Transcending Product Efficacy in Commercial Lighting Program Design: Considerations in Promoting Systems Approaches to Capture Deeper Savings

Helen Aki, Consortium for Energy Efficiency

ABSTRACT

Federal minimum efficiency standards are increasing and new state, and local building energy codes (e.g., ASHRAE 90.1-2010/IECC 2012 and CA Title 24) demand greater energy savings from commercial lighting through more rigorous controls and lighting power density requirements. As a result, efficiency program administrators are challenged to design voluntary programs that move beyond traditional, product efficacy-oriented approaches. Program administrators must capture verifiable energy savings from a range of strategies including advanced fixtures, controls and design, while being flexible enough to address emerging lighting technology, differing regulatory environments, and varying customer priorities.

This paper seeks to accomplish three things. First, it will highlight common drivers affecting commercial lighting program design in a dynamic regulatory and market context, and draw from existing energy efficiency program typology to describe the spectrum of programmatic approaches in use today. Second, it will identify initial program design elements and performance metrics being tested in some programs to promote a systems oriented approach, often transcending traditional program categories as they seek to characterize and capture savings beyond one-for-one replacements. Finally, this paper will suggest next steps towards building a national level, consensus based framework that could help bring these program design elements and performance metrics to scale in the marketplace. The intended outcome is to advance a conversation around future efforts that, if coordinated at scale, have the potential to transform program design to accelerate the adoption of highly efficient and effective lighting strategies and systems.

Background and Market Context for Programs

Commercial lighting programs have long been a staple of the energy efficiency industry. In 2012, US and Canadian program administrators estimated incremental savings of 27,000 GWh of electricity, of which approximately 44 percent was attributed to ratepayer funded programs for commercial and industrial (C&I) customers (CEE 2014). The Database of State Incentives for Renewables and Efficiency (DSIRE) lists 464 individual commercial lighting programs actively operating in 48 states. Between 2001 and 2010, the average efficacy of installed lighting across all sectors increased 28 percent, due to the adoption of compact fluorescent lamps (CFLs) in the residential sector and from replacement of T12 linear fluorescent lamps with T8 and T5 lamps in the C&I sectors. These market transformations can be largely attributed to ratepayer funded efficiency programs that have historically targeted these measures (DOE 2010).

Coordinated utility program promotion of replacements of T12 lamps with efficient T8s, such as those defined and specified in the Consortium for Energy Efficiency (CEE) Commercial Lighting Systems Initiative and qualifying product lists, has historically accounted for a significant portion of claimed savings for commercial lighting programs, often between 30 to 40 percent (Rosenburg 2012). However, the most recent US Department of Energy (DOE) energy

conservation standards for general service fluorescent lamps effectively eliminated the sales of T12 lamps, affecting baselines for voluntary programs in the US and thereby eroding their ability to continue cost-effective incentives for T12 replacements.

At the same time, state and local building codes increasingly demand more efficient lighting performance. For the first time ever, ASHRAE/IES 90.1-2010 cuts lighting power density allowances below one watt per square foot in common applications, such as schools and offices. ASHRAE/IES 90.1-2010 also increases minimum controls requirements, including mandatory automatic shutoff, occupancy sensors in a broader range of applications, multilevel lighting in many spaces, and automatic multilevel lighting and daylight control in some applications. While building energy code adoption is a patchwork based on state and local regulations, these codes affect program baselines and the ability to claim savings. Most new construction programs require performance better than a baseline energy code in order to administer incentives; in addition, California, subject to the even stricter Title 24 Building Energy Efficiency Standards, requires projects in existing buildings to claim savings only in excess of code.

In the face of these pressures, the lighting industry continues to evolve, and rapidly. Solid state LED lighting (SSL) has emerged as a serious contender for market share, particularly in certain product lines, such as reflector and directional lamps, and is estimated to have the potential to become the dominant lighting technology across market segments in the next 20 years (DOE 2013). LED centric startups compete with established market players, who in turn are beginning to shift their business models toward becoming providers of "lighting solutions." In part due to the increased potential for dimming and intelligent, networked controls presented by SSL, controls manufacturers and electronics companies are beginning to emerge as players in the lighting industry as well.

