Fundamentals of Lighting Control

Presented by The Watt Stopper and the U.S. Department of Energy's Rebuild America

U.S. Dept. of Energy
Rebuild America

“Rebuild America helps communities become stronger, cleaner, and more environmentally and economically sound through smarter energy use. The program starts with building renovation – and expands from there – to include renewable energy, efficient new building design, energy education, and other innovative energy and resource conservation measures. Ultimately, communities benefit from revitalized neighborhoods and main streets, improved school facilities, better low-income housing, and the positive economic impact brought by keeping local dollars at home. Rebuild America and its Business Partners work together to make the connection between the energy efficiency needs of the community and market-based solutions of industry.”

The *Fundamentals of Lighting Control* is intended to provide an overview of the lighting controls field for the facility manager, property owner, or building tenant who may be unfamiliar with the control technologies, how they look, how they work, and how to best implement them. Although the title of this guide refers to only lighting, controls can also be used to save energy in applications such as HVAC – typically the largest energy consuming system in larger buildings.

The guide is organized in five sections:

Section 1: Introduction

Introduces the need for lighting controls and how users can benefit from them.

Section 2: Lighting Control Strategies and Products

Discusses lighting control strategies as well as the basic product technologies used to achieve those strategies.

Section 3: Assessing Lighting Control Applications

Reviews the process involved in developing and implementing a lighting control application, including some preliminary considerations and other factors important to the success of a lighting control application.

Section 4: Application Examples

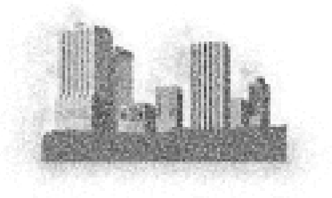
Provides examples of lighting control strategies and how they are implemented with specific systems or devices. These examples can suggest to the reader some ideas for applications in their own buildings and facilities.

Section 5: References and Resources

Lists useful reference and resource information.

Introduction

Today, nearly 40% of an average business's energy usage occurs in lighting its facilities. Next to heating and air conditioning systems, lighting systems account for the greatest energy consumption and costs. These significant costs can be managed more effectively through the use of lighting controls, a fact that spurred the federal government to require states to adopt energy codes that require the use of automatic lighting controls in nonresidential facilities.



Over the past several years, the use of lighting controls has increased throughout the country. According to a 1995 survey conducted by the Energy Information Administration (EIA), more than 60% of the total commercial floorspace in the United States utilizes some form of lighting control.

Organizations that have implemented lighting controls have realized a wide range of benefits.

• ***Energy savings.*** Perhaps the primary benefit is that of energy savings. Lighting controls can result in energy savings of more than 30%, reducing building operating costs by 10% or more.

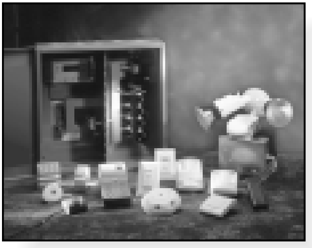
• ***Convenience.*** When selected and implemented correctly, lighting controls operate transparently in the background, enabling users to reduce their energy usage conveniently and without disruption for building occupants.

• ***Flexibility.*** Many lighting control systems are designed for maximum flexibility, to accommodate changes in workspace configuration, schedules, and activities.

• ***Information.*** Some lighting control systems, particularly centralized ones, can provide a great deal of information about lighting energy usage, identifying when and how much energy is being used by a specific department or facility space. This information facilitates the ability to divide overhead costs among departments accurately.

• ***Productivity.*** One less tangible benefit of significant economic value to businesses is the increase in employee productivity that can result from optimal lighting. For instance, recent studies indicate that daylighting boosts productivity of grade school students, increasing test scores by 7-26%. Other studies have documented an average increase of 40% in retail sales in stores employing daylighting through the use of skylights.

