Something to Celebrate: A Quarter Century of Lighting Progress and Emerging Technologies to Watch

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A quarter-century ago, the only energy-saving lighting strategy available was delamping. In commercial spaces, magnetic-ballasted T12 lighting systems and incandescent lamps proliferated in overlighted designs, while mercury vapor, high-pressure sodium and probe-start metal halide ruled in many industrial, warehouse and outdoor area lighting applications.

In the 1970s and 1980s, saving energy implied sacrificing productivity and comfort. By the end of the decade, a new way of thinking emerged. Manufacturers began developing technologies that delivered more light output for less electrical input, and the era of lighting efficiency was born. The Illuminating Engineering Society (IES) recommended lower light levels and ASHRAE 90.1-1989, requiring minimum application efficiency, would soon be required to be adopted by most states.

It's now 2008, and lighting in the United States is much more energy-efficient, a process being accelerated by technology, the sustainable construction movement, energy codes and legislation. In fact, most of the venerable workhorse lighting technologies that dominated industrial and commercial spaces in 1983 have become or are in the process of becoming illegal to manufacture in the United States due to their inefficiency today.

Top technologies

The lighting technologies that have made a major impact over the past 25 years are T8 lamps and electronic ballasts, compact fluorescent lamps, pulse-start metal halide systems, T5HO systems, occupancy sensors, intelligent control panels and LED exit signs. Let's look at a few of these—T8 lamps, electronic ballasts and fluorescent hi-bay systems—in more detail. How far have they come, and what's new?

T8 lamps: T8 lamps are now standard in new construction and therefore are becoming the "new T12"—the new standard to beat. Lighting technology has already moved past this remarkable, highly efficient light source with "energy-saving" versions (25W, 28W, 30W) and high-output versions ("3100+ lumen Super T8"). Potential energy savings can be as high as 18-30 percent—or more, if lower light levels are acceptable.

Over the past 10-15 years, the standard T8 system has included four-foot basic-grade 700 series lamps operated by 0.87 ballast factor generic electronic ballasts, installed in troffers and other fixtures. Several options can be considered to replace this system in an existing installation. Some options involve achieving target or lower light levels for a lower fixed wattage. Examples include energy-saving T8 lamps in 25W, 28W and 30W models operated on low (0.71-0.78) and normal (0.87-0.88) ballast factor ballasts. Other options involve using high-lumen lamps with a low ballast factor ballast or using a high-lumen system and then reducing the size of the system (delamping). Examples include high-lumen T8 (“Super T8”) lamps with a low, normal or high (1.14-1.20) ballast factor ballast, a dimming ballast, or a programmed-start ballast if occupancy sensors are used.

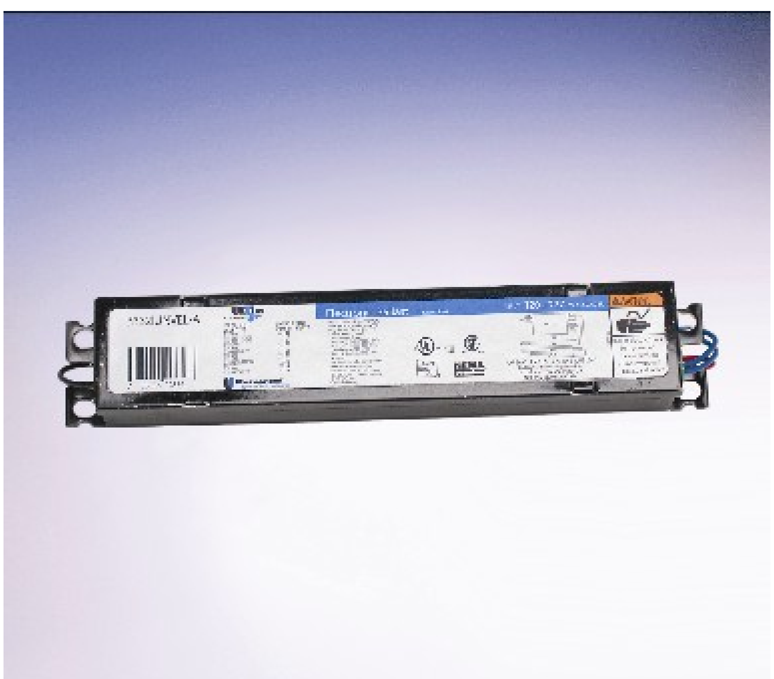
Note that energy-saving T8 lamp types have some significant limitations, such as incompatibility with dimming. Also note that because energy-saving and Super T8 lamps look the same as standard 32W T8 lamps and fit the same 4-ft. sockets, there is potential for “snap back” unless the maintenance and purchasing departments are properly trained.

