ELECTRICAL DESIGN LIBRARY

Lighting Trends: Energy Rules and Technology Rolls

NECA
NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION

Contents

Electrical Design Library (EDL) publications are prepared for architects, consulting engineers, and qualified electrical contractors, as well as owners, developers, investors, and their electrical construction specifying personnel. Issued periodically by the National Electrical Contractors Association (NECA), the publications provide factual explanations of the increasing variety of sophisticated electrical systems and the economics of their installation by professional electrical contractors. They are distributed by the Association's chapters, located in all sections of the United States.

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Abstract

Lighting is the traditional electrical industry's most active area—in terms of new products, new technologies, and research—for while lighting specialists can be found, it is not easy for the rest of the construction industry to stay abreast of what's new and what's important in this fast-moving area.

This report will update the non-expert with vital information. It is intended to help the building owner/manager and the architects, engineers, electrical contractors, and other professionals that serve the owner. Information is presented in the following pages on:

1. A major regulatory development.
2. How lighting figures into the "green" building trend.
3. Recently unveiled research data on dirt depreciation—portents in the data for major changes in lighting design.
4. A look at the march of lighting technology into the future, including some parting words on LEDs.

This information provides an overview only. For further details—and the most up-to-date information about the lighting industry—visit the web sites listed in the box at the right.

Lighting Installation Has Standards, Too!

Working with the Illuminating Engineering Society of North America, NECA has developed three lighting installation standards. These ANSI standards cover commercial, exterior, and industrial lighting. Each standard can be purchased separately. A packet of three is offered (purchasers save 15%). For details, see the National Electrical Installation Standards Web site (*www.neca-neis.org*)—where you'll find nearly two dozen industry consensus standards on electrical installation.

NEIS National Electrical Installation Standards™

For further information on lighting and lighting standards, check out the following web sites:

- ✓ Energy Star Program (*www.energystar.gov*)
- ✓ Illuminating Engineering Society of North America (*www.iesna.org*)
- ✓ International Association of Lighting Designers (*www.iald.org*)
- ✓ Lighting Research Center (*www.lrc.rpi.edu)*
- ✓ National Lighting Bureau (*www.nlb.org*)
- ✓ U.S. Green Building Council (*www.usgbc.com*)

The Energy Code Cometh!

The basis for building codes and the standard for construction in more than 30 of the 50 states is ASHRAE/IES 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings. States that have adopted the Standard as code or as the basis of code are working with various versions, including 1989, 1999, or the latest—2001. The 2004 version of the Standard is under development.

Each version of the Standard is marked by attempts to make it easier to understand, interpret, and enforce as a code. It is also marked by efforts to reduce power allowances and save energy at the same pace as commercially available technology and design methods allow.

For example, roughly nine out of 10 existing commercial buildings were constructed before 1986. Lighting accounts for 50% of electrical energy use in most of these older buildings, according to the New Building Institute.

In newer buildings that meet ASHRAE/IES 90.1-1999, lighting accounts for only 30% of electrical energy use.

