Lighting Evaluations and Upgrades

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Marc Karell, P.E., CEM

CED engineering.com
PDH FOR THE PROFESSIONAL

Continuing Education and Development, Inc.

P: (877) 322-5800
info@cedengineering.com

Lighting Evaluations and Upgrades

Direct Benefits of a Lighting Evaluation and Upgrade

Researchers have been paying increased attention to lighting. Studies show that Improvement in the work environment is closely tied with improvement in the performance and safety of workers. Light has a direct correlation with ease of reading, lower eyestrain, reduced errors, better turnaround time, reduced risk of musculoskeletal injuries and psychological well being. There is a vast amount of data indicating that light is one of the biggest challenges to workplace productivity and an area where investments have the fastest payback time and highest return on investment.

The American Society of Interior Designers report that 68% of employees complain about the light in their offices. A study done of Silicon Valley firms showed that 79% of office workers want better lighting. It confirms the need to identify the best methods of lighting the workplace.

Research has established a link between light and circadian rhythms which determine your sleep cycle, stimulation, and relaxation. Studies by the lighting company, Philips, has also shown that lighting has also been found to decrease depression, reduce anxiety and improve mood.

According to the US Energy Information Administration (EIA), as much as 8% of total US power usage is used for lighting. For certain industries, the percentage is higher. With rising electricity rates, this can be a significant financial issue for many firms. There are many benefits to evaluating and updating the lighting of your facilities. According to a number of recent studies, a lighting upgrade has one of the best returns on investment (ROI) of any energy efficiency upgrade. Benefits include:

- <u>Greater worker productivity</u>. A worker is more productive if he/she can see what one's doing properly. According to Verifone, an improvement in lighting in their Costa Mesa, CA office was a major factor in boosting productivity by 5-7%.
- A post office in Reno, Nevada achieved a 6% productivity gain and 150% ROI within the first year of switching to indirect light emitting diode (LED) lighting. Employees could sort mail faster and more comfortably, a minor change that resulted in a profit gain of $400,000 - 500,000.
- A Cornell University study showed that one in four workers experienced a loss in work time based on vision problems and discomfort caused by poor

lighting. Improvements in lighting can result in a 3-5 % productivity gain.

- Increased safety. A better-lit area means fewer accidents. According to the World Health Organization, the rate of automobile fatalities at properly lit streets is 77% lower compared to unlit streets.

- Reduced energy/electricity usage and costs. As will be shown below, the selection of the type of light fixture used and its use can have a significant effect on electricity usage and cost. Given recent rising electricity rates, any opportunity to reduce electricity usage will result in significant cost saved. Lighting is a major component of electricity usage.

- Reduced greenhouse gas (GHG) emissions. Worldwide GHG emission registries list electricity usage as a Scope 2 GHG emitting source. While the facility does not directly emit GHGs, demand for electricity means that a power plant is potentially combusting more fuel and emitting GHGs to meet that demand. Thus, in all registries, reduction in electric usage demonstrates a reduction in GHG emissions.

- Increased sales. Proper lighting can influence business performance. For example, good lighting can attract shoppers to a store and put its products in a good position to influence sales. Two GNC stores installed innovative, energy efficient display lighting to highlight certain products and compared shopping behavior. The percentage of shoppers entering the stores increased from 2.6% to 4.6% when the special display lights were on. Of the larger number that entered, 33.3% made purchases compared to 14% of the smaller number who entered the store with the display lights off; a 133% increase in purchases when the special display lighting was on. (*Survey by Merchant Mechanics*).

- Lower cooling costs. Fluorescent, incandescent, and other lights give off heat or other radiation which forms heat. It can be significant enough to cause an extra load to cool, raising electric usage and cost to cool a building, particularly during cooling season when electric rates are highest.

- Lower maintenance. Certain light types last much longer than others, requiring fewer replacements and, thus, fewer trips up ladders (and risk) and time spent by maintenance crews up the ladders to replace them.