Electronic ballasts: In terms of both dollar and unit volume sales, electronic ballasts dominate the fluorescent lighting market after a meteoric rise since the early 1990s. While millions of magnetic ballasts are still in service in existing facilities, with electronic and magnetic ballasts having achieved a rough cost parity in recent years, the electronic ballast has become the standard in new construction.

With passage of the Energy Policy Act of 2005, in July 2009, ballast manufacturers are phasing out production of magnetic ballasts designed to operate F40T12, F96T12 and F96T12HO lamps, a process that will culminate on July 1, 2010. On that date, ballast manufacturers are also required to stop producing replacement ballasts, with few exceptions.

Like the T8 lamp, manufacturers are already moving beyond the “standard” electronic ballast to offer premium versions. A major example is the “high-efficiency” electronic ballast (see Figure 1). This type of ballast provides the same level of light output as a standard electronic ballast, but does so more efficiently—reducing lighting power by another 2-5W, typically 3W.

Figure 1. High-efficiency fluorescent ballasts can produce an additional 5-7 percent energy savings in typical projects. Photo courtesy of Universal Lighting Technologies.



High-efficiency ballasts can cost 10-20 percent more than standard electronic ballasts while producing an additional 5-7 percent energy savings in typical projects. In an installation with two-ballast four-lamp fluorescent fixtures on 10x10 centers (100 sq.ft. area), using high-efficiency ballasts can add about $0.03-$0.06 per sq.ft. to the cost of the project—while reducing annual operating costs by about $0.04 per sq.ft., based on an assumption of savings of $2 per ballast (or $1 per lamp) per year.

To help dispel confusion about what a “high efficiency” ballast is, the National Electrical Manufacturers Association (NEMA) created the NEMA Premium Ballast label (see Figure 2) to identify the most efficient fluorescent electronic ballasts. As of the time of writing, Advance, GE, OSRAM SYLVANIA and Universal Lighting Technologies had achieved NEMA Premium Ballast certification for their high-efficiency products.

Figure 2. The NEMA Premium Ballast special mark distinguishes the ballast as the highest-performing electronic ballast on the market.

Other ballasts to watch include load-shedding (demand-response) ballasts and high ballast factor ballasts (Figure 3). Load-shedding ballasts, suitable for new construction and retrofit, enable facility operators to initiate load-shed dimming events to reduce demand charges and participate in demand response programs. High ballast factor ballasts support use of lighting systems in hi-bay applications, which brings us to—

T5HO and T8 hi-bay systems: Indoor spaces with high ceilings, such as factories, warehouses, big box retail stores, gymnasiums and all-purpose rooms are often lighted by probe-start metal halide lighting systems. In most applications, 400W units are common. These lighting systems are obsolete in terms of efficiency. In fact, starting January 1, 2009, the Energy Independence and Security Act of 2007 will begin to regulate the efficiency of ballasts in new light fixtures containing 150-500W metal halide lamps, with some exceptions. Fixtures that comply will (qualify to continue being manufactured in the U.S. and) have a capital “E” printed in a circle on their packaging and ballast label. In a nutshell, probe-start magnetic ballasts for operation of lamps up to 400W will be virtually eliminated from new fixtures and with them, most 175-400W probe-start metal halide lamps.

Figure 3. Load-shedding ballasts were installed at the Spence School in New York City in a demonstration project funded by NYSERDA. The ballasts were linked to a building management system, allowing the school to reduce lighting energy consumption by 30 percent when desired. At the click of a button on a laptop or mobile phone, Spence School can now temporarily reduce demand by 261 kW during emergency grid events. “The success of this project shows the huge potential of our new Demand Response Platform,” says Stephen Lynch, president of ACE Energy Company, Inc. “This technology will not only reduce Spence School’s energy cost but will also make the world a greener, more energy-smart place.” Photo courtesy of OSRAM SYLVANIA, Inc.

As many pulse-start magnetic and most, if not all, pulse-start electronic ballasts comply, this system is expected to become the new standard in construction.
Many pulse-start magnetic and most, if not all, pulse-start electronic ballasts comply, taking probe-start’s place as the new standard.