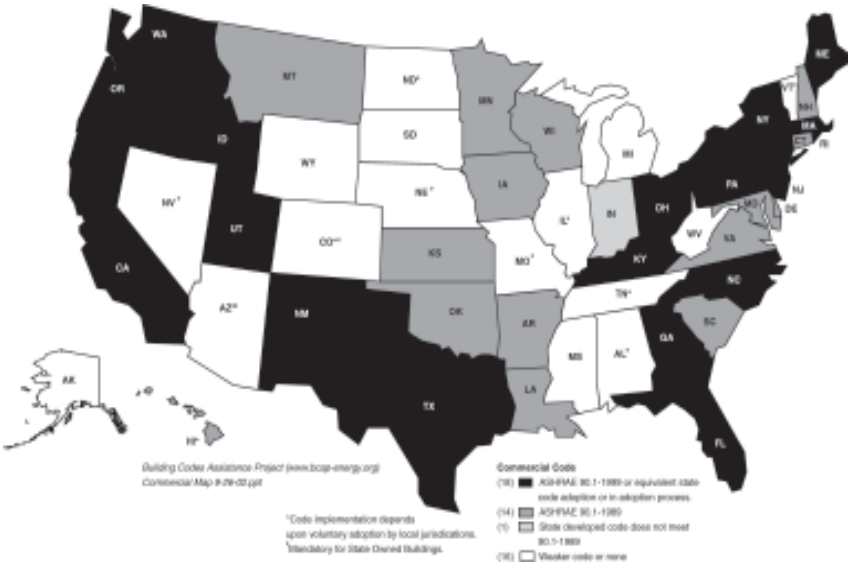

Figure 1. ASHRAE/IES 90.1-1999 or Equivalent Code Adoption, September 2002. Note that this map identifies code adoption for general energy requirements, although requirements for lighting may be stricter in a number of states. Source: Building Codes Assistance Project.

Changes Coming by July 2004

With authority from the Energy Policy Act of 1992, the U.S. Department of Energy has set down an important rule. By July 15, 2004, all states must certify that they have an energy code in place that is at least as stringent as Standard 90.1-1999—or they must justify why one cannot be adopted. Under this approach, the 1999 Energy Standard is treated as a baseline; individual state energy codes may be more stringent.

Fewer than 20 state energy codes met or exceeded the 90.1-1999 requirements as of fall 2003. At the same time, 15 states met 90.1-1989 and 17 states had either no code or a code that did not meet either standard (see Figure 1).

About the 1999 Standard

Designed for easier use than previous standards, Standard 90.1-1999 was written in clear, mandatory, enforceable language. It applies both to new construction and renovations.

Further, the 1999 standard expands the range of building categories covered. For example, while the 1989 standard covered 11 building types, the 1999 version covers 31 building types. In addition, the 1999 version omits many of the exceptions found in the 1989 version.

The 1999 standard establishes lighting power allowances for indoor and outdoor spaces, with indoor spaces addressed using either the "whole-building" method or "space-by-space" method. It mandates the calculation procedure for luminaire wattage, preventing under-calculation. In addition, it includes:

- ✓ Special lighting needs—such as power limits for exit signs;
- ✓ Limits for decorative, merchandise, display and accent lighting, and lighting used to reduce computer screen glare in certain spaces;

- ✓ Power allowances for building entrances, exits and highlighting; and
- ✓ Mandatory tandem wiring requirements to reduce the use of single-lamp ballasts.

Overall, lighting power allowances became stricter in the 1999 Standard, based on advancements in commercially available lighting technologies.

Efficiency Boost

Using the whole-building method, the 1999 Standard reduces the minimum required watts per square foot—from between 2.1 and 3.3 to 1.3. For retail space, it reduces the minimum watts per square foot to 1.9 and, for schools, it reduces the minimum to 1.5. Table 1 provides lighting power allowance cuts in the 1999 standard vs. 1989 for the space-by-space method.

The Standard requires that illumination levels be maintained at IESNA-recommended values because those values were used to develop its power allowances. Compliance will require more efficient technology, mostly higher efficiency lamps and ballasts. A table included in 90.1-1999 identifies equipment options (lamps, ballasts, luminaires) with associated percentages of lighting density reductions.

For more sophisticated or alternative approaches, engineers can use the energy cost budget method (computer calculations) to demonstrate load reduction within prescribed limits.

Lighting Controls

Although minimum controls were included in the 1989 standard; the 1999 version includes broad mandatory provisions. Exterior lighting not exempted in the Standard is required to be controlled by a photocell or astronomical timeclock.

For indoor spaces, automatic controls are addressed in the form of credits for higher power allowances using occupancy sensors, lumen maintenance controls, or daylight controls in the design. The 1999 Standard mandates use of scheduling or occupancy-sensing automatic shut-off strategies in buildings of 5,000 sq. ft. or larger; lighting systems in operation 24 hours per day are the only exemption.