- Improved Financials. What does improved technology and enhanced visual performance mean financially?
  - Save money on utility bills
  - Rebates / Incentives are available to make payback period shorter
  - Depending on whether you retrofit, re-lamp, replace, and in what state you

are in, the property value can improve

- 179D - Energy Policy Act ("EPAct") of 2005, the §179D deduction has yielded substantial savings for taxpayers over the years, while benefitting the environment by incentivizing sustainable design. Offers commercial building owners or primary designers—such as architects, engineers, or contractors—a tax deduction of up to $1.80 per square foot for implementing energy efficiency measures in 2021. Specifically, the deduction is worth up to $0.60 per square foot for improvements to lighting systems, $0.60 for HVAC systems, and $0.60 for the building envelope. These deductions are set to increase in subsequent years.

Since 2008, the efficiency of LEDs has significantly increased and the cost has significantly decreased. The Cost of Waiting is NOW higher than the benefits of marginal improvements in efficiency and future cost reductions. LED Lighting Upgrades can be a very effective financial tool.

Therefore, a good lighting upgrade can lead to many short- and long-term core business benefits. This course introduces the student to some basic lighting terminology and methods to approach a lighting evaluation and upgrade design.

Lighting Basics

The following are basic lighting terms:

- Lumens – quantity of light emitted from a source. Measured at light source.
- Foot-candle – density of light reaching a receptor, expressed as lumens per sq. ft. Usually, foot-candles are measured with a lightmeter. In Europe, this is expressed as "lux". One foot-candle equals 10 lux. Measured at the light surface/destination.

The following are recommended lighting requirements which derives from the Illuminating Engineering Society:

Task Area (depends on exact task)	Footcandles
Offices	20-50
Conference rooms	20-50
Retail	15-40
Food prep manufacturing	50-100
Detailed manufacturing	100-200
Corridors/stairways/hallways	5-20
Loading docks/shipping prep.	10-30
Classrooms	30-50
Medical offices	50
Laboratories	100

Therefore, a good lighting evaluation performed to reduce energy use not only includes more efficient light bulbs and fixtures, but also adjusts the number and location of fixtures so that all areas are lit appropriately. An underlit area could result in errors by workers and even safety issues, such as tripping over unseen items incorrect use of equipment. Overlighting areas not only is a waste of energy, but also may cause excessive shadows and glare and results in a non-optimum work environment and eye strain for the worker. This may mean reduction or adjustment of the lumens given off by fixtures.

Factors Involved in Effective Lighting

Before one designs or modifies the lighting system of a building or area, it is important to understand the occupants' needs. What type of tasks will be performed (manufacturing, office work, walking, etc.) and where? How many people willbe involved? Even issues like the age of people or workers can influence their lighting needs. Together, this is called a "task lighting" analysis.

One issue that must be addressed is the need either for direct lighting onto a subject or indirect lighting. Direct lighting falls directly on a task, and is the most efficient type of lighting, but it tends to produce shadows and glare. Glare can be reducedby moving the task object (usually a personal computer) away from the directlight source, such as at a 90° angle from a window. Indirect lighting is light reflected off adjacent ceilings and walls. It produces less eye strain and is more comfortable to work under than direct lighting. However, sinceindirect lighting is reflected, it is less efficient and can be more costly than direct lighting.

In designing offices, one often wants flexibility on where desks or other task locations will be, so usually ceiling lights are centrally located. In some instances, the most effective lighting for office tasks andfor energy efficiency is to utilize small desk lamps at opposite ends of a work station or table.

