Moving Targets and Moving Markets in Commercial Lighting

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ABSTRACT

This paper develops recommendations for changes in some of the most common features found in public benefit programs that promote efficient commercial lighting, based on a review of recent technical and market assessment research. Commercial lighting improvements typically account for 30 – 50 percent of planned net savings in energy efficiency program portfolios. Commercial lighting markets and technologies are currently experiencing profound changes. Technologies long viewed as "efficient" when compared to standard practice are now being widely adopted, even in states and regions that have never hosted energy efficiency programs. Moreover, many of those technologies will soon be incorporated into Federal product efficiency standards and state-level building codes. At the same time, new technologies, particularly LEDs, are emerging that promise significant new sources of energy savings in general lighting applications.

Although these technology and market trends have been apparent for some time, most resources in commercial lighting programs sponsored by utilities and other state-level organizations continue to support a roster of long-established measures. Review of recent market studies and technology forecasts clearly suggest that those resources could be more cost-effectively applied by following a number of guidelines, including:

- Focus support for retrofit of T12 linear fluorescent technology in market segments, particularly small business, in which that technology persists in high saturation.
- Discontinue financial incentives for fluorescent lighting in high bay applications; the technology is already enjoys high market share.
- Provide increased support for retrofit of lighting controls, which provide significant savings, but continue to have relatively low saturation.
- Work closely with manufacturers and federal programs to facilitate market trials of LED products for general lighting applications.

Introduction

Lighting is the largest single category of end-use energy consumption in the commercial sector. According to the most recent federal Commercial Building Energy Consumption Survey (2003), lighting accounted for 38 percent of all electricity used in commercial buildings, and for 20 percent of total site energy for all fuels. Moreover, lighting contributes 20 – 30 percent of peak hour commercial loads, depending on local climate and building stock. (Goldman et al. 2007)

Given commercial lighting's large share of consumption and load, the end use clearly presents a significant opportunity for energy efficiency programs. Since the advent of utility-sponsored programs in the 1980s, program administrators have identified commercial lighting measures as major sources of savings and have targeted large portions of their program budgets to those measures. As Table 1 shows, this approach to constructing program portfolios persists.

Table 1. Portion of Total Portfolio Planned Savings Accounted for by Commercial Lighting Measures

State	Full Portfolio	C&I Programs
States with Long-Established Programs		
CA	18%	46%
NY	15%	40%
States with Recently-Initiated Programs		
DE	14%	36%
PA (PP&L)	15%	40%

Sources: CA PUC 2012, NY PSC 2009, PECO 2009, Center for Energy & Environmental Policy 2009)

Currently, the commercial lighting market is undergoing many important changes that will affect the extent to which the projected savings highlighted in Table 1 can be realized. Specifically, changes in federal product standards, state building codes, and standard specification practices among contractors and engineers are all working to increase baseline efficiencies and reduce net energy savings from commercial lighting programs. At the same time, rapid development of LED technologies will provide opportunities to capture increased savings in this market. Moreover, savings available through application of long-established principles of efficient lighting design and control remain widely available.

This paper provides components of a strategic view of the commercial lighting market. The information needed to develop this view is fragmentary and scattered across many sources -- technology assessment, market research, and program planning, and program evaluation reports. We hope the compilation and interpretation of this information laid out below will help administrators of state- and utility-level energy efficiency program portfolios address the following questions:

- How long are currently-supported measures likely to yield significant net savings?
- In which market segments will those savings be available?
- What steps can be taken to accelerate the integration of new technologies and design practices with higher savings into the program portfolio?

Summary Characteristics of the Commercial Lighting Market

The installed inventory of commercial lighting equipment is composed primarily of four technologies: linear fluorescent, compact fluorescent, high intensity discharge (HID), and incandescent. Table 2 displays the distribution of lamps, average wattage per lamp, average daily hours of use, and estimated annual electric use by technology type. (Navigant, 2010)

Table 2 clearly shows the importance of linear fluorescent lighting in the commercial inventory. That technology accounts for 80% of the installed equipment and 72% of total annual energy consumption for commercial lighting. Linear fluorescents are the technology of choice for general lighting and have gained a growing market share for high applications, which account for 9 – ~20% of total commercial floor space. (KEMA, 2010; KEMA 2012). High intensity discharge (HID) technologies such as metal halide fixtures account for 14% of interior lighting energy.