In existing buildings, a wave of retrofits have occurred driven by the efficiency of T5HO and Super T8 hi-bay lighting fixtures, which promise up to 50 percent energy savings over probe-start metal halide fixtures (see Figures 4a and 4b). This opportunity has become the new low-hanging fruit in the retrofit world; this market continues to be quite active and an area of innovation by fixture, lamp and ballast manufacturers.

Figures 4a and 4b. Industrial and commercial applications lighted by probe-start metal halide lamps (3a) are good candidates for upgrade to fluorescent hi-bay lighting fixtures (3b) for up to 50 percent energy savings and other benefits. Photos courtesy of Lithonia.

Emerging technologies

Emerging technologies to watch over the next 25 years include dimmable ballasts, digital networks, integrated lighting control and solid-state lighting such as LED lighting. Major trends within the controls field include daylighting controls, wireless control, demand response systems, fixture-integrated controls such as pre-wired occupancy sensors and photosensors, intelligent lighting systems and distributed intelligence.

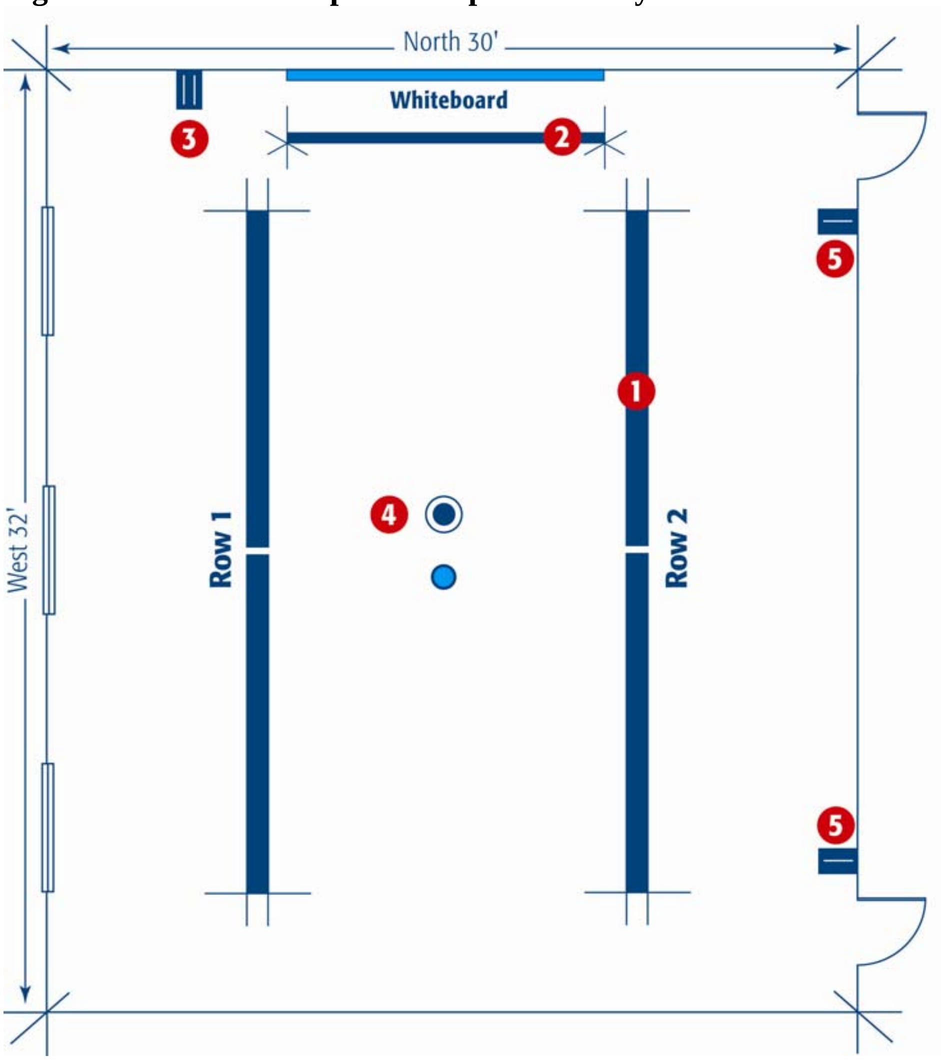
Daylighting controls are now considered best practice and will become adopted into energy code standards starting as early as 2010, currently driven primarily by the LEED program and in general the sustainable construction movement. Daylighting control systems, like load-shedding systems, often include dimming ballasts.