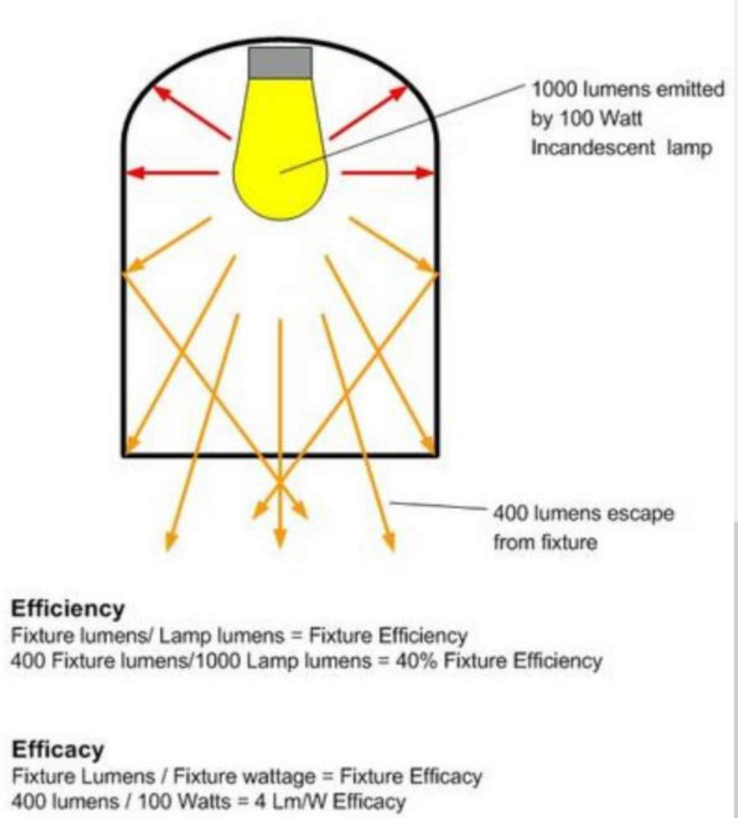
Uniformity is the ratio of the minimum lighting level to the average lighting level in a specified area. ... A working environment with a 0.60 ratio is one in which people don't notice different lighting levels with the naked eye and feel themselves in an environment in which light is well-distributed. In an area where the uniformity is off, people will feel visual discomfort as they travel between the areas.

The way to best determine if the lighting in an area is meeting the needs of the occupants of the area is to do a photometric analysis which will show the range of footcandles and uniformity for every square foot of the area. An experienced lighting designer can build a computer generated model of the space, insert the IES files from the manufacturer of the proposed fixtures, and determine if they will accommodate the occupants of the space.

How to Compare Effectiveness of Different Light Bulb Types

There are many ways to compare light sources to determine effectiveness in addition to doing a photometric analysis of the space. It is prudent to review the light efficacy (in lumens per watt) and life expectancy (how long they last) before they must be replaced (usually in total hours of use). Light efficacy is one determinant in selection of lighting for those interested in energy savings alternative.

Efficiency is calculated by comparing the amount of light produced by the light source to the total amount of light coming out of the fixture. Efficiency is measured in percentage. This is important to understand, since many types of fixtures trap the emitted light inside the fixture. Many downlights, wall packs, ceiling troffers, and other fixtures have low efficiency, requiring much more lumens from the lamp than actually makes it outside the fixture to provide useful light output.



How long a type of light fixture lasts is based on many factors including quality of electrical supply, harmonic distortion, maintenance, and more; thus, it is inherently difficult to maximize. However, many manufacturers do issueestimated ranges of hours for comparison purposes. Lamp types that last long before needing to be replaced can result in significant O&M savings in terms of the cost of replacement, space freed up not having to store as many lamps as before, reduced labor to replace, and fewer trips up and down a ladder to ceilings or other hard-to-reach locations (reduced risk of accidents). These benefits result in significant, quantifiable savings.

Performance of bulbs in Light Color terms:

Color rendering index (CRI) – appearance of lit object compared to appearance in sunlight. CRI = 100 if object looks the same as in sunlight. Most lights in offices, schools, hospitals, and in the places the public visits often are between 80-85 CRI. In places that require specialized lighting like museums, photo studios, and operating rooms, the CRI tends to approach the 90s.

Correlated color temperature (CCT) – appearance of overall room or area expressed in degrees Kelvin. However, although counterintuitive, please note that the greater the number of degrees, the “cooler” the area appears. Commonly ranges from 2700K (“hotter” or “warmer”) to 6000K (“cooler”). Warmer colors tend to highlight better personal and intimate uses, such as in homes and restaurants, where detail is less important. Light bulbs with mid-range K ratings (generally, 3000 to 4100K) are generally assigned to spaces devotedto reading. High K ratings (generally, above 5000K) results in an increasingly bluish light that enhances detail. Such light bulbs are, therefore, used in applications where brightness, details, and the graphic nature of items are more important to be noticed by the viewer, such as, jewelry stores, and medical examination areas. Higher K-rated lights are often referred to as "daylight".