Together, these drivers and dynamic market conditions call for utility program administrators to consider program design models that channel investment in energy efficiency towards measures that go beyond efficacy-based, per product incentives. Several administrators, particularly in regions that have adopted more recent energy codes, have already begun to test program delivery models and incentive structures that promote more effective installations, greater customer satisfaction, and maximized per project energy savings. Since 2009, CEE has been working to respond to member program administrator needs to go beyond savings from individual components and begin evaluating opportunities to promote aggressive savings through whole lighting systems, controls, and design. This sentiment has been echoed by the lighting industry as represented by the National Electrical Manufacturers Association (NEMA). In 2012, the NEMA Lighting Division published a white paper emphasizing the need to shift the regulatory focus from appliance standards, e.g., efficacy measured in lumens per watt, to lighting systems standards, e.g., lighting power density measured in watts per square foot, as described in building energy codes such as ASHRAE/IES 90.1 in order to maximize energy savings (NEMA 2012).

Commercial Lighting Programs Today

As an end use targeted for energy efficiency, commercial lighting is often woven throughout the typical program portfolio. While efficiency program administrators often run specific prescriptive programs for commercial lighting, they will also promote lighting measures through other programs that target commercial and industrial (C&I) customers, such as new construction or small business programs.

Over the past few years, CEE has been working in collaboration with researchers at the Lawrence Berkeley National Laboratory (Berkeley Lab) to develop a typology for energy efficiency program categories in order to enable multistate analyses of programs (Hoffman et al. 2013). These program categories are arranged by portfolio sector (residential, commercial, etc.) and broken down into more detailed categories based on a review of annual energy efficiency reports. The following detailed program categories describe a broad range of program designs, and can be used to demonstrate how program administrators promote commercial lighting measures throughout their portfolio:

- **Prescriptive:** Probably the most commonly implemented lighting program, prescriptive C&I lighting programs provide incentives or rebates for efficient lighting products, such as lamps, fixtures, and component-based controls (occupancy sensors, timers, photocells). Prescriptive programs can be further broken down by the approach to delivering incentives. Downstream programs pay incentives directly to the customer, whereas upstream programs pay incentives to manufacturers, distributors, or retailers in order to drive higher stocking and sales of select products.
- **Custom:** Custom programs are designed to capture and incentivize savings from site-specific projects based on performance, and include uniquely selected measures that tend to be identified through an energy audit and verified through commissioning or retro-commissioning. In particular, efficiency program administrators often report using custom programs to accommodate more advanced or complex lighting measures that don't fit readily into a prescriptive program, such as networked lighting control systems.
- **New Construction:** Many program administrators maintain a separate new construction program to incentivize energy efficient of new buildings, generally beyond a code baseline (such as ASHRAE/IES 90.1, IECC or CA Title 24). While custom programs generally target existing building retrofits for savings beyond measured/existing conditions, new construction programs can generally only incentivize measures (such as highly efficient lighting and controls) that provide savings in excess of code requirements.
- **Street Lighting:** Some program administrators implement programs that specifically provide incentives or other support for efficient street and traffic lighting, likely buoyed by the recent surge in popularity of LED technology for street light replacements. Between the 105 program administrators that provided program level data to support the CEE 2013 Annual Industry Report, about $27 million was reported in spending on street lighting programs.
- **Small Commercial:** Programs that specifically target small commercial facilities may be either prescriptive and involve the direct install of prequalified measures, or custom and require approval for measures based on an assessment. Both types of programs typically include lighting measures, generally replacements with efficient T8s.

