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Position Paper on Solid State Lighting in Efficiency Programs

This position paper is intended to support the energy efficiency program industry in its effort to effectively communicate with the SSL industry and responsibly identify and assess applications that appear ready for SSL promotion and market introduction. The information below was developed by CEE members in response to questions and considerations typically encountered by members in the course of communications with the SSL industry. By having the benefit of responses developed and considered by a host of program administrators and making these readily available to all CEE members, the intention is to better ensure that members' interests are consistently and accurately conveyed to the SSL Industry. This will help to advance the greater objective of our work, to accelerate the integration and promotion of quality, efficient SSL products by CEE member organizations and others that can benefit from resulting momentum.

Basics on Voluntary Efficiency Programs

What are common drivers of energy efficiency programs?

Energy efficiency programs, including those administered by CEE members, independently determine the nature and approach employed within their respective programs, considering a host of objectives and factors. Although there are variations across energy efficiency programs in the U.S. and Canada, many independently opt to incorporate standard elements recommended by CEE, such as CEE's Super-Efficient Specifications or Recommended Guidelines (See the Energy Efficiency Program Requirements for SSL section).

Energy efficiency programs are usually funded through utility ratepayer contributions—assessed through utility bills—with the money specifically designated for advancing energy efficiency goals. Together, U.S. and Canadian energy efficiency budgets topped $4.5 billion in 2008, as explained in the CEE's 2008 Annual Industry Report. Because most energy efficiency programs are overseen by state regulatory entities (e.g., public utility commissions), sales data and/or project information is generally required to demonstrate that the money spent by the efficiency program is generating the expected benefits in its jurisdiction.

In addition, energy efficiency programs need assurance that the expected energy savings will be realized over the life of the product they helped to promote. This aspect explains why energy efficiency programs require detailed product information as described in the Recommended Guidelines and why many reference specifications, such as those set by CEE and ENERGY STAR, in their programs. The price of products is also an important factor because if a fixture costs more than the energy savings delivered over its lifetime, it won't be cost-effective for the end consumer.

Lastly, energy efficiency programs often (though not in all cases) need to demonstrate to the end customer that they supported the product in some way, e.g., through a rebate.

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What types of incentives do efficiency programs commonly use?

Generally, energy efficiency programs use several methods to promote energy efficient products and services (and some programs may combine elements). One common method is to offer incentives for the more efficient product or service. Although individual programs often include incentives, the incentive amounts often differ as they are typically determined by a screening process that includes considerations such as the total cost of the incentive (to the end customer) and the total benefits (energy and non-energy benefits in that particular service area based upon the costs of delivering incremental energy services). In most cases, the resulting system and/or customer benefits must be equal to or greater than the cost.

- There are two basic types of incentives.
- Prescriptive Incentives – These incentives are provided at a set dollar amount per product as detailed above. This approach is most commonly used in residential programs, as well as some commercial programs. Prescriptive incentives are generally at the product scale.
- Performance Incentives – These incentives are more customized than prescriptive incentives. They are commonly used in the commercial sector (generally businesses and industrial facilities) and they vary based on the energy savings that are applicable to the particular project in question. Performance incentives generally apply to more complex system-level improvements.
- Incentives can be directed to different market actors.
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Upstream Incentives – These incentives target manufacturers or retailers. These incentives can have a greater impact on the end buyer than downstream incentives (see below) because they result in a lower wholesale cost.

Market Share Incentives – One type of upstream incentive is a market share incentive, where a manufacturer or retailer is rewarded when they increase the product's share in the market over time. The incentive level may be measured based on manufacturer shipments to the service territory, retailer sales data, or retailer shelf-space surveys.

Cooperative Advertising – In this type of upstream incentive, funding is made available to participating market actors (manufacturers, retailers, contractors, etc.) for advertising designed specifically to promote energy efficient products. The advertising copy is approved by the energy efficiency program and the cost of approved advertising is shared by the energy efficiency program and the market actor.