The 1999 Standard requires that each space enclosed by ceiling-high partitions have at least one control device that independently controls the space's general lighting. The device must be activated by an automatic motion sensor or manually (by an occupant). Other controls provisions cover display/accent, display case, hotel and motel guest room, task, demonstration area, and non-visual lighting (such as lighting for plant growth).

California's Title 24 energy code goes a step further, mandating bi-level switching to achieve 50% energy savings, with exceptions being corridors, storerooms, restrooms, public lobbies, guestrooms, areas with only one luminaire, and spaces where occupancy sensors are used.

Building-wide dimming is not addressed by Standard 90.1-1999, although it can be incorporated into computer calculations under the energy cost budget method to demonstrate load reduction.

Table 1. Reduction In Lighting Power, 1999 Over 1989

	Lighting Power Allowances (watts per square foot)	
Space	*90.1-1989*	*90.1-1999*
Office Enclosed	1.8	1.5
Office Open	1.9	1.3
Conference	1.8	1.5
Training	2.0	1.6
Lobby	1.9	1.8
Lounge/Dining	2.5	1.4
Food Prep	1.4	2.2
Corridor	0.8	0.7
Restroom	0.8	1.0
Active Storage	1.0	1.1

Operating Trends: 'Green' Designs

Sustainable or "green" design is a catch-all term for practices that can be used to reduce or negate the harmful impact of buildings on the environment. The focus includes site planning, energy efficiency, renewable energy, water protection and efficiency, and materials and resource conservation.

Formed in 1993, the U.S. Green Building Council's mission is to "promote buildings that are environmentally responsible, profitable and healthy places to live and work." A Washington, D.C.-based non-profit, the GBC currently has more than 1,400 members. These include Fortune 500 corporations, manufacturers, and service providers spanning the construction industry.

Leadership in Energy & Environmental Design (LEED) is the GBC's primary market transformation effort. LEED is a system developed to define "green" design, promote green design practices in the entire building, stimulate the market, and elevate awareness.

Additionally, the LEED program recognizes companies that adopt green design and demonstrate genuine commitment to improve the internal and external environment.

Originally developed for commercial, institutional and high-rise residential new construction and large renovation projects, LEED is evolving. It addresses existing buildings, multiple buildings, core and shell, interiors and residential areas.

LEED's Point System

LEED is flexible, enabling buildings to become certified according to their level commitment to green design. Earning LEED points requires an integrated approach that addresses all areas of the building . Participants earn recognition based on this points and LEED labeling system:

LEED Certified	26-32 points
Silver Level	33-38 points
Gold Level	39-51 points
Platinum Level	52+ out of 69 possible points

Energy and atmosphere is the largest part of the LEED program, providing the ability to earn 17 (27% of all possible) points. Out of these 17 points, optimization of energy performance can result in 10 points. A first step is to achieve minimum energy performance. LEED presents this as either of:

- ✓ an EPA Energy Star label score of 60; or
- ✓ meeting the requirements of the ASHRAE/IES 90.1-1999 model energy code using the system/component method, or local energy code (whichever is more stringent).

Achieving the minimum requirement entails adoption of systems/components such as T8/T5 lamps, electronic ballasts, lower-wattage HID lamps, compact fluorescent lamps, more efficient luminaires, LED exit signs and other equipment.

Once minimum performance is achieved, the facility owner can add LEED points by exceeding the Energy Star base of 60 or ASHRAE/IES 90.1-1999 code scale (as shown in Table 2).

With the 1999 standard's tough requirements, however, there are a limited number of ways for most buildings to go beyond them—and earn LEED points:

- ✓ Innovative design methods, such as indirect lighting combined with task lighting;
- ✓ Facility-wide dimming; and
- ✓ New technologies that will improve energy efficiency such as "Super" T8 lamp-ballast systems.