Not all lights can achieve the same effect: LED lighting has a white, clear quality on the kelvin temperature scale and color rendering index, mimicking natural sunlight. Our eyes not only perceive this light as brighter, but also take it as a cue for tapping the body's peak energy levels. When it's time to upgrade, LED lighting offers the brightest, cleanest light to the greatest advantage. This translates into real ROI.

Lamp Lumen Depreciation (LLD) - the reduction in lumen production given constant electrical input over time. Some depreciate markedly over the lamp life; some little.

Lamp Holders - The items that hold light screw in bulbs are called sockets. The items that hold linear tubes are called tombstones and they are responsible for connecting the electrical wires from one end of the fixture to the other and receiving the current of electricity which powers the lamp into creating illumination. Tombstones come in shunted and un-shunted forms. If you use the wrong one, it can void the UL listing on the fixture. It can also lead to potentially costly and dangerous electrical shortage issues such as melted fixtures, exploding lamps, and even fires.

A ballast is the equipment needed by electric-discharge light sources such as fluorescent or HID lamps to regulate voltage and current supplied to the lamp during start and throughout operation. hold the light bulb, It may be either electromagnetic or electronic; Ballasts are being installed less and less as people migrate to LED lighting technology. LEDs do not require a ballast although some are engineered to work with an existing ballast, in order to minimize lighting upgrade costs. You will find ballast-compatible or "plug-and-play" LEDs that are designed to replace linear fluorescents, compact fluorescents, or HIDs. Incandescent and halogen lamps do not require a ballast.

Here is a picture of one type of ballast used in linear fixtures:

Here is a picture of a tombstone lampholder used for linear tubes

Here is a picture of a socket lampholder used for screwin bulbs

Light Bulb Types

Type	Lumens per Watt	Average Light (Hours)
Incandescent	5-20	1,000 – 8,000
Mercury	25-55	12,000 – 24,000
Fluorescent	30-80	7,000 – 20,000
Light Emitting Diode (LED)	60-80	

Incandescent – Electricity heats a filament (usually tungsten) which emits light. Note that federal rules mandating lighting energy efficiency have made many incandescents unavailable.

Advantages:

- Low cost to buy (although expensive to use)
- Small, compact size
- Many are dimmable
- Instant starting
- Can achieve warm color
- Excellent color rendering (CRI of 90-95)
- Requires no ballast

Disadvantages:

- Very energy-inefficient source of light. In fact, many do not meet the Energy Independence & Security Act of 2007 and cannot be purchased
- Relatively short life span
- Generates significant heat, a problem during cooling season

Fluorescents – Electrical current inside tube excites mercury atoms, causing it to emit photons. Phosphor coating inside the tube releases light when it is hit by photons. Fluorescents are often tube-like in shape. The three most common types of fluorescent tubes are T-12 (12 x 1/8” diam. = 1.5”: diam.), T-8 (8 x 1/8” diam. = 1” diam.), and T-5 (5/8” diam.). They are commonly sold in lengths of 2, 4, and 8 feet. Pins are identically spread, so a T-12 tube can fit into a T-8 ballast. T-5 fluorescent tubes are more energy efficient than T-12 or T-8. However, a T-5 tube does not fit into a T-12 or T-8 ballast, requiring a new ballast, raising the cost of replacing with T-5 and potentially lengthening the ROI.

Advantages:

- Low lamp cost (although expensive to use)
- Available in a variety of sizes and color temperatures, and color rendering indices
- Less heat generated than incandescents

Disadvantages:

- Not as energy efficient as other lighting types
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- Outdoor bulbs may be difficult to start in winter in northern climates (need initial warmth to excite electrons)
- Mercury in lamp must be disposed of carefully
- Generates heat that adds cooling load in many applications

<u>Compact Fluorescent Lights (CFLs)</u> – Compact fluorescents are being used to replace incandescent and halogen lights. They provide relatively shadow-free lighting in and because of their small size can fit nicely into sconces, ceiling lights and table lamps. They can be either be screwed in and fit in an incandescent light socket or have two or four pins, or a GU base. Compared to incandescent lamps giving the same amount of visible light, CFLs can use one-fifth to one-third the electricity and last up to fifteen times longer. Like all fluorescent lamps, CFLs contain toxic mercury, which complicates their disposal. Many municipalities have banned the disposal of CFLs together with regular garbage.

