High-Efficiency Lighting Systems

What is a High-Efficiency Lighting System?

Not only can lighting systems affect an occupant's sense of well-being and physical comfort in a building, but they are also major consumers of electricity as well as a source of unnatural heat during the summer. Each year in the United States, $37 billion is spent on electricity with 30% of those annual electric expenses being consumed in commercial buildings. These expenses can be reduced with a high-efficiency lighting system. A high-efficiency lighting system is one that uses both natural and electrically sourced lighting schemes, along with a smart lighting control system, to provide a comfortable environment for occupants while reducing energy costs. New technologies in energy efficient, environmentally friendly lighting equipment have been developed that can reduce operational costs 30-60% and improve light quality, if installed.¹

How to Incorporate a High-Efficiency Lighting System?

Incandescent lights are now outdated and new lighting technology is available that is both energy efficient and cost effective. Choosing the right system of lighting is important to achieve these measures. When choosing lighting, it is vital to take into account a balance in design that maximizes light quality while minimizing the amount of fixtures and lamps needed. Other factors to consider are the availability of such lights, maintenance requirements, dimming capabilities, and cost. Choosing the right type of light fixture, or luminaire, can also provide energy savings depending on the lighting system design. A luminaire consists of lamps, lamp sockets, ballasts, reflective material, and shields. The right type of luminaire will optimize the performance of your lighting system.²

Lighting Technologies and Placement Strategies

Fluorescent Lamps (3 types): New lighting technologies such as T-8 and T-5 linear fluorescent lamps and compact fluorescent lamps (CFL's) can achieve goals of being

more cost effective and environmentally friendly. These lamps are not only more energy efficient than conventional lights, but they also have: a longer lifespan, can be controlled easily, are available in the market, and are affordable. Fluorescent lamps are about 3 to 5 times as efficient as standard incandescent lamps and can last about 10 to 20 times longer. Consider placing fluorescent lamps in areas where they conform to architecture and natural light while being coordinate with dimming controls.

1. The first type is the linear fluorescent lamps that are starting to replace T-12 lamps as the dominant lighting choice. These small diameter lamps provide great surface lighting while improving overall light performance. Linear fluorescent lamps are most effective when implemented as the ambient light source for an area.

2. The compact fluorescent lamps (CFL) are small in size and thus best used as a recessed lighting device, as a wall or ceiling mounted light, or even task lighting. Compared to incandescent lights, CFL's have a much longer lifespan and have greater energy efficiency.

3. Inductive fluorescent lamps are used as white light sources and have extremely long lives with durations of over 100,000 hours along with being energy efficient. These lamps can be used indoors or outdoors as well as having an instant-on capability and reduced maintenance requirements.

Fluorescent/Electronic Ballasts (4 types): Installing electronic ballasts instead of the conventional magnetic ballast can save at least 12% on energy consumption depending on the type of ballast chosen.

1. The first type is the fluorescent ballast, which should be used alongside with fluorescent lamps to achieve energy savings. One type of ballast is rapid start ballasts, which are the most common type of ballast and come at an affordable price with a long life.

2. A second type is the instant start ballast, which is the least expensive model because it has a shorter lifespan but with a higher efficiency than rapid starts. Instant start ballasts are effective when installed in buildings that need to leave lights on constantly and for long periods.

3. Another type of ballast is the program rapid start ballasts, which are most cost effective and energy efficient when installed in the proper lighting system. While they are more expensive than the standard rapid start ballast, they can last longer in situations where lights are turned on and off regularly.

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4. Lastly, dimming electronic ballasts should be considered in a holistic lighting system that generally doesn't use lower light levels and will dim the lights when natural daylight is available to achieve energy savings. Dimming levels can be achieved as low 5% to 10% or there are more expensive architectural dimming ballasts that can achieve a light output as low as 1%. Overall, electronic ballasts help to reduce fatigue and eyestrain upon occupants while providing a smoother light quality without flickering. This also helps to achieve a longer lifespan and increased performance of lamps.