• ***Safety & security.*** Often, lighting controls are used to ensure that critical lighting remains on for the safety of occupants. This can include the continuous operation of emergency lighting and exit signage, as well as the effective lighting of exterior parking facilities, walkways, or tunnels.



section 2

Lighting Control Strategies and Products

Control Strategies

Many lighting control professionals make a distinction between a control strategy and the control technology that is used to carry out that strategy, although at times, the two are very closely related.

Generally speaking, a lighting control strategy refers to the basic method that will be used to control lighting systems. Control technologies, on the other hand, usually refer to the actual device that will be used to carry out a specific strategy. For instance, one control strategy is known as scheduled control, which refers to the approach of using time intervals to control lighting. The technologies actually used to perform scheduled control, however, can vary from centralized control systems that manipulate lighting systems throughout an entire building to individual timer switches that control single rooms.

The principal lighting control strategies include:

• ***Occupancy-based.*** This strategy involves switching lighting off and on in response to the occupancy of a particular space. It is not dependent on time intervals or scheduled periods, but responds to the individual usage of a controlled space.

• ***Scheduled.*** Scheduled control involves the management of lighting according to pre-set time intervals. These intervals can be relatively brief periods of time (i.e., five or ten minutes) or larger blocks of time (i.e., ten or 12 hours). Some control professionals consider astronomic control to be a subset of this strategy, as it is based on predictably occurring astronomical events (such as dawn and dusk).

• ***Light level control.*** This strategy involves adjusting the level of light output in a number of ways to achieve specific objectives. Important types of light level control include:

a. Daylighting. In interior building areas that receive abundant natural light, this strategy uses that light to supplement, and replace, the use of artificial light.

b. Tuning. This approach uses the adjustment of lighting levels to achieve appropriate light levels for different occupant activities. For instance, an individual engaged in drawing or reading will require a higher light level than someone engaged in shelving merchandise. This is also often referred to as "task tuning" or "task lighting."

c. Lumen maintenance. This strategy focuses on maintaining an even level of illumination throughout the lifespan of the lighting system lamps. To do so, it relies on reducing initial light levels at the outset of the lifespan, and gradually increasing light levels as lamps age.

• ***Load shedding.*** Load shedding is directed toward reducing a facility's lighting load to achieve an overall reduction in demand, usually at peak usage times, such as midday.

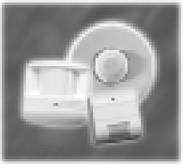
Control Technologies

To achieve these various control strategies, a wide variety of technological devices and systems are available.

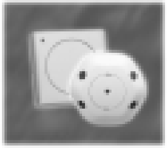
• *Occupancy sensors*

Occupancy sensors use a variety of technologies to detect occupants and send appropriate signals to area lighting. Since the most common sensing technologies are passive infrared, ultrasonic, or dual technology, those are described here. Usually, the best applications for occupancy-based lighting control involve settings where space usage is intermittent and lights would otherwise be left burning when the space is vacant.

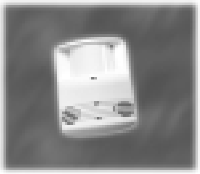
a. PIR technology. Passive infrared technology detects occupancy by reacting to infrared energy sources, such as a human body, in motion. By identifying the difference between such energy sources and the background space, the sensor can locate occupants and signal lights to turn on. To operate effectively, PIR sensors require a direct line-of-sight view that encompasses the coverage area.



b. Ultrasonic technology. To detect occupants, this type of occupancy sensor utilizes Doppler signaling. The sensor emits ultrasonic sound waves that bounce off objects in the covered space, and then measure the amount of time it takes for the waves to return. When there is movement in the space, these sound waves will return to the sensor's receiver at different frequencies, resulting in occupancy detection. This technology is ideal for applications where the sensor would not have line-of-sight views of occupants or where activity levels may be low.

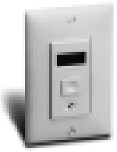


c. Dual technology. Occupancy sensors that employ multiple sensing technologies are usually referred to as "dual technology" or hybrid devices. Most commonly, these type of sensors employ PIR and ultrasonic technologies, where lighting is turned on when both technologies detect occupancy, and remains on as long as at least one of the sensing technologies continues detecting occupancy.