As lighting programs evolve, specialized offerings for commercial lighting measures that do not fit neatly into the program categories described above have begun to develop. Generally speaking, these programs seek to promote savings beyond increased product efficacy and one-for-one replacements, while sending a more upfront and clearly defined signal to the market than a typical custom program. A consistent nomenclature has not yet emerged; a sampling of CEE members will quickly reveal a range of programs operating under designations such as

"Advanced," "Enhanced," "Comprehensive," or "Performance." Some common elements of these programs include:

- **Incentives for "Advanced" Products:** In order to promote greater incremental savings per product installed, some programs provide higher levels of incentives for advanced lamp or luminaire products, which are associated generally with higher upfront associated cost and customer values in addition to high efficacy, such as improved color quality or intelligent controls. Some program administrators provide incentives for advanced technologies as part of their standard program offerings; others view these investments as part of an emerging technology or pilot program. These incentives tend to be prescriptive in nature, but may vary between prescriptive amounts per product, per project, or per square foot.
- **Performance-Based Incentives:** Some programs require minimum threshold energy savings for projects to qualify for incentives, agnostic of technology, and may provide tiered incentives for incremental performance above that threshold. Incentives under these programs tend to be calculated or custom in nature, but may differ from custom programs in that they establish minimum requirements and performance targets for lighting upfront. Some programs administer incentives based on deemed values; others leverage a staged incentive approach, with a portion of the incentive being awarded only after a designated measurement and verification (M&V) period.
- **Qualifying Project Requirements:** Beyond a minimum energy savings threshold, some programs require additional minimum project scope elements to ensure performance and qualify for incentives, such as: addressing a certain percentage of light fixtures within a project, requiring certified professionals to design or commission a system, or meeting minimum performance requirements at the system level. These may often be addressed as part of a whole building performance program. Incentives may be either predetermined/prescriptive (per project, per square foot) or custom/calculated (based on energy savings or a percentage of total project cost).

Examples from Commercial Lighting Programs

MassSave Networked Lighting Controls

The MassSave Networked Lighting Controls initiative, launched in late 2013, is an effort specifically designed to promote the "specification, installation, programming and commissioning of Network Lighting Controls Systems [sic]" in commercial buildings (MassSave 2013). Networked lighting controls systems are made up of lighting, sensors and controls that are programmable, addressable, and networked to a central server (Bartholomew and Castellino 2013). The MassSave initiative offers a predetermined incentive amount of $0.50 per square foot of controlled, conditioned interior space, for up to 75 percent of the incremental project cost (for new construction) or 50 percent (for retrofits), to projects that can meet minimum requirements, including:

- **Project Size:** Minimum of 25,000 square feet and 150 lighting fixtures controlled by the networked lighting controls system.
- **Qualified Equipment and Contractors:** Installed controls equipment must be from a vendor prequalified by participating utilities. At least one person on the project team must

hold one of the following: International Association of Lighting Designers (IALD) membership, Lighting Certified (LC), Certified Lighting Efficiency Professional (CLEP), or Professional Engineer (PE) license.

- **Minimum Energy Performance:** Projects must meet or exceed Massachusetts energy code requirements for controls and lighting power density (LPD), as well as model a 40 percent reduction in kWh below code. This initiative is further supplemented by the MassSave Performance Lighting program, which provides a tiered, additional per kWh incentive for projects that achieve 15 percent or better LPD than code.
- **Post-installation Training and Commissioning.** Customer must commit to training for owners, occupants, and facilities personnel upon installation and 12 months after installation; also to providing 12 months of energy data post-installation and performing final commissioning three months after system initialization and space occupancy.

In order to verify performance and promote commissioning, the MassSave initiative makes use of a staged incentive approach, where 80 percent of the incentive is paid upfront once project requirements are met, and the remaining 20 percent paid after the project is commissioned (MassSave 2013).