*High Intensity Discharge (HID) Lamps (1 type):*

1. HID lamps are most effective when used to light large areas and long distances and are great for outdoor applications. It should be noted that HID lamps don't work well with occupancy sensors because HID lamps take time to warm up if they have been shut off for a while. HID lamps can be restarted immediately after being turned off since they retain the heat they used while turned on. There are ballasts available that can be used on HID lamps with occupancy sensors because they give the HID lamps dimming capabilities.

*LED Lamps:*

1. Light emitting diode (LED) lamps are the newest light source technology. LED lamps can last between 40,000 hours and 100,000 hours depending on the light color chosen. While LED lamp technology is still advancing, current applications exist in exit signs, under cabinet lighting, and decorative lighting. Due to their current technological state of have poor lighting efficacy, they are not productive as an overall lighting source.¹ LED technology does have its other benefits though. LED lamps use 75% less energy than incandescent lamps, which also reduce operating expenses. LED lamps last 35 to 50 times longer than incandescent lamps and 2 to 5 times longer than fluorescent lighting. LED technology also uses very little heat and this will decrease cooling costs in a building. LED lights are very durable and Energy Star qualified LED lighting comes with a 3-year warranty. Indoor dimming models and outdoor automatic daylight shut-off models with motion sensors are available.²

*Lighting Controls*

Implementing various lighting controls will also help in creating a more efficient and flexible lighting system. Besides the basic on/off switch, there are five other lighting controls that can improve the overall efficiency of your lighting system.

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¹ US DOE and US EPA. "Why Choose ENERGY STAR LED Lighting?"

² US DOE and US EPA. "Why Choose ENERGY STAR LED Lighting?"
1. Manual dimming is one way to achieve energy savings by being able to adjust the input power, reducing peak power demand, and overall lighting flexibility. Slider switches allow occupants to change the lighting in an area or dimmer settings can be adjusted so that lights are outputting a specific amount of light at different times of the day.

2. Photosensors can be used to detect illuminance and adjust the lighting output accordingly. Photosensors are used mainly for the electric power demand in a lighting system, which subsequently reduces the amount of cooling required in a building. Using photosensors requires an analysis of solar heat gain and energy usage of the entire building for photosensors to be productive.

3. Occupancy sensors are another means to achieve energy savings. Occupancy sensors work by detecting motion or sound (depending on the sensor) in an area and turn the lights on and off accordingly. Occupancy sensors can even be used together with dimming controls to maximize efficiency. Occupancy sensors are most effective when placed in smaller, enclosed spaces.

4. Clock switches and timers can also be used to control lighting for preset periods. These devices are preset by the user to have lights turn on and off depending on the time of year. Clock switches can be used together with photosensors.

5. For a building-wide lighting system, centralized building controls can be implemented to automatically adjust the lights in a building (on/off, dimming, etc.). For example, lights can be preset to turn on right before workers arrive at the office and the lights can then be dimmed during the afternoon, then off after the workday. A centralized building control system can significantly reduce energy usage in a building because lights can be programmed to not be in use when people aren't occupying the facility. 

6. DALI stands for Digital Addressable Lighting Interface and describes the new interface standard for lighting controls solutions defined by the lighting industry.

Example

Refrig-It Cold Storage (Kearny, NJ)

http://www.aceenergy.com/showcase/case-studies/100007/refrig-it-cold-storage-kearny-nj

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Benefits

Human Health

- A study by Aaras et al found a link between an improved lighting system and a 27% reduction in headaches by employees. This accounts for a $35 savings on employee health insurance costs per year.\(^7\)

Energy Savings

- A study by Carnegie Mellon University's BIDS\(^{TM}\) showed that implementing a high performance lighting system saves $82 on energy costs per employee annually (or $0.41 per square foot). This can also lead to productivity gains of $1,600 annually in conjunction with an improved lighting system. In terms of lighting costs, 4.9kWh can be saved per square foot per year and 0.2 kWh on cooling can saved per square foot annually.\(^{219}\)