• *Time switches*

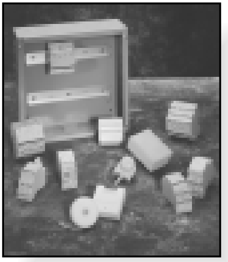
Either mechanical or electronic, these devices turn lights on or off after a specified interval. The interval can be varied to meet the needs of the occupant, usually from brief periods of five minutes up to intervals as long as 12 hours. Often, these switches can replace conventional wall switches without the need for additional wiring. Furthermore, users can take advantage of various features that provide additional functionality, such as user-adjustable settings (i.e., time-out period, time scroll, one-minute flash warning, and beep warning features) and compatibility with central time clocks or building management systems.



Often, practical uses for time switches will be areas that are used frequently but for short periods of time, such as utility or control rooms, storage areas, and library book stacks.

• Photo-sensitive controls

This technology incorporates sensing of natural light to adjust the level of artificial lighting, based on the adequacy of the available natural light. Some types of photo-sensitive controls operate by turning the controlled lights on or off based on natural light levels, while others operate by continuously dimming the controlled lights.



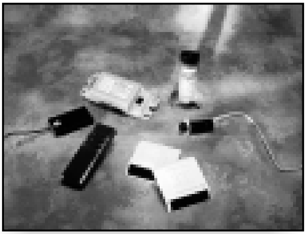
Usually, devices that control interior lighting are referred to as "daylighting" controls. Another common phrase is "daylight harvesting." This strategy is an obvious choice for areas with access to natural light, such as atriums, perimeter offices, hallways, and other types of areas with skylights. Most exterior lighting will be ideally suited for light level control as well, such as parking areas, customer service areas (i.e., drive-through facilities), and building entranceways.

• Lighting control panel systems

Facilities managers achieve long-term scheduled control through the use of lighting control panels. These systems enable facility lighting management from a single location for days, weeks, and even months in advance. These products can also interface easily with building management, security, and HVAC systems.

• ***Remote/dimming controls***

For personal control of work areas, users can choose remote controls that switch lighting on, off, or dim light levels. These types of controls are particularly useful in implementing task tuning, since the individual user can match their needed light level to their specific work tasks.



Assessing Lighting Control Applications

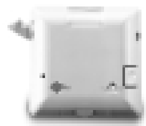
Careful planning can help ensure the success of your lighting control application. This involves looking at a wide range of issues, including assessing which control strategy and technology will work best for a specific application. Just as importantly, however, is a thorough understanding of what occupants expect from their lighting, how they currently use it, when they use it, and for what activities. One must also assess the characteristics of the space and the type of lighting being used there. Is the space outdoors? Is it indoors but near sources of natural light? What kind of fixtures are in the space? What kind of lights and ballasts are in use?

Finally, the age of the application itself is important. Is the facility an existing one or will it be newly constructed? If implementing lighting controls for a retrofit project in an existing facility, there may be specific controls that are better suited than others; occupancy sensors may work better in a retrofit application than other types of control methods. If the application involves a newly constructed facility, the designer and ultimate occupant have a unique opportunity to optimize the effectiveness of lighting controls by integrating the control systems most harmoniously with the rest of the building systems. For instance, designing the control system along with the lighting systems may enhance the design of both systems, while defining a control strategy and technology can help identify fixture types or how fixtures should be circuited.

• *Preliminary considerations*

Many designers consider these issues at the outset of any lighting control project, whether in new construction or in an existing facility.

a. Lighting audit. At the start of a retrofit project, a lighting control designer or engineer may want to identify how the lighting energy is currently being used. This will be determined by conducting a lighting audit, during which



lighting in different locations will be connected to monitoring equipment to track a number of factors. These include how often a space is occupied, how long the lights currently operate, what the space is used for, and what special equipment or fixtures may be located in the space.