Sacramento Municipal Utility District Advanced Lighting Controls Incentive Program

The Sacramento Municipal Utility District (SMUD) Advanced Lighting Controls Incentive Program, a demonstration effort subsequently adopted as an ongoing program, encourages "large-scale commercial customers" to install advanced lighting controls by offering a $0.25 per kWh incentive, up to $100,000 or 80 percent of project cost. SMUD offers an additional incentive of $200 per kW for projects that use a contractor certified by the California Advanced Lighting Controls Training Program (CALCTP). To qualify for an incentive, projects must install a new control system listed on SMUD's Qualified Product List with some minimum specified capabilities, and comply with California Title 24 Building Energy Codes. While the program cannot be combined with other SMUD rebates, savings resulting from the installation of new LED fixtures in combination with the control system can be eligible for the per kWh incentive as long as the LEDs installed are dimmable (SMUD 2013). In 2012, 14 projects achieved between 50 and 90 percent in energy savings. Approximately 60 percent of the savings came from lighting upgrades, and 40 percent from controls. SMUD found that the best candidates for savings through this program were parking garages, big box retail, and industrial or warehouse facilities (Parks 2013).

Bonneville Power Administration Lighting Calculator

The Bonneville Power Administration (BPA)'s Lighting Calculator (version 3.1 at the time of writing this paper) empowers a hybrid approach to administering performance incentives for commercial lighting projects by simultaneously considering prescriptive and custom measures. To qualify, a project must achieve a minimum overall 25 percent reduction in kWh, compared to either a code baseline (for new construction projects) or existing conditions (for retrofits). BPA's calculator adjusts savings estimates for interactive HVAC effects, and includes a baseline adjustment factor for lighting measures related to the increased federal general service fluorescent lamp (GSFL) standards. Approved measures (i.e., one-for-one replacements) use deemed savings values that are loaded automatically, while custom measures (such as

nonstandard technologies, or decommissioning-redesign efforts that alter installed fixture quantity) are either calculated based on user inputs or require hands-on approval from BPA staff.

BPA offers tiered, performance-based per-kWh incentives for projects at 40 percent energy savings and 60 percent energy savings, but caps their incentive award at 70 percent of total project cost. They also offer a performance incentive for advanced lighting controls that that can report verifiable energy savings above a deemed 25 percent value. As a wholesale power agency serving hundreds of local program administrators, BPA offers the additional functionality for individual administrators to adjust per measure incentive levels, total incentive caps and other elements within the calculator to tailor to their specific program needs (BPA 2013; J. Wilson, Nonresidential Lighting Programs Manager, BPA, pers.comm., March 6, 2014).

Puget Sound Energy Enhanced Lighting Program

The Puget Sound Energy (PSE) Enhanced Lighting Program seeks to promote savings beyond one-for-one replacements with greater efficacy products by requiring qualified projects to be "comprehensive," i.e., to address all lighting on the associated PSE account, both interior and exterior (ACEEE 2011). As of 2013, to obtain the "enhanced" tier incentive ($0.30 per kWh saved versus $0.20 for a standard project), projects must achieve an LPD at least 10 percent better than the applicable Washington State Energy Code. Technologies must either be approved with a deemed savings value (for prescriptive measures) or calculated using the PSE Lighting Calculation Worksheet (PSE 2013).

Table 1. Example program elements

	Incentives for Advanced Products	Performance-Based Incentives	Minimum Project Requirements
MassSave	$/sf subsidy for incremental cost of networked lighting controls	Tiered $/kWh incentive for projects that exceed code LPD by 15%	Certified professional Minimum project size Minimum 40% kWh savings MassSave qualified products
SMUD	$/kWh incentive for lighting controls and dimmable LEDs		SMUD qualified products Additional $/kW incentive for CALCTP certified contractor (optional)
BPA	Deemed values and calculated measures	Tiered $/kWh incentive for projects with 40% and 60% kWh savings	Minimum 25% kWh savings
PSE	Deemed values and calculated measures	Tiered $/kWh incentive for projects that exceed code LPD by 10%	"Comprehensive" – address all lighting on account

Performance Metrics in a Dynamic Lighting Market

Historically, commercial lighting programs have been primarily widget-based, defining performance relative to appliance standards, typically represented as either component or luminaire efficacy, and expressed in lumens per watt (LPW). The advance of solid state lighting

(SSL) technology, which produces a more directional photometric distribution than incumbent incandescent and fluorescent light sources, presents challenges for the LPW metric from a design standpoint, as it cannot be used as readily as a proxy for delivered footcandles and illuminance performance. Furthermore, lamp or fixture efficacy as a metric for performance does not reflect the opportunity to capture savings from changes in total installed lighting power that might be affected by fixture quantity, spacing and other design strategies, or changes in total energy consumption that result from the use of controls.