Four-pin CFL base

Two-pin CFL base

GU CFL base

Light Emitting Diodes (LEDs) – These units emit light in bands. The unitsappear as dots. LEDs emit light when an electrical current is driven through the junction of two semi-conducting materials.

The main advantage of LEDs is the very high energy efficiency. Currently, LEDs can produce as much as 150 lumens of light per watt, exceeding incandescent lights by 6 to 10 times. Therefore, a 60watt incandescent bulb can be replaced by a 6-9 watt LED.

Another major advantage of LEDs is how long lasting they are. Many vendors warrantee up to 50,000 hours of operation before replacement is necessary. This is about 6 times longer than CFLs and more than twice that of conventional fluorescent tubes. Unlike fluorescents, LEDs containno mercury or other toxic substance, so do not require special disposal handling.

Another advantage is their compact size, allowing them to be used in small-sized applications, such as backlighting of cell phones, hand-held games, etc.

LED lighting is available in all color temperatures and is fully controllable (dimmable, turn on and off electronically). Prices of LED lighting dropped in the 2010's as it has grown in popularity, but, in most cases, is more expensive than other forms at the point of sale, although they are less expensive products when you consider the entire lifecycle because they are very inexpensive to use. Many utilities and states offer incentives to switch to LEDs because of the increased efficiency, which reduces the stress on their electric grids. However, in the 2020's, many such programs are ending or have become less lucrative as the savings for using LEDs is so pronounced that incentives are no longer needed.

LED lighting technology can easily replace fluorescent, compact fluorescent, incandescent, halogen, induction, and HID (mercury vapor, metal halide, low/high pressure sodium, etc.) technologies, providing a better light source at greater efficiency.

Therefore, switching to LED lighting is the popular choice as a “low hanging fruit” to save energy costs and a first step toward becoming more sustainable or “green”.

Other Specialty Lamps

Mercury vapor lamps – These create light by an electronic discharge through mercury. They are commonly used for outdoor security lighting.

Advantages:

- Wide variety of shapes, sizes and lumen ratings
- Long life: up to 24,000 hours; important as they are located often high up at high, inconvenient locations

Disadvantages:

- Poor Lamp Lumen Depreciation
- Requires 5 or more minutes of warmup time (generally, acceptable as dark arrives in outdoor areas gradually)
- Distinctive bluish light
- Requires a ballast

Metal halide lamps – Mercury plus iodidic discharge of light.

Advantages:

- Can successfully replace mercury vapor lamps in many applications.
- Long lamp life
- More energy efficient than mercury vapor and many fluorescents
- Good color rendition; high CRI. This makes it attractive to people; good for stores, malls, etc.

Disadvantages:

- Requires 2-5 minutes of warmup time
- Long cool down period
- Some lamps are position sensitive and some are prone to breakage, requiring closed fixture
- Requires a ballast

High pressure sodium – Light caused by electric discharge through sodium. It is also great for outdoor use. However, it has a clear yellow hue in the light.

Advantages:

- Can successfully replace mercury vapor lamps in many applications.
- Long lamp life
- Relatively short warmup.
- Good lumen maintenance and low lumen depreciation

- Wide range of sizes, types and wattages available

Disadvantages:

- Yellowish light
- Light tends to “blink” in period before burnout; a sign to replace it
- Requires a ballast

Low pressure sodium – While good light to use outdoor, it does not allow strong differentiation of objects (all cars in the parking lot “look” the same; grayish tint of receptor). It has a clear orange hue in the light. Is rarely used in the U.S. and, if found, should probably be replaced with High pressure sodium bulbs.