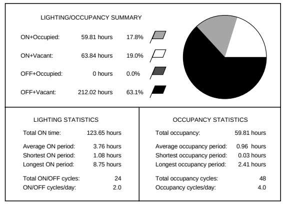
b. Applicable energy codes. Another important preliminary task is to identify what the applicable building or energy codes require for lighting controls. This may differ from state to state. For instance, in California, the governing code is Title 24, which requires any commercial building larger than 5000 square feet to use a control system to automatically turn off lighting during periods when the building is not normally occupied. In addition, commercial buildings must utilize area controls that allow lighting in each individual partitioned space to turn on or off via either a manual switch or by an occupancy-based device. Spaces larger than 250 square feet that receive adequate natural light must use that daylight to illuminate the space.

In numerous other states, the governing codes are based on ASHRAE 90.1 requiring all lighting systems to include manual, automatic, or programmable controls. Only emergency and security lighting are exempted from this requirement. Every space that is enclosed by walls or ceiling-high partitions must also contain control devices capable of turning off all the lights within the space. (For more information about applicable energy codes and resources for complying with them, see Section 5, References and Resources.)

• *Project considerations*

These factors primarily influence the selection of the control strategy that will be most beneficial.

a. Space usage. The results of the lighting audit should reveal how occupants are using their workspaces. This information is vital to selecting an optimal control strategy. Some general rules regarding control strategies apply to space usage patterns. If a space is intermittently and unpredictably occupied, an occupancy-based strategy to control lighting will provide the greatest opportunity for energy savings. If, on the other hand, the space is occupied on a regular basis, a scheduled control strategy may be more effective.



A sample report from an occupancy/lighting logger reveals the amount of time areas are vacant while lights continue to run. This can be used to project energy savings if lighting controls are implemented.

b. Space location. Another basic consideration is the location of the space and its proximity to natural light. Areas with abundant natural light, such as offices on the perimeters of buildings or atriums, will be ideal candidates for daylighting (sometimes called light level control).

c. Types of lighting to be controlled. One important factor in the planning stage is to identify what types of lighting exist throughout the facility. Different lighting types demonstrate different compatibility characteristics with control technologies. The presence of dimming ballasts will be essential, for instance, for use of continuously dimming daylighting systems. Systems that employ non-dimming ballasts can be compatible with a wide range of control technologies, including occupancy sensors and lighting control panels. High Intensity Discharge (HID) lighting will not be amenable to ON/OFF control, but can be controlled by bi-level switching technology.

d. Electric rate and demand charges. Understanding what your electric rate is and how your electricity costs are affected by demand charges is important to the decisions you'll make about the right lighting control system.

The higher the electric rate, the greater the economic benefit and motivation a user will have for reducing the lighting energy consumption in their facility. This may translate into a return on investment that justifies a more elaborate control system. Likewise, recognizing a facility's peak demand and the impact on electric rates can spur a user to adopt a load shedding control strategy to focus on minimizing demand charges.

Application Examples

In this section, you will find sample scenarios that illustrate how each control strategy might work in a "real life" setting. Of course, actual results will vary depending on many factors.

A. Occupancy-based control

Application #1: Individual, enclosed office in commercial office building.

Details: The office occupant is a manager who frequently leaves the office for moderate intervals of time (15-30 minutes or for an hour or two for meetings). Often, other employees will enter the office briefly to deposit items on the desk.

Control Strategy: Occupancy-based.

Rationale for Strategy: While many commercial office buildings employ energy management systems for facility-wide lighting control (i.e., sweep-off of lighting at pre-set times), occupancy-based control can increase the amount of energy savings by turning off lights at other times when they are not needed.

Control Technology: PIR wall switch occupancy sensor.

Special Features: Manual-ON option.

Reasons for Specific Product Selection: A wall switch sensor is very cost-effective, with quick and easy installation that replaces a standard wall switch. The manual-ON feature enables the room's lights to remain off when an occupant enters the room until they physically activate the switch. This ensures that the lights remain off when there is "pass-through" activity, such as when someone enters only to place something on the desk. This enables maximal energy savings.