Table 2 depicts a brief overview of some technology-agnostic metrics that reflect performance at the system or project level, and some of their associated benefits and limitations from a program design perspective.

Table 2. System-level performance metrics

Metric	Units	Benefits	Limitations
Lighting Power Density (LPD)	watts per square foot	Used in building codes; allows designers and specifiers to select lighting to meet needs rather than being constrained by components	As a power metric it doesn't address controls and kWh savings based on operations
Lighting Energy Density (NEMA 2012)	kWh per square foot per year	Measures energy use; can address controls; allows designers and specifiers to select lighting to meet needs rather than being constrained by components	Standards would need to assume standard operating hours for building types or spaces; challenging to enforce and best suited for custom program approach
Lighting Energy Code Comparison (LECC) (NBI 2012)	% savings over code for W/SF, kWh/SF-year, and peak demand W/SF-year	Estimates code predicted energy consumption and % energy savings for a given particular application assuming select occupancy patterns	Not commonly adopted; would require additional work to establish as a standardized and measured performance language implemented by control system manufacturers
Illuminance Efficacy	footcandles per watt	Design-oriented, allows for meaningful comparison of component performance within a design context	Only meaningful in context of a relevant design template that establishes common space characteristics (e.g., mounting height, surface reflectance values)

The majority of the programs described in the previous section build their approach around a combination of LPD targets, percentage energy savings requirements and deemed and calculated measure savings values in order to customize performance-based incentives for an individual project. One notable exception is the incentive model used in the MassSave Networked Lighting Controls initiative, which delivers a predetermined per square foot incentive

to projects that can meet certain minimum requirements in addition to LPD and energy savings targets. The advantage to the per square foot incentive is that it has the potential to send a more consistent, upfront signal to the market than a performance incentive, which cannot be determined until after the project scope is complete and some initial engineering calculations have been run. A per square foot incentive can be more readily anticipated and incorporated into initial project budgeting, as well as leveraged by lighting controls industry stakeholders to help customers understand the degree to which utility incentives may offset incremental costs. Further development of metrics such as lighting energy density or LECC could be used to support characterization of measures and projects that include both energy and load reduction, in order to inform these types of prescriptive incentives at the system level.

In order to characterize useful performance levels for the purposes of system oriented commercial lighting program design, other performance requirements may be necessary in addition to the types of metrics described above. For example, in order to delineate performance levels for a measure like the installation of an advanced lighting control system relative to a metric such as lighting energy density, programs may require that energy savings be measured in a consistent and comparable manner. CEE has been working to develop an assessment procedure for lighting controls that would help to ensure that assessments done at the emerging technology stage yield results that can be compared, apples-to-apples, between like projects with consistently measured and document controls strategies. It is possible that something similar could be developed and implemented at the M&V stage, as part of project requirements to qualify for incentives, or even specified as part of the core functionality of a control system.

Scaling Up: Next Steps to Transform Program Design

As programs work to capture the next level of savings from commercial lighting, innovative practices and program designs have begun to emerge. By achieving consensus from a critical mass of players around performance metrics, program design models, and market strategies, these efforts can be leveraged as the basis for a national approach to accelerate this market transformation.

Over the coming year, CEE intends to revise its Commercial Lighting Systems Initiative beyond T8 specifications in order to support the needs of the commercial lighting program industry at a portfolio level, as well as provide a framework to enable the transition to a systems oriented approach to promoting savings. Once established, this framework will have the potential to inform minimum program elements and performance levels for voluntary adoption by US and Canadian program administrators in support of the types of programs described in the previous case studies. The framework would also describe expectations for performance, from product to lighting system level that could inform individual program work with local and regional trade allies, such as distributors, designers, specifiers, and installers.