Induction lighting – A high frequency generator can induce a current in a bulb. Because there are no electrodes in the bulb under stress, using an electric current from the outside induction lighting has a very long life, generally from 60,000 to 100,000 hours. Other advantages include good CRI (about 80) and good efficiency (70-80 lumens per watt). However, induction lighting is relatively new and does not have a strong track record.

Example to illustrate energy cost savings:
A warehouse operates 375 440-watt (after ballast factor) halogen light bulbs on their large ceiling about 4,000 hours per year.

Usage: 375 X 0.44 kW X 4,000 hours / year = 660,000 kWh / year
At a cost of $0.22/kWh, lighting the warehouse costs them $145,200/year.

They propose to replace the halogens with 108-watt LEDs (no ballast factor). The cost is $157,000. They apply for a rebate from the local utility, which grants them a rebate of $56,250, making the net cost about $100,000.

Savings: wattage 440 – 108 = 332 watts x 375 lights = 125 kW, 495,000 kWh/year

$0.22/kW X 495,000 kWh/year savings = $108,900/year cost savings, a simple payback, after rebate, of 1.0 year.

Lighting Controls

While it is beneficial to replace nearly any lights with LEDs, savings can also be achieved by minimizing total hours of operation of all or many lights, particularly by installing controls over hours of operation. After all, turning a light off for the many hours when it is not needed reduces any wattage to zero. Control devices include:

- Occupancy and vacancy sensors. These devices turn off lights when no one is detected in a room. These sensors use infrared technology which turns on a light when the IR beam is disturbed (due to motion). A timer turns off the light after a period of time when there is no motion in the room. Some sensors do not use motion, but use instead body heat to detect occupancy, which is better for spaces like restrooms.

- Motion sensors. T hese aremost popular for outdoor use. They ensure that lights are off until there is movement in the area, indicating a need to light the area so the personcan see his/her way through. It is critical for the sensor to ensure that extraneous movements do not trigger an inappropriate turning on of the light, such as the swaying of trees by the wind. In addition, it is importantto ensure that the motion detector is properly pointed at the appropriate area (i.e., the front of a doorway or a parking lot).

- Timers. Timers can be programed to turn one or many lights on or off based on the time of day (shuts off lights on a weekday at, say, 7:00 pm, when the office's occupants have likely left for the night, and turn lights back on at 7:00 am the next morning)

- Daylighting sensors. These sensors detect sunlight enteringa room and turn off a group of lights, mainly lights near the window through which sunlight enters. When the sunlight passes over the room, the daylighting sensor turns on those lights again.

- Photo sensors. These sensors turn on light when the surrounding area is dark, such as at sunset. These are common sensors for outdoor street lights.

- Dimmers. Allows the user to reduce the electricity fed to the fixture(s), resulting in less intense lighting when called for. Not all dimmers are compatible with CFLs or other fluorescent bulbs.

- Integrated Bi-level fixtures - are equipped with occupancy sensors which dim fixtures when no motion is sensed. These are most useful in areas, such as apartment building stairwells and corridors, places that people tend to pass through, but not occupy - but the lights are required to stay on for safety and security reasons.

Most controls have a reasonable simple payback or return on investment (ROI). Care should be taken in buying sensors that are compatible with the existing type of light fixture in the building. Because retrofitting a lighting fixture with LEDs often costs the same as installing a new fixture (the material may be cheaper with the retrofit, but the labor is more expensive), most people chose to replace their old fixtures with new ones. Decent quality lighting fixtures come with the option to have integrated sensors built into the fixture.

Note that many of these sensors involve data programming (i.e., what time a certain activity should happen, etc.). Ensure that a professional is involved in this. Also ensure that under certain circumstances, information can be overwritten by the user. In modern systems, sensors, photocells, and time clocks can be programmed and overridden by signals from mobile phones and similar devices.

Other lighting notes:

- Skylights. Installation of skylights in the proper location(s) in the ceiling can allow sunlight into a building and minimize air losses. If the skylight is large enough, it can illuminate and reduce the use of lighting fixtures in a large area of the center of a building where windows would be ineffective.

- Painting. Walls near windows (particularly of offices) can be painted a light color to minimize light absorption and maximize its reflection throughout the space to use natural light and reduce the need for general lighting in the area.