If LEDs are ultimately the future of lighting, *integrated lighting control* may be the near future due to very promising energy savings. Here are two examples:

The California Lighting Technology Center (CLTC) recently demonstrated a task/ambient Integrated Office Lighting System (IOLS) combining high-efficacy direct/indirect luminaires with an LED Personal Lighting System (task lighting). The system demonstrated lighting power densities of 0.5-0.7W/sq.ft., 36-55 percent lower than ASHRAE 90.1-2004/2007. The addition of an occupancy sensor controlling the task lighting was found to reduce energy consumption by another 20-30 percent.
The Lighting Research Center (LRC) recently studied another system produced by CLTC and manufacturer Finelite: the Integrated Classroom Lighting System, or ICLS (see Figure 5). ICLS

consists of teacher-controllable direct/indirect and whiteboard luminaires, occupancy sensor and optional photosensor. LRC studied ICLS in 28 classrooms and found it to produce an average 0.73W/sq.ft., nearly 50 percent lower than ASHRAE 90.1-2004/2007.

Figure 5. The ICLS template. Graphic courtesy of Finelite.



1) Two rows of two-scene indirect/direct luminaires mounted perpendicular to the main teaching wall (parallel to window wall) and spaced 14-15’ apart.
2) A dedicated luminaire is used to illuminate the whiteboard on the main teaching wall.
3) Teacher control is placed at the front of the classroom. For easy teacher access place controls within 6 inches of the whiteboard.
4) Sensors are placed in the center of the classroom. Sensors always include occupancy and daylight harvesting is added where appropriate.
5) A master ON/OFF switch is by every door to the classroom.

And *intelligent lighting* is about to get a major boost. Many ESCOs are by now familiar with the potential for digital dimming offered by lighting control systems based on the DALI protocol. An interesting development in this area is a new DALI protocol called DALI XP that will include standard DALI control devices, not just the ballasts. At the time of writing, DALI XP was expected to receive NEMA approval by the end of 2008. With DALI XP, designers can truly mix and match ballasts and controls to create a control system. If a device fails, another can be purchased and installed from any manufacturer as long as the product is designed to DALI XP. (Alternately, the designer can continue to work with proprietary systems based on DALI, such as Lutron's EcoSystem and Acuity Brands' SIMPLY5.)

What's next: NEMA is now working with the ZigBee Alliance on a protocol to facilitate wireless communication for DALI systems, an opportunity that holds significant potential as it would bring together all of the advantages of DALI and wireless control. For example, the wireless aspect would reduce wiring installation costs and enable controls to be placed or moved beyond the restrictions of the wiring layout.

What about LEDs?

LEDs are beginning to show promise as an architectural light source in niche applications such as undercabinet, accent and landscape lighting, but is currently not yet ready for prime time, particularly for retrofit applications.

For example, there is currently a push to replace linear fluorescent T8 and T12 lamps with linear LED replacement lamps, but are LEDs really ready to take on this workhorse in general lighting? The evidence suggests no, not yet anyway—except perhaps in some specialty applications such as refrigerated display cases.

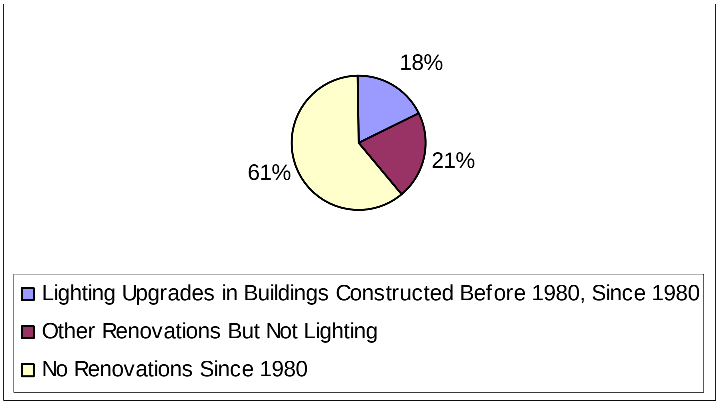
Lots of opportunity in existing buildings

According to the 2003 U.S. Energy Consumptions survey produced by DOE and released in the spring of 2006, there were a total of about 4.6 million commercial buildings (not including malls) in the U.S. in 2003, representing about 64.8 billion square feet of floorspace. The average nonresidential building was about 31 years old, operated about 50 hours per week, and housed about 16 workers who each occupied about 1,000 sq.ft. of space.