HID technologies are used primarily to provide general lighting in high bay areas, that is: spaces with ceiling heights greater than 15 feet. They account for a much smaller percentage of installed lamps due to the high output of HID fixtures. Screw-in bulbs that do not require separate ballasts account for most of the remainder of the inventory: 16% of installed lamps and 12% of annual energy. Compact fluorescents – a relatively efficient technology – account for roughly two-thirds of the installed lamps in this technology category, but only 42% of annual energy use in the category. Table 2 also shows that only one-quarter of total lamps, representing 32 percent of total annual lighting energy use, are connected to automated controls. Of these roughly two-thirds are controlled by energy management systems. The rest are evenly distributed over three types of controls: motion sensors, time clocks, and dimmers.

Table 2. Distribution of Installed Commercial Interior Lighting Inventory by Technology

Lighting Technology	**% of Total Lamps**	**Average W per Lamp**	**Average Daily Op Hours**	**% with Automated Controls**	**% of Total Com Ltg Energy**
Incandescent	4%	53	10.4	24%	4%
Halogen	2%	67	12.4	27%	3%
Compact Fluorescent	10%	21	10.4	23%	5%
Linear Fluorescent	80%	35	11.1	34%	72%
High Intensity Discharge	2%	352	11.1	29%	14%
Other	2%	13	20.8	15%	2%
Average		42	11.2	25%	

Source: Navigant 2012b

Given their importance in the inventory, we focus the remainder of the analysis and discussion in this paper on four sets of technology groups: general lighting with linear overhead fixtures; high bay lighting, integral screw-in lamps to replace incandescent and halogen bulbs, and controls. For each technology group, we discuss technical savings potential, evolution of codes and standards, and results of research on current standard or baseline practices, including saturation of competing technologies in the installed inventory and share of current sales.

Characterization of Technologies and Market Conditions

Linear Fluorescents

Technology and standards. Table 3 shows wattages, savings, and costs for successive generations of linear fluorescent technologies, using a typical 4-foot, 2-lamp fixture as an example. The electronic ballast/T8 combination has been available commercially since the mid-1980s. As shown in Table 3, it offers significant savings over the predecessor magnetic ballast/T12 technology (33%). By 1998, the market share of electronic ballasts exceeded that of magnetic ballast, and the electronic ballast/T8 combination represents baseline practice for replacement and new construction applications. (XENERGY 1997) Standards issued under the

National Appliance Energy Conservation Act (NAECA) of 1988 effectively proscribed the sale of magnetic ballasts for new and replacement T12 fixtures beginning in July 2010. Standards set to take effect in 2014 will effectively require the use of electronic ballasts for all important categories of linear fluorescent fixtures. Finally, lighting power density standards incorporated into most state building codes effectively require the use of the T8 technology in new construction and major renovation projects subject to code review.

Table 3. Linear Fixture Technology Performance and Costs*

TECHNOLOGY/APPLICATION Measure	Baseline Unit	Baseline Wattage	Measure Wattage	Measure Savings	Measure Cost	Payback Range (Yrs)[1]
LINEAR FLUORESCENT: 2 LAMP 4' FIXTURE						
Electronic Ballast/T8	Magnetic Ballast/T12	72	59	13	$62 -$92	11.4 – 16.9
Electronic Ballast/High Performance T8 Retrofit	Magnetic Ballast/T12	72	48	24	$70 - $100	7.0 – 10.0
Electronic Ballast/High Performance T8	Electronic Ballast/T8	59	48	10	$70 - $100	16.7 – 23.9
Electronic Ballast/ Reduced Wattage T8	Electronic Ballast/T8	59	41	18	$82 - $112	10.9– 14.9
LED Luminaire – 2010	Electronic Ballast/T8	59	N/A	N/A		
LED Luminaire – 2015	Electronic Ballast/T8	56	21	35	~ $150	10.3
LED Luminaire – 2020	Electronic Ballast/T8	56	16	40	~$80	4.8

***** Sources**:** Fluorescent fixture performance and price data: VEIC 2010; DEER 2008. LED performance and price data: Navigant 2012. DOE 2012.