Costs

For a 20,000 square floor building considering upgrading their lighting units from conventional T-12 fixtures to T-8 fixtures:\(^8\)

<table>
<thead>
<tr>
<th>Fixture</th>
<th>Watt Usage per individual T lighting unit</th>
<th>Burn-hours per individual T fixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-12 (2-lamp 40 watt) fixtures with magnetic ballasts technology</td>
<td>80 watts (40 watts x 2)</td>
<td>20,000 hours</td>
</tr>
<tr>
<td>T-8 (2-lamp 32 watt) with electronic ballasts technology</td>
<td>60.2 watts (32 watts x 2 - 3.84 watts saved using electronic ballasts)</td>
<td>30,000 hours</td>
</tr>
<tr>
<td><strong>Savings (converting from T-12 to T-8)</strong></td>
<td><strong>19.8 watts (24.8%)</strong></td>
<td><strong>10,000 hours (33%)</strong></td>
</tr>
</tbody>
</table>


Assuming that this facility would need to light the entire building 10 hours a day all year with 400 fixtures paying New Jersey's retail electricity price forecast for commercial buildings ($0.14/kWh):²

<table>
<thead>
<tr>
<th>Fixture</th>
<th>Watt usage per unit for 3650 hours (Watts/unit * 365 days x 10 hours)</th>
<th>Annual watt usage for 400 units (watt-hrs/unit * 400 units)</th>
<th>Annual lighting cost ($0.14/kWh * kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-12 (2-lamp 40 watt)</td>
<td>292000 watt-hrs/unit</td>
<td>116,800 kWh</td>
<td>$16,352</td>
</tr>
<tr>
<td>T-8 (2-lamp 32 watt)</td>
<td>219730 watt-hrs/unit</td>
<td>87,892 kWh</td>
<td>$12,304.88</td>
</tr>
<tr>
<td>Savings (converting from T-12 to T-8)</td>
<td>72,270 watt-hrs/unit</td>
<td>28,908 kWh</td>
<td>$4,047.12</td>
</tr>
</tbody>
</table>

Incentives are often available for implementing a high-efficiency lighting system. The Energy Policy Act of 2005 includes a tax reduction for investments in "energy-efficient commercial building property" for various energy efficient measures including indoor lighting of a new commercial property. If the project is eligible, a $0.60 per square foot tax deduction can be awarded if energy efficiency improvements are made in the lighting sector. To qualify for the lighting tax deduction, a design that improves energy efficiency by 16 and 2/3% must be achieved. This tax deduction will benefit the person or organization (usually the building owner or tenant) that pays for the construction of the project.⁹ The CBTD expiration date has been extended twice, most recently by the Energy Independence Act of 2007 (EISA). With this extension, the CBTD can be claimed for qualifying projects completed before January 1, 2014.¹⁰

For more information, visit:
http://www.energystar.gov/ia/business/comm_bldg_tax_incentives.pdf or
http://www.lightingtaxdeduction.org/tax_deduction.html

Equipment incentives are also available through the New Jersey Office of Clean Energy (NJ OCE). These financial incentives can be applied for by implementing qualified prescriptive lighting equipment. For more information, visit:

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Resources

ENERGY STAR

US DOE - Commercial Buildings: Lighting and Daylighting
http://www1.eere.energy.gov/buildings/commercial/lighting.html

Commercial Lighting Systems Initiative

Illuminating Energy-Efficient Options
http://www.lrc.rpi.edu/researchAreas/reducingbarriers/index.asp

High Performance Commercial Lighting Systems

Lighting Technology Information Sheets
http://www.lightingtaxdeduction.org/technologies.html

Commercial Lighting Solutions
https://www.lightingsolutions.energy.gov/comlighting/login.htm;jsessionid=191F6C08289BBFD90F86946E4878E7FA.jvm3