Savings must be demonstrable using either the Energy Star Label benchmarking tool or the energy cost budget method included in ASHRAE/IES 90.1-1999 (which entails building calculations that can demonstrate the energy-savings potential of dimming).

Changes in Lighting Norms

Lighting systems are designed to provide a more-than-sufficient amount of light output to compensate for "depreciation" over time. Various light-loss factors cause a decline in the delivered light levels.

Dirt and dust build-up is a primary cause of light loss. As dirt and dust accumulate on luminaires and lamps, the particles *absorb* light rather than reflect it. The resulting light loss is called Luminaire Dirt Depreciation (LDD).

A recently completed three-year landmark maintenance study (see page 6) indicates that in a typical commercial environment, the extent of dirt depreciation on luminaires *is not as high as the accepted norms*.

These "norms" have been used by the lighting community for more than 50 years. In the time frame of a two- to three-year cleaning cycle, for example, the new findings recommend assuming a loss of about 10% for many areas. (See Figure 2.) Standards now in place—based on the "accepted norms"—recommend allowing for light loss on the order of 20%.

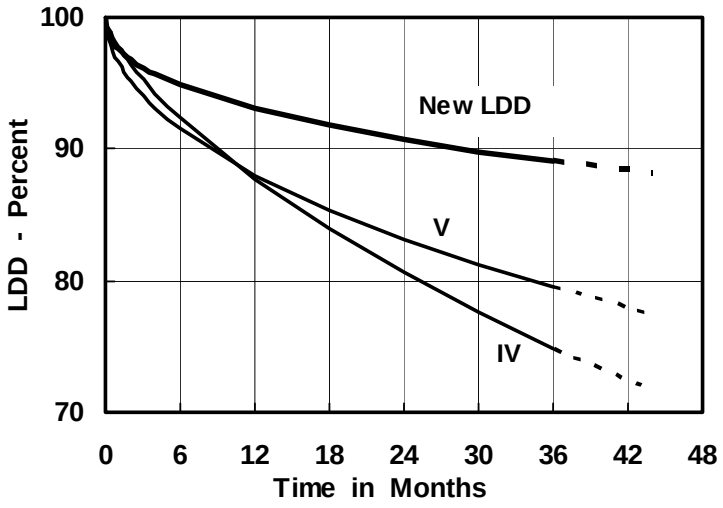

Figure 2. The LDD function for both louvered and lensed fluorescent luminaires determined by analysis of the LDD study test results (top curve). Previous IESNA procedures place louvered luminaires into Maintenance Category IV and lensed luminaires into Maintenance Category V, with their LDD curves shown for comparison. Source: NALMCO

Table 2. LEED Points for Facilities.

ASHRAE Scale			
New Building	*Existing Building*	*Energy Star Scale*	*LEED Points*
0%	0%	60	0 (Minimum Required)
20%	10%	70	2
30%	20%	75	4
40%	30%	85	6
50%	40%	90	8
60%	50%	95	10

With funding from the U.S. EPA and the Illuminating Engineering Society of North America, the 1996-1999 study generated data that could change "standard" approaches to lighting design. The new data translate to a reduction of overlighting of spaces for new lighting systems. This creates a reduction in lighting equipment, installation, and operating costs for the owner. These benefits can be increased by incorporating planned lighting maintenance.

Commercial facility lighting design—where fluorescent, flat-bottomed, and either recessed or ceiling-mounted luminaries will be installed—will change as the result of the new LDD data. In a new installation, fewer luminaires can be specified, installed, and operated to generate initial and operating cost savings.

For existing installations, the systems can be redesigned or retrofitted to generate operating cost savings by using various new ballast and lamp technologies, thereby maximizing potential energy savings specific to application variances. Retrofits include a variety of upgrade options with reduced light output for significant energy savings.

About the Luminaire Dirt Depreciation Study

The LDD field study examined four popular recessed fluorescent lighting luminaire types—2x4 lensed, 2x4 louvered, 2x2 louvered, and 2x4 air exhaust louvered—in more than 200 office, retail, and school facility sites. About half of the luminaires were lensed and half were louvered. Based on estimates, the four fixtures in the study represented roughly 90% of recessed luminaires operating in the United States during 1995.