[1] Payback calculations are illustrative and incorporate assumptions of $0.11/kwh for commercial electricity and 3,800 hours of operation per year.

Over the past 10 years, manufacturers have developed a number of technologies that provide incremental improvements to linear fluorescent efficiency. High Performance (HP) ballasts use less energy than standard electronic ballasts to power matched high performance T8 lamps, which also provide a higher level of lumen output than standard T8s. HP fixtures can replace standard T8 fixtures in nearly all applications. In new construction and remodeling, additional savings can be gained through use of lighting designs that take advantage of the HP systems' higher output. Reduced wattage T8s offer higher savings versus conventional T8s, but may not serve as suitable replacement in all applications. Lighting output from reduced wattage T8s is roughly 10 percent lower than standard T8 technology, and these lamps may experience performance problems in cold conditions.

As of this writing there are no direct replacements for linear fluorescent lamps using LED technology. A number of manufacturers offer tube-shaped LED replacements that can be fitted into existing fixtures, generally bypassing the ballast. Recent tests by the U. S. Department of Energy's Commercially Available LED Product Evaluation and Reporting (CALiPER) Program found that products available as of April 2010 did not provide sufficient light output to replace fluorescent lamps. Since then, manufacturers have continued to introduce products. However, troffer-type LED fixtures have not achieved efficacies significantly better than current fluorescent fixtures. (DOE, 2011a)

Studies of LED technology development commissioned by the U. S. Department of Energy and manufacturers forecast rapid increases in efficacy and decreases in cost. (Navigant 2012, McKinsey, 2011) These forecasts are based on trending of recent developments as well as interviews with manufacturers and other market actors. The results are consistent with major investments in technology development currently underway. International manufacturers and national government agencies have been working to address the key technical and manufacturing issues that inhibit the widespread acceptance of LED lighting. As of 2010, industry/government consortia in the United States, Europe, China, Korea, and other Asian countries had already committed over $600 million in funding for basic scientific research, product development, and demonstration of manufacturing improvements. (DOE 2011b) These developments are reflected in the measure wattage and cost forecasts shown in Table 3 for linear LED fixtures in 2015 and 2020. If the forecasts concerning performance and price of LED luminaires are relatively accurate, then we can expect that payback periods for LED replacements for linear fluorescents approach current paybacks for efficient fluorescent technology by sometime in the 2020s. Depending on the degree to which customers recognize and value extended useful life, this point may arrive even sooner.

Table 4 shows the trend assumptions for LED lamp and luminaire price and efficacy used in the DOE technology forecast. (Navigant 2012a) Applying these assumptions to linear fluorescents results in the forecast that LED luminaires will reach approximate price parity (cost per lumen output) with fluorescent technology by 2020 while offering a 71% reduction in wattage.

Table 4. Forecasts of LED Performance and Price

LED Product	**2010**	**2015**	**2020**	**2025**
LAMPS				
Efficacy (lumens/W)	37	113	182	189
Price ($/kilolumen)	$55	$11	$6	$4
LUMINAIRES				
Efficacy (lumens/W)	70	145	193	202
Price ($/kilolumen)	$181	$42	$24	$17

Source: Navigant 2012a

Saturation and market share. Saturation refers to the portion of the installed lighting inventory accounted for by a given technology at a given time. It reflects the accumulated interaction of many events, including turnover in occupancy, renovation, replacement purchases, and additions and deletions to the building stock. Market share refers to the portion of sales in a given period accounted for by the subject technology. Market share reflects the interaction of many factors, including product performance, availability, and price, customer awareness, and the professional practice and business concerns of firms in the supply chain.

The federal government collected and published data on shipments and prices of fluorescent ballasts and lamps through 1997. Manufacturers stopped providing input data for those series, largely out of concern for competitive position. Since then, a number of utility sponsors have undertaken studies to estimate technology market shares in their own service territories, based on surveys of lighting product distributors and installation contractors. Technology saturation studies generally require on-site fixture inventories, and are therefore expensive to conduct. However, a number of utilities and government agencies have undertaken technology saturation studies for their service areas.