Application #2: Classroom

Details: Students participate in group learning activities, which involves considerable moving around, as well as individual study time, which involves very low levels of activity.

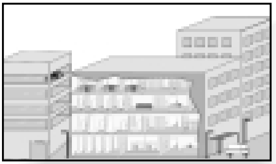
Control Strategy: Occupancy-based.

Rationale for Strategy: Throughout the day, there are numerous times when the classroom is vacant, such as lunch hour, recess breaks, and school assemblies. Occupancy sensors can reduce energy consumption during these time periods. In addition, the classroom may be used intermittently by teachers throughout the day; occupancy sensors can ensure that teachers will have the lighting they need without the inconvenience of having to switch lights on and off. Finally, the sensors will make sure that lighting is off at the end of the day.

Control Technology: Dual technology occupancy sensor.

Reasons for Specific Production Selection: Because of the differing activity levels in the classroom, the dual technology sensor is better suited for detecting continued occupancy than any single detection technology. Combining PIR with ultrasonic avoids “false offs” that can disturb occupants as well as “false ons” that can occur with movements caused by air currents when ultrasonic technology is used alone.

B. Scheduled control



Application #1: Large retail department store.

Details: The store is partially occupied from 4 a.m. until 9 a.m. for merchandise restocking and maintenance. Customer shopping hours run from 9 a.m. to 9 p.m. After regular business hours, the store remains occupied for two hours for administrative and accounting personnel to close the accounts for the day.

Control Strategy: Scheduled control.

Rationale for Strategy: Hours of operation are predictable for this store, with regularly scheduled customer hours, as well as scheduled stocking and maintenance hours. By establishing a regular lighting control schedule, the manager can depend on the lighting operating in a reliable, consistent fashion that provides security for employees and customers, in addition to the convenience in administration.

Control Technology: Networked system of multiple lighting control panels.

Special Features: Interface with security alarm system; interface with photocell for exterior lighting. Another possibility would be an interface with occupancy sensors for controlling lighting in stockrooms.

Reasons for Specific Product Selection: One of the most important concerns in a retail setting is the reliable and convenient operation of building systems. The programmable lighting schedule enables the store manager to streamline maintenance responsibilities, yet minimize energy consumption and costs by reducing lighting when it isn't needed. In addition, the interface between the lighting and security systems also enhances employee and store safety. In the event of an intrusion, the activation of the security system would signal the lighting control panel to turn on some or all of the lights, ensuring greater safety for arriving employees or police.

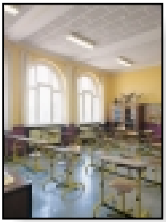
C. Daylighting

Application #1: Grade school classroom.

Details: The classroom contains an entire wall of windows. Classes are conducted regularly throughout the school day, which runs from 8 a.m. until 3 p.m. The teacher often remains in the classroom until 4:30 or 5 p.m.

Control Strategy: Daylighting (light level control).

Rationale for Strategy: The classroom is located on the perimeter of the building, and receives abundant natural light.



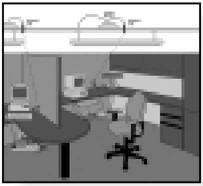
Control Technology: Continuous dimming daylighting control product.

Special Features: Three-zone daylighting control with manual dimming and ON/OFF control.

Reasons for Specific Product Selection: Classrooms with large windows that enable incoming daylight to illuminate the room from the sides. This type of lighting pattern is well suited to multi-zone dimming control. The lights closest to the windows can be dimmed or even switched off for long periods of time, while lights in other parts of the room may need to be maintained at a higher level. A three-zone application will divide the classroom according to the light levels found in three discrete zones of the room: two rows of lights closest to the windows where the most daylight is received (zone 1), three rows of lights in the middle of the room that receives a moderate amount of daylight (zone 2); and two rows of lights on the hallway side of the classroom opposite the windows, in an area that receives less direct light from the windows (but more diffuse light from the adjacent hallway) (zone 3).

