The American Council for an Energy-Efficient Economy
Emerging Technologies Report

Integrated Daylighting Systems (Dimming Ballasts)

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Summary

Definition	Digital network of dimmable fluorescent ballasts, environmental sensors (light, occupancy), workstation controls, and building management options				
Basecase	12, 2' x 4', 60-watt general purpose recessed louvered fluorescent fixtures (two 32-watt T-8 lamps each), spread over an area of 503 s.f. (1.4 w/s.f.); one-quarter of fixtures are located along building perimeter with access to daylight				
New Measure:	Add electronic dimmable ballasts, photosensors, and occupancy controls where appropriate, and network components	Percent Savings	2020 Savings TBtu (source)	2020 Cost of Saved Energy	Success Rating (1-5)
		52%	99	$0.03/kWh	4

Background and Description

In most office buildings and schools, lighting is designed to provide equal amounts of light to all occupant spaces. Even large office buildings in which lights are turned on and off according to a time-of-day schedule do not adequately meet worker needs or optimize lighting demand reduction because they can not adapt to daily changes in the work environment. Integrated control systems that can respond to daylight and occupancy have been available for about 3 decades. However, they have achieved limited success in the market due to the costs and complications associated with installing, programming, and re-calibrating the components, which are in most cases produced by a variety of vendors. New products have entered the market in recent years to simplify the installation and commissioning process by better unifying or networking various system components. All of these can be controlled at the workstation and building manager level. Research continues to facilitate commercialization of improved dimming ballasts, photosensors, and communication networks that have the potential to dramatically reduce installation costs. We examined the costs and savings associated with the simplest systems that are commercially available today with a look ahead to the potential impact of wireless building controls.

Data Summary

Basecase: 12, 2' x 4', 60-watt general purpose recessed louvered fluorescent fixtures (two 32-watt T-8 lamps each), spread over an area of 503 s.f. (1.4 w/s.f.); one-quarter of fixtures are located along building perimeter with access to daylight

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Application and Status			
Market Sector(s)	**Application(s)**	**End Use(s)**	**Fuel Type(s)**
Commercial	New Construction Retrofit	Lighting	Electricity
Market Segment	**National/Regional**	**Region(s)**	**State(s)**
Office Education Medical Retail	National		
Current Status	**Date of Commercialization**	***Notes***	
Commercialized	1999	Most recent product entered market in 2005	
Market Players/Manufacturers	**Life**		
- Lutron Electronics Company, Inc - Easylite - Ledalite Architectural Products - DALI - Nexlight	**15 years**		

Basecase Information			***Notes (Source)***
Efficiency	720	avg watts	100% output (12 fixtures @60 watts each)
Electric Use	2,059	kWh/yr	2,860 effective zone operating hours (11 hr/day, 5 day/wk, 52 wk/year) (DOE 2002)
Summer Peak Demand	0.598	kW	83% coincidence
Winter Peak Demand	0.533	kW	74% coincidence
Gas/Fuel Use	0	MMBtu/yr	
New Measure Information			***Notes (Source)***
Efficiency	594	avg watts	Automatic 90% output, ¼ of fixtures at 60% around perimeter
Electric Use	988	kWh/yr	2,080 effective zone operating hours (11 hr/day, 5 day/wk, 52 wk/year) (DOE 2002)
Summer Peak Demand	0.493	kW	83% coincidence
Winter Peak Demand	0.44	kW	74% coincidence
Gas/Fuel Use	0	MMBtu/yr	
Savings Information			***Notes (Source)***
Electric Savings	1071	kWh/yr	
Summer Peak Demand Savings	0.105	kW	
Winter Peak Demand Savings	0.093	kW	
Gas/Fuel Savings	0	MMBtu/yr	
Percent Savings	52	%	
Feasible Applications (%)	31	%	
Industrial Savings Potential (>25%)	NO		
2020 Savings Potential	**9,480**	**GWH**	
2020 Savings Potential (Source)	**99**	**TBtu**	
Cost of Saved Energy	**$0.03**	**$/Kwh**	
Cost Information			***Notes (Source)***
Incremental Cost	$377	2006 $	Assuming 1.4 (basecase) watts/s.f., or 42 s.f./fixture; @ $0.75/s.f.
Other Costs / (Savings)	0	$/yr	

Success Factors			
Market Barriers	**Non-Energy Benefits**	**Current Promotional Activity**	**Next Steps**
- Public awareness - Initial cost - Commissioning	- Comfort - Productivity - Control over peak lighting demand	- Utility incentives (scattered) - Federal tax credits (2006-2008)	- Incentives - Specification - Designer training - Publicity - Demonstrations
Priority (1-5)	**Likelihood of Success (1-5)**	**Success Rationale**	
4	4	Few cost-related or technical barriers for new construction, but high upfront retrofit cost and some reliability hurdles.	

Data Quality Assessment (A-D)	Data Explanation
C	Based on manufacturer data and limited third-party sources

Current Status of Measure

Dimmable fluorescent ballasts make up about 4% of the commercial lighting market. Daylighting control solutions are installed in no more than 2% of new commercial buildings and in a negligible portion of retrofit applications due to the costs and restrictions associated with re-wiring components. At least three lighting manufacturers in the U.S. currently market "packaged" integrated daylighting control systems. Each has entered the market within the past 1–6 years and brings a different set of advantages and drawbacks. Only one of these products, Lutron's "Ecosystem," claims to be an end-to-end single-source vendor. Easylite has designed and packaged a system based around an electronic ballast that is integrated with the system's power control. Ledalite's "Ergolight" represents yet another approach: a single workstation lamp fixture that incorporates dimmable ballast, photosensor, and occupancy sensor in one unit, which can then be networked with other Ergolights within lighting zones and throughout the building. Each of these systems is relatively new. None of them claim more than a few thousand systems installed.