Table 5 summarizes the results of linear fluorescent saturation and market share studies conducted over the past 8 years. The regions represented in the table vary in terms of the level of energy efficiency programming they had experienced at the time of the study. The Pacific Northwest, Vermont, and Wisconsin had all hosted significant public benefits programs. In Maryland and Colorado, those efforts had been smaller and less consistent. The key findings to be derived from Table 4 and the studies that support it are as follows.

- Electronic ballast/T8 combinations are well-established as the baseline for replacements and new construction, even in areas that had not experienced significant programming.

Table 5. Linear Fluorescent Technology Saturations and Market Shares

Sponsor	Region	Year	Mode/n	Mag/T12	Elec/T8 (HP)	T5	Other
SATURATION STUDIES							
NEEA	OR, WA, ID	2009	On-site/585	35%	55%	3%	6%
MD PSC	MD	2009	On-site/86	30%	65%	5%	
VT PSC	VT	2007	On-site/116	40%	41% (5%)	4%	17%
XCEL	CO	2006	On-site/152	50%	50% (6%)		
MARKET SHARE STUDIES							
MD PSC	MD	2009	Phone/20	7%	80% (21%)	13%	
WECC	WI	2005	Phone/35	10%	70% (22%)	20%	

Sources: Cadmus 2009, Itron 2010, KEMA 2005, KEMA 2006, KEMA 2007

- Related to the first finding, the inventory of magnetic ballasted fixtures has been declining over time, regardless of the level of program activity. In the Northwest, for example, a 2003 on-site survey estimated the saturation of magnetic ballast/T12s at 55% v. 35% in the 2009 study.
- Adoption and saturation of efficient linear fluorescent technology is closely related to market segment. The XCEL Colorado survey found that the saturation of T8s in small facilities (<10,000 sf) was 24%, versus 45% for facilities up to 100,000 sf, and 77% for facilities over 100,000 sf.

High Bay Lighting

Technology and Standards. Table 6 displays performance and cost data for current high bay lighting technologies, using a standard 20,000 - 24,000 lumen fixture as an example. As shown, pulse start HIDs provide significant savings compared to older probe start technology at relatively low incremental cost. Fluorescent technologies nearly double those savings, with negligible incremental costs for T8s. Fluorescent technologies offer additional benefits over HID fixtures, including lower installation and maintenance costs, longer lumen maintenance, no delay in restart, and dimming capability. Despite their price premium, T5 technologies have gained popularity among end-users and contractors because their light input is intense and provides high color rendition.

As of early 2012, a number of manufacturers have begun to sell LED luminaires that can replace HID fixtures. However, the models available to date have relatively low output. Replacement of HID fixtures has been identified as a strong application for LEDs due to the intense, highly directional light they provide. LED technologies are already becoming established in outdoor and roadway applications due to their long expected useful life.

The Energy Independence and Security Act of 2007 set minimum efficiency standards for metal halide lamp fixtures. Effective January 1, 2009, the law requires a minimum ballast efficiency of 88% for pulse start ballasts and a minimum ballast efficiency of 94% for magnetic probe start ballasts. The California Energy Commission recently adopted a two-tiered standard for metal halide lamp fixtures: the Tier 1 standards became effective January 1, 2010, and the Tier 2 standard will become effective January 1, 2015. Savings estimates are based on the Tier 2 standard, which requires a reduced-wattage lamp in combination with either a more efficient electronic ballast (90-92% depending on lamp wattage) or a ballast with a minimum efficiency of 88% as well as integral controls that dim lamps when not in use (occupancy sensors or daylight controls). These statewide standards effectively require the use of fluorescent technology in high bay applications

At this stage of market development, the payback periods for replacement of HID with fluorescent upon burnout are less than one year. Even for retrofit projects in which full measure costs are taken into account, paybacks range from 3 to 5 years, depending on the baseline and target technology.