Because teaching activities may involve a range of tasks, the lighting requirements may vary substantially. For instance, during presentations or videos, the teacher may want to darken the room completely. During periods when the students are working on drawing or other fine work, the teacher may want the room to be fully illuminated. To achieve these objectives, the teacher can operate the lighting system in manual mode via a switch. By using the switch's override OFF button, the teacher can darken the room regardless of daylight contributions or light level signals. Similarly, by activating an override ON button, the teacher can raise lighting levels to full output. With these capabilities, the teacher can adjust light levels to accommodate a range of specific activities.

D. Tuning (also called Task tuning)



Application #1: Individual workstations in an office building.

Details: Many employees do paperwork that requires higher light levels, but they also do computer work, where lower light levels are preferred.

Control Strategy: Light level control (tuning).

Rationale for Strategy: Different employees have different light level requirements throughout the day.

Control Technology: Personal desktop lighting controls.

Special Features: Infrared desktop transmitter.

Reasons for Specific Product Selection: This product provides each occupant with local control over their area lighting. Using the desktop transmitter, they can adjust light levels without getting up from their desks.

E. Lumen Maintenance

Application #1: Hospital corridors.

Details: Because the corridors are used for access to patients' rooms, and between departments, needed light levels are lower than they are for nursing stations and patient rooms. With new lighting, full output will result in overlighting of the corridors.

Control Strategy: Light level control (lumen maintenance).

Rationale for Strategy: The fluorescent lighting in the corridors has recently been relamped and cleaned.

Control Technology: Photo-sensitive controls and fluorescent dimming electronic ballasts. An alternative would be a lighting control panel equipped with a photocell that could be scheduled to dim the lights to a pre-set level at specific times of day or night.

Reasons for Specific Product Selection: With its ability to continuously sense light levels, the photocell can dim the lights continuously to user-defined settings. At the same time, users can still adjust the control settings to adjust the dimming rate, maximum dimming levels, and sensitivity.

F. Load Shedding

Application #1: Manufacturing facility

Details: This factory operates 24 hours per day, with three shifts of eight hours per shift. The greatest use of energy, also known as peak demand, occurs at predictable times, most often between 10 a.m. and 3 p.m.

Control Strategy: Occupancy-based and light level control (load shedding).

Rationale for Strategy: Since the demand charge is quite costly, reducing the energy load at peak times will result in significant energy savings.

Control Technology: Lighting control panel interfaced with occupancy sensors and with the facility's energy management system.

Reasons for Specific Product Selection: The facility's assembly equipment cannot be switched off to reduce demand without substantially affecting productivity and output. However, the facility's lighting is more discretionary, since some vacant areas can be switched off and other areas, such as shipping and receiving, can be dimmed to reduce the facility's overall demand.

References and Resources

Members of the lighting and controls industry support numerous organizations that provide resources for the novice and expert alike. The following organizations produce a wealth of materials that can be very helpful in developing and implementing a lighting control project.

Rebuild America

Rebuild America is a program of the U.S. Department of Energy (DOE) that focuses on energy solutions as community solutions. Rebuild America "partners" with small towns, large metropolitan areas, and Native American tribes, creating a large network of peers. Rebuild America supports communities with access to DOE Regional Offices, State Energy Offices, national laboratories, utilities, colleges and universities, and non-profit agencies. Visit the Rebuild America web site at:
http://www.eren.doe.gov/buildings/rebuild.

Information on Energy and Building Codes

For information about local building/energy codes:

Building Standards & Guidelines Program (BSGP)
U.S. Department of Energy
Hotline: 800/270-CODE (2633)
http://www.energycodes.org
BSGP has developed a comprehensive line of support tools for builders, designers, and code officials to help them with energy code compliance. COMcheck is a free software tool that demonstrates compliance with the ASHRAE/IESNA Standard 90.1-1989 energy code for non-residential buildings.