Lawrence Berkeley National Laboratory (LBNL), DUST Networks, and SVA Lighting are developing and testing a wireless lighting system for commercial retrofit applications. Wireless networking technology (in which each part of the system can be connected to any other part of the system) is just breaking into the commercial and industrial building market with the introduction of advanced, fast-responding mesh wireless protocols such as Zigbee and Z-wave. Large-scale commercialization of this technology for commercial lighting applications may take place within the next 5 years.

Savings Potential and Cost-Effectiveness

Available case studies for commercial office spaces that have installed integrated daylighting control systems report annual savings between 40% and 80% of lighting energy consumption, with most buildings achieving a minimum of 50%. Our study shows a 17% peak demand reduction, which is in line with available case studies. Savings depend on which system is used, and which of the following aspects are possible, emphasized, and operated properly (these savings levels are estimates based on manufacturer case studies and PIER research):

- Scheduling and light level tuning 10–25% savings
- Fewer fixtures or workstation control 0–35% savings
- Daylight harvesting 12–17% savings (35% in daylit spaces)
- Occupancy control 15–35% savings
- Variable load shedding 15–20% savings (peak only)

The cost-effectiveness of a lighting control system depends on the price of individual components (which can vary dramatically), installation, commissioning, energy rates, and required labor, as well as the physical layout of the building. Although the simplified, "plug and play" systems available today involve more expensive patented ballasts and/or fixtures, reduced wiring and labor costs can exceed this incremental cost, reducing the overall cost to around $1 to $2/s.f. for new construction, and $2 to $4/s.f. for existing buildings. This represents a dramatic cost reduction from older lighting control systems that could range from $3 to $7/s.f. for new buildlings (Mills 2006).

According to LBNL research (Rubenstein 2004), wiring typically comprises around 40% of the total cost in an average retrofit installation, and installing a wireless lighting control system reduces this installation price by 30%. Payback time ranges from 2 to 6 years depending on the price of the ballasts and the percent energy savings achieved.

Market Barriers

Available systems continue to improve in accuracy and simplicity as individual components (ballasts, photosensors, network protocols) become more refined. Correctly commissioning photosensors is critical to the technical success of the system. In a recent study of 120 side-lit buildings that employed photocontrols (HMG 2005), recorded savings were roughly half what was expected. Newer, more integrated systems cut out some of the commissioning and installation issues. Still, installation costs are still considered prohibitive for most retrofit applications, although payback periods tend to be no more than 5 years. For new construction, however, the costs are now competitive with static T-8 fluorescent designs, particularly in light of stricter codes in certain states (CA Title 24).

Not only is the market for lighting control systems fragmented, but the construction channel involves a number of players. This limits the likelihood that building owners will recognize a daylighting control system as a good investment. Furthermore, because the commercial leasing process encourages building owners to transfer utility costs to their tenants, building owners have little incentive to take on projects with high upfront costs and little direct return.

Widespread availability of a reliable and secure wireless protocol for building control systems is one of the most important technical barriers to widespread adoption in existing buildings. Some manufacturers believe that reliability and security pose too great a risk and would like to see other approaches such as tapping existing power wires for networking.

Next Steps

It is unclear whether and how soon advanced wireless networking protocols will revolutionize commercial building subsystems such as lighting. There is considerable interest among large lighting and buildings systems manufacturers to develop such an opportunity, but further research, testing, and demonstrations are needed to overcome security and reliability concerns. The greatest current barrier to the adoption of advanced daylighting systems is a lack of public awareness and promotional activity aimed at all the players involved in the construction channel (architects, owners, reps, specifiers, wholesalers, contractors, project managers). The best vehicles to accomplish increased recognition include incentives for building owners, better lighting specifications for dimming fluorescent systems, and better field data on upfront and maintenance costs for accurate price comparisons. Any policies or activities to encourage adoption of whole-building energy-saving guidelines, such as ASHRAE 90.1, LEED, and CA Title 24, would also provide valuable publicity. If such problems are addressed, one manufacturer estimates that the cost of its system could come down 15–20% from increased market penetration alone.

Key Assumptions Used in Analysis

This study is based on a simplified, conservative, theoretical example of how energy use would be impacted by correctly installing integrated, dimmable fluorescent ballasts, photosensors, and occupancy controls. Different systems on the market yield different benefits, and the layout and lighting design of each new construction or retrofit project are too varied to summarize in one study. For electricity savings, we assume a minimum watts/fixture reduction based on baseline reductions upon installation of the Lutron system. Background maximum lighting levels are dimmed to 90% of full capacity upon installation, and roughly one-quarter of the installed fixtures are assumed to be located around the building's perimeter and dimmed to 60% to take advantage of daylight. Electricity savings from reduced cooling loads are not included in the total savings figure, but one can assume an additional 20% savings. Incremental cost is based on a $0.75/s.f. estimate, not on an assumed number of purchased components. Maintenance costs are assumed to be roughly equivalent to the basecase.

Average Price of Electricity	$0.083/kWh
Percent New Res. Construction in 2020 (DOE 2005)	14.8%
Average Price of Natural Gas	$10.16/MMBtu
Projected 2020 End Use Electricity Consumption (EIA 2006)	0.39 quads
Real Discount Rate	4.53%
Projected 2020 End Use Gas Consumption (EIA 2006)	1.25 quads
Heat Rate	10.42 kBtu/kWh

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