Table 6. High Bay Lighting Technology Performance and Cost

TECHNOLOGY/APPLICATION Measure	Baseline Unit	Baseline Wattage	Measure Wattage	Measure Savings	Fixture Cost	Payback Range (Yrs)[1]
HIGH BAY LIGHTING: 320W PULSE START HID FIXTURE EQUIVALENT	Probe Start HID				$164	
Pulse Start HID	Probe Start HID	506	365	142	$203	0.8 – 1.1
Fluorescent T8, 6 lamp/ Electronic Ballast	Pulse Start HID	365	226	139	$210	<1
Fluorescent T5, 4 lamp/ Electronic Ballast	Pulse Start HID	365	234	131	$283	<1
LED Luminaire – 2010	Fluorescent T5	234	250	-16	N/A	
LED Luminaire – 2015	Fluorescent T5	234	121	113	$885	22
LED Luminaire – 2020	Fluorescent T5	234	91	143	$471	10

[1] Payback calculations are illustrative and incorporate assumptions of $0.11/kwh for commercial electricity and 3,800 hours of operation per year. Source: KEMA 2010.

Market share. The saturation studies of which we are aware do not distinguish between high bay and other kinds of spaces in estimating technology saturations. However, two recent studies have estimated the market share of high bay technologies using self-reported sales information from samples of installation contractors. These studies cover California, Massachusetts, and a comparison area consisting of four southern states in which no commercial lighting promotion programs had been conducted prior to the study. Table 7 summarizes the results of those studies.

The key findings to be derived from Table 7 and the studies that support it are as follows.

- In regions with a history of significant energy efficiency programs, linear fluorescents have clearly been established as the baseline replacement technology for high-bay lighting, accounting for a 78 - 80% market share. Even in areas that had not experienced promotions for efficient commercial lighting, fluorescent fixtures accounted for the majority of sales, although a significant portion of those were T12.

Table 7. Market Share of High Bay Lighting Technologies

Technology Type	California (2006 - 8)	Massachusetts (2006 - 9)	Comparison (2006 - 8)
Fluorescent Tube: T5HO/Electronic Ballast T5HO	65%	64%	29%
Fluorescent Tube: T-8 /Electronic Ballast T-8	14%	13%	16%
Fluorescent Tube: All other, including T12	1%	1%	11%
FLUORESCENT TUBE SUBTOTAL	**80%**	**78%**	**58%**
HID: Pulse-start metal halide	14%	3%	31%
HID: High-pressure sodium	3%	1%	8%
HID: Other HID: probe-start metal halide	1%	1%	3%
HID SUBTOTAL	**18%**	**4%**	**42%**
OTHER: INDUCTION, LED, CFL, INCANDESCENT	**2%**	**17%**	**2%**

Source: KEMA 2011

- Probe start metal halide technology, which is often claimed as a baseline in technical resource manuals and program plans, had virtually vanished from the market by 2008 in both the program and comparison areas.
- In the non-program areas, pulse start metal halides accounted for significant market share, thus offering significant efficiency improvements through substitution of fluorescent technology.

Medium Screw Base Lighting

Technology and standards. The federal EISA legislation raised standards for common light bulbs requiring them to use about 25-30% less energy than current incandescent light bulbs. Under the efficiency standards, which will be phased in between 2012 and 2014, the traditional 100-watt bulb will not meet the new standard of 72 maximum watts. The same will be true for the traditional 75-watt bulb in 2013 and the 60- and 40-watt bulbs in 2014 when the new maximum wattages become effective. The new efficiency standards, which are technology neutral, can be met by some advanced incandescents, compact fluorescent lamps (CFLs), and LEDs. Advanced incandescents that meet the EISA standards are already available from major manufacturers. California set similar standards in 2008 with a phased-in implementation beginning in January 2011.

Compact fluorescent bulbs represent a mature alternative technology to incandescents and offer significantly lower energy costs and longer life. CFLs currently on the market can provide lighting levels equivalent to incandescent bulbs rated up to 300 watts. As of this writing, the maximum light output available from omnidirectional medium screw base LED replacement bulbs is equivalent to a 60W incandescent. However, the maximum output of such lamps is increasing rapidly, and, directional LED lamps, such as PAR types for recessed down lighting fixtures, have been available for some time in higher output categories.

Table 8 displays information on medium screw base technology performance and price, using a 60W incandescent equivalent as an example. Generally, commercial applications will require higher wattages. However, as mentioned above, a 60W equivalent is the brightest LED omnidirectional bulb currently available.