The Building Code Assistance Project
http://www.solstice.crest.org/efficiency/bcap
This organization focuses on assisting states with developing energy codes; visitors can find valuable information about code developments in their states.

Organizations in the Lighting and Lighting Control Industry

Electric Power Research Institute
3412 Hillview Ave.
Palo Alto CA 94304
650/855-2000
http://www.epri.com
EPRI is an R&D organization for the energy industry that sponsors research and development of energy-efficient technologies, including projects in the field of lighting and controls. It publishes project results and other publications that are available to members. EPRI also operates the Lighting Information Office, providing information to commercial and residential users: Lighting Information Office
501 14th St., Ste. 210
Oakland CA 94612
800/525-8555

E Source
4755 Walnut Street
Boulder CO 94612
303/440-8500
http://www.esource.com
This organization is a membership-based information services entity that provides independent analysis on retail energy markets, services, and technologies. Lighting Technology Atlas, part of a 5-volume Technology Atlas series, is published by E Source.

Lawrence Berkeley National Laboratory (LBNL)
1 Cyclotron Road
Berkeley CA 94720
510/486-6845
http://eetd.lbl.gov/btp/lsr
As part of the Building Technologies Program in LBNL's Environmental Energy Technologies Division, the Lighting Research Group conducts R&D

in the areas of fixtures, controls, and software that employ and promote energy efficient lighting.

Lighting Research Center (LRC)
21 Union St.
Troy NY 12180
518/276-8716
http://www.rpi.edu/dept/lrc/LRC.html
The LRC conducts research into numerous lighting areas. They provide information on lighting and control products as well as sponsor research into innovative lighting technologies and studying various aspects of lighting and controls performance. LRC sponsors the National Lighting Product Information Program (NLPIP), providing manufacturer-specific information on lighting products. They also publish a wide range of materials, including the free quarterly newsletter *Lighting Futures*, and the DELTA *Snapshots*, which can offer valuable insights about successful control strategies and applications.

Energy Star® Program
U.S. Environmental Protection Agency
http://www.energystar.gov
This federal program makes a wide range of technical resources available to its partners. Visitors to the web site can browse through case studies of lighting controls applications in a variety of commercial settings.

Illuminating Engineering Society of North America (IESNA)
120 Wall St.
New York NY 10020
212/248-5000
http://www.iesna.org
A professional organization dedicated to developing and promoting sound lighting practices, IESNA produces numerous publications, including design guides and a lighting handbook.

Lighting Control Association (LCA)
http://www.alcp.com
LCA is a broad consortium of lighting controls manufacturers who promote efforts to educate and assist building designers, specifiers, engineers, and end users in the design of lighting control applications. The group has produced an instructive CD-ROM on lighting control design.

National Electrical Manufacturers Association (NEMA)
2101 L Street, NW
Washington DC 20037
202/841-3200
http://www.nema.org
This association develops many of the standards for electrical equipment. Lighting controls manufacturers are represented by the Lighting Controls Council of NEMA's Lighting Systems Division. The organization publishes a Guide to Lighting Controls.

Other Resources on the Web

A wealth of information is available on line. An ideal starting point for those new to lighting control is one of the several industry portal sites:

http://www.lightsearch.com
http://www.lightforum.com
http://www.qualitylight.com
http://www.lightingresource.com

These sites offer articles, discussion groups, product and manufacturer directories, guides, and links to other useful sites in the lighting and controls industry.

Notes

Acknowledgments

One of the primary goals of Rebuild America's Business Partners is to pass along the expertise and lessons learned from private industry to the network of community partnerships that comprise Rebuild America. By working hand-in-hand, The Watt Stopper and Rebuild America have shown tangible results of a partnership forged from common goals and concerns. The *Fundamentals of Lighting Control* explains, in an easy-to-follow manner, how property owners and tenants, facilities managers, and energy managers can use energy wisely by letting different components of a building's lighting system communicate with each other.

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