The challenges presented by a dynamic market context and increasingly stringent regulatory environments also unlock new opportunities to rethink commercial lighting program designs and pursue savings opportunities beyond one-for-one replacements. By working together, there is an opportunity for programs to move beyond product efficacy and explore other methods to advance markets for efficiency.

Resources

ACEEE (American Council for an Energy-Efficient Economy). 2011. *Commercial Lighting – Exemplary: Enhanced Lighting Program, Puget Sound Energy, Program Administrator and Implementer*. Washington, D.C.: American Council for an Energy-Efficient Economy.

ASHRAE (formerly American Society of Heating, Refrigerating and Air Conditioning Engineers). ASHRAE/IES 90.1 – 2010 and 2013. *Energy Standard for Buildings except Low-Rise Residential Buildings*.

Bartholomew, E. and K. Castellino. 2013. "Lighting Control Systems: New Construction and Retrofit." Presentation given as a National Grid Webinar, September 26.

CEE (Consortium for Energy Efficiency). 2008. *Commercial Lighting Systems Initiative*. Boston, MA: Consortium for Energy Efficiency.

———2014. *CEE Annual Industry Report, 2013 State of the Efficiency Program Industry: Budgets, Expenditures and Impacts*. Boston, MA Consortium for Energy Efficiency.

DOE (United States Department of Energy). 2013. *Solid-State Lighting Research and Development: Manufacturing Roadmap*. Washington, D.C.: Department of Energy.

———2014. Status of State Energy Code Adoption. Washington, D.C.: Department of Energy. http://www.energycodes.gov/status-state-energy-code-adoption.

———Building Energy Codes Program. Accessed 3 March 2014. http://www.EnergyCodes.Gov.

DSIRE (Database of State Incentives for Renewables & Efficiency). Accessed 3 March 2014. http://www.dsireusa.org/

Hamilton, B., A. Cortese, and D. Harris. 2012. *Establishing a Data Collection Methodology, Common Metrics and the Lighting Energy Code Comparison for Lighting Control Systems Research*. Vancouver, WA: New Buildings Institute.

Hoffman, I., M. Billingsley, S. Schiller, C. Goldman, and E. Stuart. 2013. *Energy Efficiency Program Typology and Data Metrics: Enabling Multi-State Analyses Through the Use of Common Terminology*. LBNL-6370E. Berkeley, CA: Lawrence Berkeley National Laboratory.

LCA (Lighting Controls Assocation), 2011. *ASHRAE Releases 90.1-2010 – Part 2: Lighting Controls. Lighting Controls Association*. 16 May. http://lightingcontrolsassociation.org/ashrae-releases-90-1-2010-part-2-lighting-controls/

MassSave. 2013. Network Lighting Controls Project Requirements. Mass.: MassSave. http://www.masssave.com/business/eligible-equipment/networked-lighting-controls

NEMA (National Electrical Manufacturers Association). *NEMA Lighting Systems Division. 2011. Systems Approach for Lighting*. LSD 62-2011. Rosslyn, VA: National Electrical Manufacturers Association.

PSE (Puget Sound Energy). 2013. *Commercial Rebates, Grants and Programs*. Puget Sound, WA: Puget Sound Energy.

Rosenburg, M. 2012. *Moving Targets and Moving Markets in Commercial Lighting*. Washington, D.C.: American Council for an Energy-Efficient Economy.

Parks, J. 2013. "SMUD's Advanced Lighting Controls Program." Presentation given at CEE Industry Partners Meeting, Atlanta, Ga. September 19.

Sacramento Municipal Utility District. 2013. *2013 Advanced Lighting Controls Incentive Program Project Requirements and Frequently Asked Questions*. 23 January. Sacramento, CA: Sacramento Municipal Utility District.

Sondhi, R. 2013. "Advanced Commercial Lighting Opportunities." Presentation given at CEE Industry Partners Meeting, Atlanta, GA. September 19.