Table 8. Medium Screw Base Bulb Performance and Price

TECHNOLOGY/APPLICATION Measure	**Baseline Unit**	**Baseline Wattage**	**Measure Wattage**	**Measure Savings**	**%Savings v. Baseline**	**Lamp Cost**
MEDIUM STANDARD BASE LAMP: 60 W INCANDESCENT EQUIVALENT						
Compact Fluorescent Lamp	Incandescent	60	14	46	77%	$3
LED 2012	Incandescent	60	12	48	80%	$15*
LED 2015	EISA-compliant Incandescent	43	8	35	81%	$10
LED 2020	EISA-compliant Incandescent	43	5	38	88%	$6

* Philips model currently available from a number of on-line and brick-and-mortar retailers.

Clearly, increased LED market share in this submarket will depend on customers' perceptions of the relative merits of CFLs and LEDs. As Table 1 showed, CFLs are already the baseline for medium base screw bulbs in the commercial sector. According to LED technology forecasts, LEDs will remain at least twice as expensive as CFLs with equivalent output well into the 2020s. (Navigant 2012a) LEDs offer a number of potential advantages over CFLs, including better color rendition, better dimmability, and effective useful lives 3 to 5 times longer than their CFL counterparts. The simple paybacks for switching from incandescent to LEDs range from 1.2 years in 2012 to less than one year in 2020, assuming 2,400 hours of operation per year. The payback on switching from CFLs to LEDs ranges from 30 years currently to 7 years in 2015 and finally to two years in 2020. However, if commercial customers take the value of longer life and reduced maintenance costs into account, the payback periods will be significantly lower.

Controls

As noted above, less than 1/3 of the energy used in commercial lighting is under any kind of automated control. An in-depth treatment of the market for lighting controls is well beyond the scope of this paper. However, a recent meta-analysis of 88 papers and reports analyzing energy savings from actual controls installations concludes that, properly installed, these measures can produce significant energy savings. Table 9 summarizes the results of studies that contained observations and analysis of post-installation performance (Williams et al. 2012). Average energy savings ranged from 24% to 38% of baseline consumption, depending on the control strategy employed.

Table 9. Energy Savings from Lighting Control Strategies

Strategy	Example/Definition	# studies reviewed	Average % Savings	Standard Deviation
Occupancy	Occupancy sensors	38	24%	+/- 17%
Daylighting	Modulation according to level of natural light	32	28%	+/- 10%
Institutional Tuning	Central adjustment of light levels through commissioning of systems	13	36%	+/- 18%
Personal Tuning	Dimmers, bi-level controls accessible to occupants	10	31%	+/- 24%
Multiple	Combinations of the above	34	38%	+/- 18%

Source: Williams et al. 2012.

Current Patterns of Program Support for Lighting Measures

We thought it would be useful for this strategic overview to understand how the patterns of actual program support for commercial lighting measures matched up against the map of current and evolving energy efficiency opportunities traced above. Using public sources, we were able to obtain sufficiently detailed measure records from Southern California Edison (SCE) to conduct this analysis for the first seven quarters of their current program cycle. (California PUC 2012) Granted, one company's portfolio constitutes a small sample. However, in the course of preparing this paper we reviewed the on-line application packages of over a dozen programs. We found few differences in the range of measures supported or the levels of incentives offered.

Table 10 displays life cycle savings and number of measures installed by measure type for the three principal types of programs in the SCE portfolio: deemed (prescriptive) incentives, calculated (custom) incentives, and direct installation. Replacement of T12s with T8s accounts for greatest portion of savings (31%) and individual measures (32%), even after aggregating all non-lighting measures into a single group. As we would expect, fully ¾ of these savings come from the Direct Install program, which targets smaller customers, who are more likely to have retained their magnetic ballast fixtures in place. We note that these measures are accorded a very long useful life (15 years) in the savings calculator. In some jurisdictions, life cycle savings calculations take into account differences in savings over the early years following installation, when the baseline is the replaced equipment, and later years, when the replaced equipment would no longer have been in place.

Replacement of high bay lighting contributes the next largest portion of total savings – 25% -- even though this class of measures accounts for less than 2 percent of total lighting supported installations. This result can be traced to the identification of high wattage metal halide fixtures as the baseline and an assumed measure life of 15 years. Finally we note that SCE has provided significant support for LED replacement of incandescent bulbs. The measure accounted for over 4 percent of all measures supported by the three programs.

