fifth requirement is: "Any luminaire within a distance of 2.5 times its mounting height from the property boundary shall have shielding such that no light or brightness from that luminaire crosses the property boundary". It may be difficult, but LEED credit 8 can be achieved by using these critical methods in planning the design: Use proper placement and orientation of all interior and exterior lighting; Eliminate exterior uplights; and Use full-cutoff luminaries. This credit is currently being reviewed to address particular circumstances such as security lighting for buildings with zero lot lines, or in an urban setting. Since most of LEED standards are continuously reviewed, Credit 8 will likely be revised in the future to better accommodate the various applications of lighting.

2) **Section EA: Energy & Atmosphere**

The USGBC has identified two prerequisites in the LEED manual that must be fulfilled in order to gain any credits from this section. They are as follows:

Prerequisite1: Fundamental Building Systems Commissioning; Required

"Verify and ensure that fundamental building elements are designed, installed, and calibrated to operate as intended." Lighting controls, like all other building systems, must be commissioned well in order to function properly.

Prerequisite2: Minimum Energy Performance; Required

"Establish the minimum level of energy efficiency for the base building and systems." All buildings being submitted for LEED certification must meet either local energy code requirements or the provisions of ASHRAE/IESNA 90.1-1999, whichever is more stringent.

2a) Section EA: Energy & Atmosphere

Credit 1: Optimize Energy Performance

Possible point value: 1-10 Points

Achieve increasing levels of energy performance above the prerequisite standard to reduce environmental impacts as associated with excessive energy use. If the building surpasses the energy requirements of ASHRAE/IESNA 90.1-1999 by 15%-60%, then an additional 1-10 points will be granted. Reductions in lighting energy will certainly impact HVAC loads and, therefore, lead to eligibility for other LEED credits not associated with lighting.

2b) Section EA: Energy & Atmosphere

Credit 3: Additional Commissioning

Possible point value: 1 Point

"Verify and ensure that fundamental building elements are designed, installed, and calibrated to operate as intended." This credit requires the use of an independent commissioning authority to review the design prior to the construction documents phase of design. The strategies of the commissioning authority must be implemented. Also, the building operators must be trained how to use the various systems.

2c) Section EA: Energy & Atmosphere

Credit 5: Measurement and Verification

Possible point value: 1 Point

"Provide for the ongoing accountability and optimization of building energy and water consumption performance over time." This credit requires the implementation of a plan to verify building performance over time. Even though lighting is a key component of this credit since many advanced lighting systems may perform this function automatically.

3) Section MR: Materials and Resources

Credit 5.1: Regional Materials: 20% Manufactured Regionally

Possible point value: 1 Point

"Increase demand for building materials and products that are extracted and manufactured within the region, and thereby supporting the regional economy and reducing the environmental impacts resulting from

transportation." Once again lighting has a minor role in this credit, but can prove to be beneficial to specify luminaries and equipment that are manufactured within a 500 mile radius of the job site.

4) **Section ID: Innovation and Design Process**
   Credit 1: Innovation in Design
   Possible point value: 1-4 Points

This credit can be gained by developing an interesting new design approach that advances the state of the art. One approach that could help you gain this credit, or more of it, is to find a strategic balance between CPTED and energy efficiency.

Advancements in LEED

One of the difficulties of the applications of LEED standards is that it tends to focus on an individual building rather that a development as a whole. However, the new LEED Sustainable Neighborhood Pilot integrates the principles of green building, smart growth and new urbanism. After revision and upon approval of the final version, the new certification is expected to be launched for public use in late 2008. The Sustainable Neighborhood rating system addresses security lighting more efficiently than any previous LEED rating system. The results of this pilot will likely lead to similar aspects of other rating systems being revised to incorporate security lighting needs.

In the newer LEED certifications, such as LEED–CI and LEED-NC 2.2, direct credits are given for individual occupant lighting controls. LEED-EB has developed a prerequisite for reduced mercury content of light bulbs. As technologies advance and new products come on the market, LEED will offer more credits for particular uses of these breakthrough products.

Green Globes

There are numerous alternatives to LEED that can be sought after to gain a green building certification. Green Globes is an online building and management environmental audit that helps property owners measure the environmental performance of their buildings against the best practices available. This program was initially developed in Canada, but is currently in use in the United States and the United Kingdom. Green Globes design is not only an assessment protocol, but can be very useful as a guide for integrating green design principles. The program generates a comprehensive online assessment and guidance reports that help the designer achieve a building that will be energy and resource efficient, healthier to live and work in, as well as save energy costs. For lighting design, Green Globes offers strategies that are similar in scope to those included in the various LEED systems related to site design, material choices, energy reduction, and interior environment. This program can be a useful alternative to LEED, which is often difficult to decipher, in achieving

the balance between the identified energy efficiency goals and the identified security goals.