Salesperson Incentives – This type of incentive encourages the retail, showroom, or distributor sales staff to make higher sales of qualifying products. (It is currently being utilized in for select SSL products in the Wisconsin Focus on Energy program.)

Downstream Incentives – These incentives target the end buyer of the product or service.

Mail-In Rebates – This downstream incentive can be distributed by efficiency programs, manufacturers, or retailers. A mail-in rebate is submitted by the buyer, after purchase, to the sponsoring energy efficiency program for processing.

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Instant Coupons – This incentive type takes an instant discount off of the qualifying product at retail. The retailer then collects the coupons and sends them to the sponsoring energy efficiency program for processing.

Common Residential Program Types		Common Commercial Program Types	
Manufacturer/ Retailer/ Distributor	Prescriptive (most)	Manufacturer/ Retailer/ Distributor	Performance or prescriptive
	Market Share (some)		
	Cooperative Advertising (some)		
	SPIFFS (some)		
In-house programs (such as audits or new construction)	Performance or prescriptive	On-site programs (such as audits or new construction)	Performance or prescriptive

For more information, please see the Commercial and Residential Lighting Program Summaries, each of which include details about the SSL programs offered by CEE members.

Basics on Energy Efficiency Program Approaches to SSL

Efficiency programs are cautious but optimistic about SSL. Why?

Rapid progress in solid-state lighting (SSL) research and development (see the Department of Energy's SSL R&D Portfolio) has resulted in the advent of light-emitting diodes (LED) for general lighting applications. LEDs offer a number of advantages over current lighting technology. In addition to significant energy savings, high-quality LEDs have been shown to last longer and require less maintenance than incandescent and most fluorescent products. Most LEDs contain no mercury, lead, or other known disposal hazards. They excel in cold applications such as outdoor signs, street and area lighting, along with refrigerated display cases.[i]

LED technology is developing very rapidly, with new generations of LED light engines being developed about every 6 to 9 months. White LEDs are expected to replace existing lighting technologies in the not so distant future, but in the near term this rapid evolution can lead to poor quality products entering the market.[ii] Efficiency programs only want to support LED products that deliver significant energy savings and provide a high level of consumer satisfaction.

Why are energy efficiency programs interested in quality?

Recent tests conducted by the Department of Energy (DOE) CALiPER Program reveals that many product performance claims do not hold up under testing. Some time will need to pass before a level of consistently high performance can be achieved across the industry.

LED luminaires and replacement lamps available today often claim long life, usually 50,000 hours, which exceeds the life ratings of nearly all other light sources (except for some electrodeless

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sources). These claims are based on the estimated lumen depreciation of the LED used in the product and often do not account for other components or failure modes. One of the key lessons learned from early market introduction of compact fluorescent lamps is that long life claims need to be credible and backed-up with appropriate manufacturer warranties.[iii]

Applications and Product Design

Which technologies are of interest to energy efficiency programs?

Energy efficiency programs have observed rapid progress in the development of the SSL market. It has moved from niche applications (holiday strands, night lights, refrigerated cases) toward general illumination in outdoor and commercial spaces (parking lighting, commercial spaces, accent lighting).

Energy efficiency programs working in both commercial and residential buildings are interested in efficient and high-quality LED lighting products that can replace incumbent technologies without compromising light output, light quality, or the convenience of dimming. To date, efficiency program efforts have targeted applications where directional light can be maximized and where the delivered light level is close to or better than other available light sources.

Why is the design of the SSL product important?

The optical, thermal and electrical systems need to be carefully designed, in order for a LED fixture to be able to deliver energy savings, maintain its performance over time, and work successfully within the electrical network.

Fixture efficiency (lm/W) and light distribution play an equal role in determining optical efficiency. Fixture efficiency is a function of the secondary optics and light loss within the fixture. To produce a high quality fixture, a manufacturer must carefully consider the lens or diffuser they are using, the placement of the light source, the shape of the fixture housing, and materials used in the fixture housing.[iv] Good design that considers both fixture efficiency (lm/W) and light distribution is required to achieve energy efficiency and produce minimal light pollution.