Technicians at ten lighting management companies gathered the test data using an instrument especially designed to capture the total peak luminaire light output emerging from the luminaire. Eight luminaires at each site were thoroughly cleaned and relamped. After six months, one luminaire at each site was tested to record light output values when dirty and again after both lamps and luminaire had been cleaned. After 12 months, the test was repeated on another luminaire at each site; and again after 18, 24, 30 and 36 months.

Figure 2 shows the new LDD function, as determined by the test results. That is contrasted with lensed and louvered luminaires in clean conditions (assumes better than average air filtration and some generated or ambient dirt).

At 18 months, the LDD factor was 0.92 versus 0.84 to 0.85 using the traditional IESNA procedure, and at 36 months, the LDD factor was 0.89 versus 0.75 to 0.80. According to the study, lensed and louvered luminaires show virtually identical dirt depreciation, and variable operating hours per year have negligible effect.

Tomorrow's Lighting News—*Today!*

Deregulation of the utility industry and growing demand for energy, resulting in volatile energy prices, have renewed market demand for energy-efficient lighting.

New regulations are changing things, too. Impacts of the use of ASHRAE/IES 90.1-1999 as the basis for the nation's energy codes are discussed in this document. Beginning in 2005, another Department of Energy regulation will mandate the phase-out of magnetic ballasts.

Further, utilities—those still under state regulation—continue to offer more than $1 billion each year in rebates as incentives for energy-saving investments. Utilities will continue to develop their preferred form of demand-side management programs—demand response programs that reward voluntarily load-shedding during peak or emergency periods.

In addition to increasing corporate profitability and competitiveness, energy efficiency makes environmental sense while lower consumption of fuel resources can improve national security.

Commercially available technology—notably new, even-more efficient lamps and ballasts—offers reliable performance and an attractive return on investment. The next generation of lamps and ballasts include T5 systems as well as "Super" T8 systems and 30W instant-start T8 systems.

Beyond offering the potential for increased energy savings, these new technologies will form the basis for the ASHRAE/IES 90.1-2004 standard…and beyond.

Today's advanced lighting control systems offer energy savings derived from automatic shut-off based on schedule or occupancy. New control systems offer facility-wide dimming to accelerate energy savings and, perhaps most notably, reduce high demand charges from power used during peak periods.

Light-Emitting Diodes

America's energy future may be even brighter with the continued development of the light-emitting diode (LED) as a light source. Thus far, one notable development is creation of new partnerships between the lighting and semiconductor industries.

LEDs are now in use for a wide range of lighting—from "architectainment" luminaires to sconces and exit signs. Unfortunately, white-color LEDs are not yet competitive for use in general lighting situations (in performance terms) with fluorescent and incandescent sources. If technical problems are resolved as expected—by 2010—LEDs may completely change lighting systems as well as the lighting industry itself!

Why? Efficiency. LEDs can potentially produce the same amount of illumination as today's general lighting systems—with half the energy. It is estimated that widespread use of LEDs for general lighting would, over a 20-year period, cut the nation's electric bill by $98 billion!

Building owners and managers, engineers, specifiers, architects—and of course contractors—should educate themselves about new lighting technologies and methods to comply with code, minimize energy costs, and support environmental objectives.

EDL Order Form

The following monographs are $4.00 each for NECA members and $10.00 for nonmembers. Prices for bulk quantities will be quoted upon request.

	Date	Title	Index No.
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❑	6/00	National Electrical Installation Standards	302599
❑	12/00	Intelligent Building Distributed Networks	3025100
❑	6/01	The Essentials of Quality Power	3025102
❑	9/01	Specifying Integrated Building Systems	3025103
❑	12/01	Guide to Energy Efficiency Options: Using Today's Electrotechnologies	3025104
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