Crime Prevention Through Environmental Design

The current state of our nation has led to urban decay which promotes an environment ripe for crime. If you were given the tool to prevent a crime before it happened, would you use it? Crime Prevention Through Environmental Design is a proactive tool that is proven to reduce crime. Similar to how the design of a roadway can influence the speed at which a vehicle travels, the application of CPTED principles can influence human behavior. In his book on creating safe and sustainable communities, Ian Colquhoun defined CPTED as "developing defensible space through the belief that the physical environment can be manipulated to influence behavior to reduce crime."

The principles of CPTED have evolved through the work of many specialist researchers in crime prevention including Elizabeth Wood, Jane Jacobs, Oscar Newton, and Tim Pascoe, among others. Most of these specialists base their theories on the idea that if the opportunity for a crime exists, then it will likely happen. This can be prevented simply by altering the design of our physical environment so that it does not invite criminal activity.

Natural surveillance

One of the most effective methods in CPTED is the use of natural surveillance. Research demonstrates that criminal behavior is influenced by cues to the perceived risk of being caught. Natural surveillance limits the opportunity for crime by taking steps to increase the perception that people can be seen, thereby naturally reducing the risk of crime. Jane Jacobs formulated the natural surveillance strategy based on her work in New York's Greenwich Village. She found that as people are moving around an area they will be able to observe what is going on around the, provided the area is open and well lit.

One way to promote natural surveillance is through the application of nighttime lighting. A well lit parking lot or outdoor area is an extremely important feature of public spaces for numerous reasons. Not only does it deter crime and vandalism, it can attract customers, facilitate traffic and pedestrian safety, and increase economic development. Although the design of nighttime lighting is extremely important, carpet lighting of large areas is discouraged. Proper lighting provides an individual with choices on movement: whether to go forward or back from a particular area. CPTED promotes feature lighting that draws the observer's focus to access control points and potential hiding areas. This reduces the amount of exterior lighting necessary to create a secure environment at night.

Premises Liability

If a crime were to happen at a place of business, could the property owner be held liable for that crime? If the victim can prove that the property

owner failed to provide adequate security, then yes. According to the National Institute of Justice, victims of crime are seeking compensation, with increasing frequency, from the owners and managers of properties on which the crime takes place. Plaintiffs are winning these premises liability cases provided the jury finds that the property was not adequately guarded and the setting in which the crime took place could have been designed differently so as to prevent the criminal act. Courts base their decisions of liability on two significant concepts: the foreseeability of the crime and the totality of circumstances.

Lighting design is a consideration of the totality of circumstances. One example noted by the U.S. department of Justice describes how a woman was attacked and raped late one evening at a shopping mall parking lot. An analysis of the case demonstrated that poor lighting contributed to her attack. In another case, two young women were abducted at gunpoint from a mall parking. It was found that the exterior lighting, having not been updated since the 1960s, had substantially degraded output and several of the fixtures had burned out. These cases prove that bad lighting can not only invite criminal activity, but make the property owner liable for the crime.

The benefits of practicing CPTED

To what extent does the environment contribute to the crime, and what can the property owner do from a design standpoint that would be both reasonable and effective to prevent the crime? Property owners who choose to take a proactive approach towards crime by practicing CPTED reduce the likelihood that a crime will occur on their property and, also provide a strong defense of reasonable conduct against premises liability. CPTED is extremely effective in reducing crime since it applies a proactive approach towards crime prevention rather than traditional crime fighting methods such as policing and ticketing which happen after the crime has already occurred. The practice of CPTED can have many beneficial results including: more efficient use of city personnel and equipment in crime prevention, reduction in crime, reduction in potential for crime, increased business activity, an improved business environment, improvement and beautification of the physical environment, revitalization and preservation of neighborhoods, perceived greater safety and security, improved quality of life.

Energy efficient CPTED lighting plans

The role of outdoor lighting in CPTED is to create a safe environment by illuminating the grounds near the building or parking areas. However, security and utility lighting does not need to be bright to be effective. The U.S. department of energy recommends these methods to achieve energy efficient outdoor lighting:

1. Use fluorescent, high-intensity discharge, or low-pressure sodium lights. Application of incandescent lights should be automatically controlled to be on for just a few minutes each day.

2. Consider incandescent flood lights with combined photosensors and motion sensors in the place of other security lighting options.