Heat management and an awareness of the operating environment are critical considerations to the design and application of LED luminaires for general illumination. Ensuring necessary light output and life of LEDs requires careful thermal management, typically requiring the use of the fixture housing as a heat sink or at least as an element in the heat removal design. Luminaires therefore have a fundamental and typically large effect on the luminous flux produced by the LEDs, and on the rate of lumen depreciation over time.[v]

If excess heat is not properly managed, it directly affects both short-term and long-term LED performance. The immediate effects are color shift and reduced light output which can lead to accelerated lumen depreciation and, thus, shortened useful life. As a result, it is necessary for the Junction Temperature (Tj) to be kept as low as possible and within manufacturer specifications in order to maximize the performance potential of LEDs.[vi]

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The electronics of the driver selected will also significantly impact the performance of a fixture. Higher quality products will use drivers with high driver efficacy and good LED current control. In addition, fixtures with good electrical characteristics will have high power factors, and minimize total harmonic distortion and electronic magnetic interference.

LED "drop-in" replacement lamps, such as Edison-based reflector lamps or MR-16 replacements, are in theory designed to provide the necessary heat sinking for the LEDs. However, given that they are installed in fixtures not specifically designed for LEDs, good heat management could be a challenge.[vii] Efficiency programs are evaluating these kinds of products now and including them in their programs on a case by case basis.

Energy Efficiency Program Requirements for SSL

What product information do energy efficiency programs require?

Through the Residential and Commercial SSL Committee, CEE members have worked together to develop Recommended Guidelines for evaluating SSL products for inclusion in their programs. The Committee believes that the following test information and documentation is necessary to assess product performance and help enable the timely integration and promotion of quality, efficient SSL products:

Recommended Guidelines for Evaluating SSL Products for Inclusion in Efficiency Programs

Information Needs

The following is a list of CEE membership's information needs to evaluate the performance of SSL products as of June 2009.

- Results from LM-79 test reports (from independent labs, possibly including NVLAP facilities)
- Results from LM-80 test reports (from independent labs, possibly including NVLAP facilities)
- In-situ temperature testing (from OSHA approved Nationally Recognized Testing Laboratories)
- L_{70} determination
- Warranty information
- IES files
- Frequently asked questions (FAQ) or tutorials that explain the LM-79 and L_{70} reports

What specific information from the above list is required?

- LM-79 Test Reports: Energy efficiency programs require independent testing according to IES LM-79 that provides efficacy, output, color, and photometric distribution of LED products. It is important for manufacturers to note that both an Integrating Sphere Test and a Goniophotometer test are required to provide all the necessary information. Manufacturers should provide LM-79 testing report(s) with the following data:

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- Electrical Data, including input voltage, current in (A)mperes, power in (W)atts, power factor and THD.
- Total Light Output, including luminous flux in Lumens, luminous efficacy in Lumens/Watt, and a zonal Lumen summary.
- Luminous Intensity Distribution, including candela distribution and polar graph. (Additional data including spacing criteria, coefficient of utilization (CU) and isoilluminance plot may be requested.)
- Color characteristics, including color temperature (CCT), color rendering index (CRI), chromaticity coordinates, and spectral power distribution (SPD).
- LM-80 Test Reports: Manufacturers should provide the LED Package Manufacturer IES LM-80 Test Report with results showing relative (%) light output over time at 55°C, 85°C and at a third temperature at the manufacturer's choice.
- In-situ Temperature Test Reports: Manufacturers may be asked to provide a report indicating the temperature of the hottest LED In-Situ in ANSI/UL 1598-04 (hardwired) or ANSI/UL 153-05 (corded) environments. This temperature measurement will be used with LM-80 data to validate lumen maintenance and useful life of product. Note that this temperature measurement should be specially requested by the manufacturer as they are getting their UL testing.
- L^{70} Determination: Manufacturers should provide written explanations of how L_{70} lifetime of products is determined using the IES LM-80 standard and in-situ temperature tests referenced below.
- Warranty: Energy efficiency programs require manufacturers to disclose their warranties for products under consideration. Manufacturers may be asked to provide 3-5 year warranties on LED products.
- IES Files: Manufacturers may be asked to provide absolute photometric testing data in IES LM-63 electronic file format.
- Additional Criteria - In addition to the information needs listed above, select efficiency organizations may also ask to see the following:
- Product Safety Standards: Manufacturers will often be asked to provide Proof of Compliance to the Applicable Product Safety Standards from an OSHA Nationally Recognized Testing Laboratory (NRTL) such as UL, Intertek (ETL), or CSA.
- Accurate Literature Based on Testing Results: Many energy efficiency programs will seek confirmation that the test results of the product are the same as the product ratings listed in manufacturer literature or packaging. Products with inflated or inaccurate claims may not be eligible for rebates.
- SSL Lighting Facts™ label: Many energy efficiency programs will look favorably on manufacturers that have joined the SSL Quality Advocates Program, and used the Lighting Facts™ label on their product packaging or specification sheets.[viii]

Where should manufacturers submit these data?

At the present time, the above information may be submitted directly to the CEE member energy efficiency program administrator with whom the manufacturer is interested in working (although a courtesy copy to CEE is requested).

CEE has defined the necessary characteristics of a binational database that could house the necessary SSL product information and provide energy efficiency programs with an expedited,

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efficient way to access the needed information (see below). This database is envisioned as an inclusive, common screening tool that CEE members could use to access product information to inform specification development and to assess products to determine if they meet their individual program needs. The central collection of these data would inform member programs without requiring members to replicate each other's data collection efforts and without overburdening manufacturers. CEE is currently evaluating options for developing such a database.

Necessary Attributes of an Information Database

The following is a list of considerations CEE will use to evaluate options for housing the above SSL information in a centralized resource to ensure that it meets member needs.

- Scope
- Inclusive of all manufacturers of general illumination SSL products
- No minimum threshold for product performance
- Inclusive of all general illumination products:
- Commercial/residential
- Indoor/outdoor
- Luminaires/replacement lamps
- Host Organization
- Credible
- Independent
- Flexible, ability to readily add or change content, reports or system scope
- Responsive to needed changes
- Timely with changes and updates
- Challenge Process in Place
- System Functionality
- Web-based
- Searchable by one or more considerations
- Intuitive, based on Web usability principles
- Readily available and easily accessible to all CEE members
- Password protected
- Has the storage and processing capacity to handle the anticipated data needs and requests
- Includes date-stamp and flags for users when report is over one year old
- Indicates information source

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Related Issues

Why are independent testing lab reports necessary?

Energy efficiency programs are seeking key pieces of data, e.g. LM-79 and LM-80 reports, from independent testing laboratories to ensure that performance can be verified in the most rigorous assessments. Testing laboratories should be pre-qualified to follow testing standards for integrating sphere and/or goniophotometric testing of SSL luminaires and lamps. Energy efficiency programs are open to accepting test reports from all credible laboratory facilities, including independent test laboratories and laboratories that are accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) [1]. NVLAP is administered by the National Institute of Standards and Technology (NIST), which is a government agency within the U.S. Department of Commerce. This program is established based on accreditation requirements in accordance with the U.S. Code of Federal Regulations (CFR, Title 15, Part 285), The NVLAP SSL accreditation process is detailed in a published NVLAP handbook and includes a carefully constructed sequence of proficiency tests to meet the requirements of ISO 17025 Section 5.9 to ensure confidence and credibility of the testing process. At this time, only the NVLAP accreditation process is known to have the credentials and meet the level of rigor that efficiency program administers are seeking with respect to accrediting laboratories for SSL testing. CEE is open to and interested in identifying any other credible entities that have the credentials of the NVLAP program. These entities are encouraged to contact CEE.