- Light-colored furniture or shelves. These, too, would minimize light absorption, reflect to ceilings, and reduce the need for general roomlighting.

Performing a Lighting Evaluation or Audit

Building lighting evaluations or audits are generally performed as part of an overall energy audit. However, audits focused only on lighting have been performed and have their benefits.

Such an evaluation should begin with the engineer collecting relevant data from the facility, such as:

- <u>Electricity bills</u>. Determination of the total number of kilowatt-hours used on a monthly basis for at least the previous 12 months, and preferably the last two years. If the building has sub-metering, then electricity usage data of each subdivision should be collected.

- Understanding building usage. The building manager should be able to explain clearly the different uses of the building(s) in question, such as quantity of office space, lobbies, warehousing, manufacturing (and type), retail space (and type), and other functions. Ideally square footage for each type of usage should be provided. How much parking space isthere? Are there other needs for outdoor lights? Finally, the amount of time different lights are used need to be determined, which includes hours that offices or other operating areas are “open” and other needs.

- Inventory of lighting fixtures. The facility or auditor should develop an inventory of lighting fixtures throughout the subject building(s), how many, the different types, the wattages, the color temperatures, the heights, the mounting, and fixture types. A fairly accurate quantity of fixtures, operating bulbs, tubes, etc. is necessary. In addition, such information should be separated into the separate functions of the building (the office portion, the warehouse, retail, etc.). One does not need to climb upon ladders to see exactly what type of bulbs are in certain fixtures. Checking the building’s or section’s equipment storage area can provide aproper estimate of the type of lamps used, as every building normally keeps backup of lamps for replacement.

- Management of change. What future changes may occur in the building(s), such as a building addition or planned expansions or contractions of certain work areas (i.e., manufacturing, offices, etc.)?

Now that this information is collected, the auditor needs to calculate how much electricity is currently being used by lights based on the number, wattages, and hours of operation. Then the auditor can look for areas of energy savings with the basis of recommending strategies with the shortest simple paybacks.

1. Replace halogen, incandescent, sodium, and fluorescent lights (tubes and CFLs) with LED equivalents because of the huge energy savings relative to their cost. Remember to factor in the reduction in maintenance labor with fewer changes of lights, the reduction of workplace safety risk, and the reduction in additional heat adding to air conditioning load.

2. Convert any existing magnetic ballasts to electronic.

3. Use silver reflectors in ballast to shine more light onto the work area.

4. Look for opportunities to de-lamp. Get a light meter and determine whether the different work areas meet or exceed their recommended light intensity. If an area greatly exceeds the recommended standard, consider removing a lamp or two

and determine if there are any effects. Another approach is to replace ceiling fixtures with table lampsfor specific workplace areas, such as, for CADD drawing areas, and take out or disconnect overhead, ceiling lighting, if workers are comfortable with this. In many cases, two low wattage LED table lamps, one on each side of the worker may be superior (less electricity, sufficientlighting, less glare) than an overhead fluorescent. Another example is to disconnect 1 or 2 tubes of a 4-tube fluorescent tombstone because the light from all 4 tubes is excessive for the tasks at hand.

5. Install appropriate controls to turn off lights when not in use.

A key to making recommendations to upgrade lighting is the simple payback or return on investmentor ROI. While complex calculations can be performed based on the value of current and future money, most ROI calculations are based on simple paybacks: the cost of the lights and fixtures compared to the time it will take to earn back that cost in electricity savings. An example of a ROI calculation was given earlier in this course. All of the listed recommendations, if designed properly, have excellent ROIs. The ROI and ultimate long-term cost savings are the selling points to the lighting audit. A good auditor should evaluate and present options for other opportunities to upgrade lighting at a facility to ensure that the right number of lumens is involved for the task at hand (“task lighting” described earlier), even if the ROI is longer or non-existent.

A good lighting evaluation or audit should have a final report with an Executive Summary (as most clients only read this) and sections for Background, for Summary of Data, and for Options (with ROI calculations for all). Raw building or summarized data should be placed in an Appendix.