3. Use photosensors with fluorescent, high-intensity discharge, or low pressure sodium lights.

4. Make outdoor light fixtures have reflectors, deflectors, or covers to make more efficient use of the light source and help reduce light pollution.

5. Use timers and other controls to turn decorative lighting on and off.

6. Use outdoor solar lighting where and if applicable.

Optimization energy use in CPTED should involve designing appropriate light levels for spaces of different functions, using different functions that direct light where it is needed, employing controls that automatically turn lights off when they are not needed, and selecting more efficient lamps. The appropriate selection of lighting for a particular situation requires a working knowledge of the relevant luminaire types.

Lighting types

The lighting industry currently is examining exterior luminaries to determine if high quality lighting, which would appease security goals, can be achieved while reducing energy consumption, light pollution, and light trespass. Newer fixture designs minimize wasted lumens by more efficiently directing emitted light to the desired areas, ultimately producing a higher coefficient of utilization (CU). Some lighting types typically used in outdoor applications are: the cobra head luminaire, commonly used in roadway lighting as well as parking lots; the arm mount luminaire, the most common type used for parking lots; and the post-top functional luminaire.

Figure 1: Cobra Head

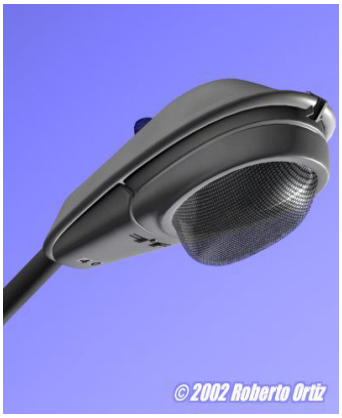

Figure 2: Arm Mount

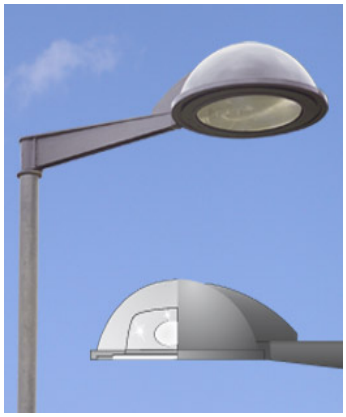

Figure 3: Post Top

Energy efficiency begins with the lamp.

The energy used by an outdoor area lighting system depends on the lamp type, the ballast, the luminaire, the number of luminaires required, and the control strategy. Older installations that utilize incandescent or MV lamps can be replaced with more efficient HPS, LPS, or MH. In a Specifier Report released in July, 2004, the National Lighting Product Information Program compared the lighting quality, and energy efficiency of the two most common lamps used in outdoor applications: metal halide (MH) lamps and high-pressure sodium (HPS) lamps. The table below describes their results:

Table 1: MH Lamps vs. HPS Lamps

	Metal Halide (MH)	**High-Pressure Sodium (HPS)**	
Light Level	X (Equal)	X (Equal)	Light Quality
Ability to Detect Peripheral Objects	X		Light Quality
Ability to Read Signs	X (Equal)	X (Equal)	Light Quality
Overall Energy Efficiency		X	Energy Efficiency
Peripheral Energy Efficiency	X		Energy Efficiency
Readability Energy Efficiency		X	Energy Efficiency

Newer light sources are now available with much higher efficacy including compact fluorescent lamps (CFLs), a wide variety of high-intensity discharge (HID) sources, and light-emitting diode (LED) sources. High-efficiency linear fluorescent lamps are also now available with better color rendering than provided by earlier models. In some situations, LEDs can provide higher application efficiency because of the directional nature of their light emission.

LED lamps

LED bulbs last an average of 100,000 hours, or approximately 10 years, and white LED bulbs last about 50,000 hours. In comparison, a typical 60 watt

incandescent light bulb uses more energy and only lasts approximately 1,000 hours. Unlike fragile incandescent lamps, LED lights can withstand shocks, vibrations, and frequent switching and temperature extremes. Operating costs can be reduced by up to 90% since LED bulbs are 10-50 times more energy efficient, and have lower maintenance and replacements costs. LED bulbs produce little to no heat, which make them safer since they are cool to the touch.