About 2.5 million of U.S. lighted commercial non-mall buildings (about 60 percent of the total), representing about 57 percent of total floorspace, were constructed prior to 1980. About 988,000 of these buildings, or 39 percent, have benefited from some form of renovation. Lighting upgrades are a popular form of renovation in these 988,000 pre-1980 buildings that have undergone some form of renovation. Second to cosmetic improvements, which were selected as a renovation in 723,000, or 73 percent, of buildings constructed before 1980 and renovated since 1980, lighting upgrades were performed as a renovation in 449,000, or 45 percent, of these buildings.

However, looking at *all* pre-1980 buildings, including buildings that have been renovated since 1980 and those that have not, lighting upgrades have only occurred in about one out of five (18 percent) of them, as shown in Figure 6.

Figure 6. Lighting upgrades 2003 as percentage of lit commercial non-mall U.S. buildings built <1980.

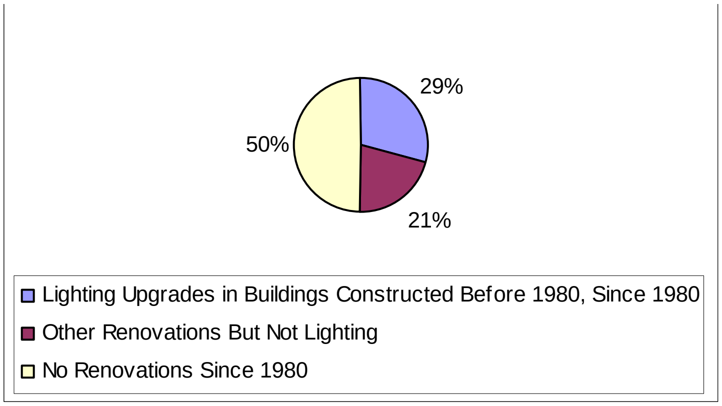


In terms of floorspace, lighting upgrades rank third in popularity after cosmetic improvements (74 percent) and HVAC equipment upgrades (61 percent). Lighting upgrades represent about 10.3 billion sq.ft., or 59 percent, of lighted commercial non-mall building floorspace constructed before 1980 that has been renovated since 1980.

However, looking at *all* pre-1980 commercial building floorspace, including floorspace renovated since 1980 and floorspace that has not, lighting upgrades have covered less than one-third (29 percent), as shown in Figure 7. Floorspace constructed before 1980 is estimated at about 35 billion sq.ft., or 56 percent of total lighted commercial non-mall U.S. building floorspace in 2003.

This suggests that about 25 billion sq.ft. of commercial building floorspace is still lighted to pre-1980 design standards (overlighted) and likely using the least-efficient lighting systems allowed by law. The owners of this space represent some of today's most suitable customers for energy-efficient lighting upgrades.

Figure 7. Lighting upgrades 2003 as percentage of lit commercial non-mall U.S. floorspace built <1980.



The future of efficiency looks bright

The last 25 years produced a remarkable revolution in energy-efficient lighting that has primarily impacted new construction due to the sustainable construction movement, energy codes and legislation. There is still considerable opportunity in the existing buildings market, however, that will keep all of us busy over the next 25.

To see a list of lighting management companies with considerable expertise in design, retrofit, installation and maintenance, available as a resource for ESCOs interested in expanding their opportunities in the lighting upgrades market, visit www.nalmco.org.

About NALMCO™

The interNational Association of Lighting Management Companies (NALMCO™) brings together lighting management companies and related companies to promote professional lighting management techniques and foster industry expansion.

Lighting management companies can provide significant lighting expertise and consulting to ESCOs interested in maximizing energy savings and lighting quality produced by lighting upgrade projects. Many of these companies also provide planned maintenance services that can be valuable to sustaining long-term energy savings.

In discussion with a lighting management company, be sure to ask about certification to ensure the potential partner offers industry-vetted experience and expertise. NALMCO™ offers three nationally recognized certifications used to identify professionals demonstrating a high degree of competence and knowledge: Certified Lighting Management Consultant (CLMC™), Certified Senior Lighting Technician (CSLT™) and Certified Apprentice Lighting Technician (CALT™).

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