In terms of qualifying for government programs such as ENERGY STAR or others, the requirements for a laboratory to be recognized as a credible facility can vary depending on the government lighting program's needs. When evaluating and choosing laboratories for product testing, manufacturers are encouraged to select those that meet the requirements of their target government program (ENERGY STAR, CALiPER, etc.) Please see the individual government program pages for an updated list of requirements and acceptable facilities,

[1] A list of laboratories which currently have NVLAP accreditation may be found in the NVLAP Directory of Accredited Laboratories. Under "Search On-Line Directory," enter "LM-79 s03 s09 s10" and click on "Google Search" to get a listing of laboratories with complete LM-79 accreditation. Alternatively, you may scroll down and click on "Energy Efficient Lighting Products," but note that this will provide a listing of all labs with any form of energy efficient lighting accreditation, so you must check the details of each listing to determine whether they are qualified for LM-79 and if so, whether that includes sphere testing and/or goniophotometry.

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Does ENERGY STAR relate to energy efficiency programs?

The ENERGY STAR label is recognized by more than 70% of American households.[ix] ENERGY STAR specifications exist for a variety of lighting types, now including some SSL applications. Energy efficiency programs often give priority to products with the ENERGY STAR label or require ENERGY STAR qualification as a prerequisite for product promotion due to the fact that ENERGY STAR helps determine which products meet efficiency requirements and customer expectations regarding performance. However, there may be certain applications and product types where energy efficiency programs will develop their own qualifying specifications for products, particularly in the commercial sector. (An example of this is LED Refrigerated Case Lighting, where an ENERGY STAR label does not apply.)

Is RoHS compliance required?

The Restriction of Hazardous Substances (RoHS) is a European directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2002/95/EC. While most LEDs contain no mercury or lead as stated above, LED manufacturers should be aware of RoHs laws. RoHS restricts or sets maximum concentration values (MCV) for six hazardous materials, two of which are lead and mercury.[x]

Products containing these materials must comply with RoHS to be sold in Europe. In the United States, RoHS is currently voluntary, with NEMA encouraging US lighting suppliers to have RoHS compliancy by 2010.[xi] California has adopted its own RoHS directive, titled Electronic Waste Recycling Act of 2003, or EWRA. CA RoHS restricts MCV for four of the hazardous materials (including lead) and applies to covered electronic devices. Other states are reviewing whether or not to adopt similar laws. As well, there is a trend for lighting manufacturers to promote their products as RoHS compliant.[xii] RoHS compliance is not identified within CEE's Recommended Guidelines (as it's not currently a universal element of member programs), though energy efficiency programs continue to be steadfast about promoting energy efficient lighting products that are high quality for consumers and that mitigate the impact on the environment and human health. It is possible that energy efficiency programs may begin requiring RoHS compliant products in the future.

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[i] http://www1.eere.energy.gov/buildings/ssl/using_leds.html

[ii] http://www1.eere.energy.gov/buildings/ssl/reliability_overview.html

[iii] http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/cfls_july_lessons.pdf

[iv] http://www.cree.com/products/pdf/LED_Luminaire_Design_Guide.pdf

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[v] http://www1.eere.energy.gov/buildings/ssl/thermal_mgt.html

[vi] http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/thermal_led_feb07_2.pdf

[vii] http://www1.eere.energy.gov/buildings/ssl/luminaire_efficacy.html

[viii] http://www.lighting-facts.com/

[ix] http://www.cee1.org/eval/2008_ES_survey_rep.pdf

[x] http://www.rohs.eu/english/index.html

[xi] http://www.geappliances.com/email/lighting/specifier/downloads/A_Short_Guide_to_Lamp_Disposal.pdf

[xii] http://www.leginfo.ca.gov/cgi-bin/displaycode?section=hsc&group=25001-26000&file=25214.9-25214.10.2

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