A recent LED street lighting assessment project conducted by the Emerging Technologies Program of Pacific Gas and Electric Company in Oakland, California studied the applicability of LED luminaries in a street lighting application. The project was conducted in two phases. After concluding from the first phase that "no significant concerns (were) so identified" of the likelihood of any negative safety impacts from the installation of the LED luminaries on a public street, the project moved into the second phase. This involved the replacement of fifteen 121 watt high pressure sodium (HPS) luminaires in an Oakland, CA neighborhood with the same number of new 'Beta' LED 78 watt luminaires from Ruud Lighting. The measured results indicate that the metered LED luminaire drew an average 35% less power than the HPS luminaire. Over the course of a year, or an estimated 4,100 hours of operation, each LED luminaire saves 178 kWh. The table below lists the results:

Table 2: HPS & LED Estimated Energy Savings

Luminaire Type	Average Power (W)	Power Savings (W)	Annual Energy Savings (kWh)
High Pressure Sodium	121.0	-	-
LED	77.7	43	178

Moreover, LED luminaries maintained minimum light levels across all spacings while significantly increasing overall uniformity. Significant energy savings can be achieved from the greater uniformity since overall lighting levels are reduced from what is required with HPS luminaries. LEDs have a lower lumen depreciation curve than HPSs, so the need for over-lighting is also reduced. The table below shows the measured luminance levels under both of these luminaries:

Table 3: HPS & LED Photopic Illuminance Levels

	Average Illuminance (fc)	Minimum Illuminance (fc)	Avg. to Min. Uniformity Ratio	Max. to Min. Uniformity
HPS Luminaires				

110' Spacing	1.00	0.19	5.40 : 1	19.00 : 1
120' Spacing	0.80	0.09	5.40 : 1	19.00 : 1
165' Spacing	0.47	0	5.40 : 1	19.00 : 1
LED Luminaires				
110' Spacing	0.58	0.19	3.11 : 1	6.50 : 1
120' Spacing	0.53	0.09	5.68 : 1	16.00 : 1
165' Spacing	0.35	0	7.47 : 1 (or greater)	26.00 : 1 (or greater)

LEDs are proven to reduce energy usage by over 1/3 compared to traditional lighting sources. Although the potential for energy savings from LED street lights is quite substantial, the payback period is relatively long. Although, as technology advances and efficacies improve, the initial installation cost of LED luminaries will likely decrease, thereby resulting in a faster payback period.

Sulphur lamps

The Sulphur lamp is an exciting technology that has the potential to become the lighting of the future. The spectral distribution of its energy is very closely matched to the sensitivity of the human eye. Owing to the completely molecular radiation produced by sulphur, the spectrum is continuous and good color rendering indices can be attained. Exciting sulfur and quartz with microwaves creates great amounts of light with similar properties to sunlight but without the ultraviolet component. Each golf ball sized bulb contains 1000 watts of power. The light is distributed though light pipe for hundreds of feet, possibly replacing hundreds of conventional fixtures. A smaller version may be installed in a torch-type indirect lighting system. The lamp itself may last indefinitely, and the microwave generator may need occasional replacement parts. Lumen depreciation is negligible, and CRI will remain fairly constant. Michael Ury originally invented this exciting technology over the period 1986-1990. Unfortunately, the commercialization of this product failed in the 1990s. It was also found to be impractical to make the system in lower wattages than with the 1000W lamp shown here. Perhaps, the advancement of other recent technologies will make the sulphur lamp functional for the future.

New products in lighting

Developments in lighting technology have resulted in several new products that mesh CPTED principles with LEED concepts. The Lumecon LED street light "Relume" model uses white LEDs to increase outdoor visibility and also meets RP-8 IES standards as well as Dark Sky initiatives. LEDtronics has released its new DC to DC Dimmer for LED lighting products that makes it possible to dim various LED lamps without the expense of a high-end electronic dimmer. The LED dimmer will lower the current to the LED, thereby extending the life of the LED. The new Topco Streetlight is a new solar powered luminaire complete with automatic controls that turn the light on and off as well as regulate the intensity of power during the various times of day. This light can operate at 100% power at night, but can conserve energy by operating at only 60% power during the early morning hours. This luminaire can also be equipped with video surveillance.

Finding the balance between CPTED and LEED will improve development and our way of life. Lighting that is poorly planned may waste energy, decrease vehicle and pedestrian safety, and may result in light pollution. It is important to follow the process of finding the balance between CPTED and LEED by: first identifying energy efficiency goals, then identifying security goals, and lastly using this information to explore the multitude of options made available through preplanning. Although lighting is a rather small component to the LEED rating system, it can be instrumental in achieving up to 22 credits. The practice of CPTED can have many beneficial results including: reduction of crime through the use of natural surveillance, increased business activity, improvement and beautification of the physical environment, and reduce the risk of premises liability. Specifying the appropriate luminaries in outdoor areas is essential to meeting the identified LEED and CPTED goals. The practice and balance of both of these design approaches will create safe and sustainable communities for our future.