Table 10. SCE Lighting Measures and Savings Q1 2010 through Q3 2011

	Deemed (Prescriptive) Incentives		Calculated (Custom) Incentives		Direct Install		Total of Three Programs	
	Lifecycle Savings GWH	# of Measures	Lifecycle Savings GWH	# of Measures	Lifecycle Savings GWH	# of Measures	Lifecycle Savings GWH	# of Measures
Total	***2854***	***3142***	***916***	***1354***	***2,765***	***5,069***	***6,535***	***9,565***
T8 replace T12	5.4%	10.2%	32.8%	28.7%	56.7%	46.6%	30.9%	32.1%
RW T8 replace T8	1.2%	9.0%	0.0%	0.1%	15.6%	9.7%	7.1%	8.1%
Other linear fluorescent	1.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.4%	0.1%
High bay fluorescent	52.5%	0.6%	1.8%	0.5%	4.7%	2.2%	25.2%	1.5%
Controls	15.2%	4.2%	3.5%	4.3%	3.1%	4.9%	8.5%	4.6%
CFLs	0.3%	3.5%	0.0%	0.0%	3.6%	15.1%	1.6%	9.2%
Other Lighting	3.9%	8.5%	11.1%	21.0%	2.4%	5.2%	4.3%	8.5%
LED replace Incandescent	0.0%	12.9%	0.4%	0.4%	0.0%	0.0%	0.1%	4.3%
Delamp existing fixtures	7.3%	18.9%	0.1%	0.2%	0.9%	1.5%	3.6%	7.0%
Non Lighting	13.2%	31.8%	50.2%	44.8%	12.8%	14.8%	18.2%	24.6%

Source: KEMA Calculations

Implications for Regional Program Administrators

Strategies for Mature Efficiency Technologies

Based on consideration of the information presented above, we draw the following conclusions in regard to programs that support mature efficiency technologies in the commercial lighting market.

- **Continue to support T12 retrofits among small businesses.** The concentration of T12 inventory in smaller commercial customers and the continued flow of participation in direct installation programs after many years of operation suggest that the occupants of small commercial establishments are unlikely to undertake the expense and hassle of lighting retrofits on their own. Thus, it makes sense to continue pursuing these savings even after federal standards result in elimination of magnetic ballasts and T12s from the market. However, retaining a 15-year effective useful life for this measure may overstate its total resource value. By now, the remaining inventory of T12s is well into its effective useful life. In these cases, it may be more appropriate to use a two-step benefits function in which T8 technology represents the baseline in later years of the measure's EUL. In light of these considerations, it may also make sense to require that retrofits use HP or RW T8 technology.
- **Stop providing incentives for high bay fluorescents**. Clearly the market is using fluorescent fixtures as the baseline, especially in regions with long-established programs. Moreover, costs have evolved to the point that unsubsidized paybacks are well within most businesses' investment horizon, especially when reduced maintenance costs and improved performance are taken into account.
- **Focus technical assistance and financial resources on vigorous promotion of controls.** The combination of low current saturation and high savings potential suggests

that customer and vendor education focused on promotion of lighting controls could yield significant net savings.

Strategies for LEDs and other Emerging Technologies

- **Cooperate actively with the DOE Solid-State Lighting program and other national efforts**. The U. S. Department of Energy has invested a great deal of resources and effort to provide key services in support of market transformation towards LED technologies. These activities have included the convening of an LED industry association, development of product standards, product testing, support of research and development, commissioning market research, and development and monitoring of technology roadmaps. These activities can be valuable to regional program sponsors in a number of ways: identification of products for demonstration and broader incentive support, identification of market segments for special attention, and so forth. Moreover, regional sponsors can reinforce the value of national efforts through monitoring product field performance, customer and vendor response.
- **Monitor LED technology development on an ongoing basis.** Review of product testing and other documents issued over the last 2 – 3 years demonstrates that LED technology is evolving rapidly. In order to "stay ahead" of the market in designing promotions and incentives, regional sponsors will need to monitor product price and performance on a continuous basis.

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