It's Not Your Father's Luminaire: DesignLights™ Consortium: Tools to Assure Quality and Performance of Solid-State Lighting in Commercial Energy Efficiency Programs

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ABSTRACT

Solid-state lighting (SSL) for use in general illumination is exploding onto the market, promising to deliver lighting quality, long lifetimes and energy savings. This emerging market opens huge opportunities for customers to save energy costs and for utilities and state programs to reach savings goals. However, as with any new technology, early adoption entails risks. The industry learned a number of lessons about these risks with the rush to market of compact fluorescent lamps. Utility incentive dollars were spent on poorly performing products, hindering both financial and energy savings goals from being met. We cannot afford to repeat those mistakes. With this in mind, over fifty utility programs have joined the DesignLights™ Consortium (DLC) to develop specifications and create a Qualified Products List (QPL) for use in their SSL programs. The list assures quality and performance, validating manufacturers' claims and relieving stresses for program managers. In this paper, we examine trends in the lighting industry with a particular focus on integral luminaires in the commercial market. We share insights drawn from over 700 product families submitted for qualification by over 100 manufacturers. And we describe the development, deployment and management of DLC resources. The lessons learned through the DLC experience will guide consortium members and others in promoting speedy adoption of quality SSL systems. This will assure long-term benefits to all market players.

INTRODUCTION

Assuring quality and performance in all solid-state lighting (SSL) equipment is essential at this early stage in the technology's introduction. There is too much at stake to let a few rotten apples spoil the whole basket. Light emitting diode (LED) lighting, a subset of SSL and the focus of this paper, offers energy and cost savings, maintenance reduction, lighting quality improvements, lighting control capability and further benefits which we have not yet recognized. In the lighting market we have seen interruptions to market introduction of past technologies, such as with compact fluorescents (CFLs) in the early 1990s. This was due to a "rush to market" at the expense of quality, resulting in products falling short of claims. We must learn from past mistakes, impose controls and cooperation among stakeholders, and assure that LED lighting delivers its benefits now.

Commercial LED Lighting: Opportunity and Risk

Why are quality and performance important in LED lighting, and who gains the benefits? In their recent publication, *Energy Savings Potential of Solid-State Lighting in General Illumination Application*, the U.S. Department of Energy (DOE) suggests that solid-state lighting (SSL) may achieve 2,700 terawatt hours of site energy savings, corresponding with savings of approximately $250 billion in energy costs and 1,800 million metric tons of carbon. As buildings represent nearly 75% of this potential, it is essential that building operators adopt and embrace LED lighting in order for the technology to catch on and continue to deliver its benefits. However, at this early stage in development of the technology any bad experiences can cause the market to stumble and impede its progress.

The industry needs to satisfy its early-adopter customers in order to spread its base of success. Manufacturers are presenting claims of fantastic performance from LED lighting products. However, there are many products with exaggerated claims, due to either poor understanding of the technology or to overzealous sales pitches.

For instance, LED light engines are capable of efficacy in the range of 130 lumens per watt and lifetimes of 100,000 hours. But once the components are assembled into a luminaire, their performance as a complete system may result in half of those numbers. A few disappointed customers can quickly and easily poison the market.

While DOE's CALiPER (Commercially Available LED Performance Evaluation and Reporting) testing program has done an excellent job highlighting the challenges in performance of SSL products, as well as in disparities between tested and claimed performance. Another example of quality assurance can be seen in the DesignLights Consortium (DLC) Qualified Products List (QPL). While the DLC QPL currently contains no controls on a manufacturer's marketing claims (providing a mechanism for comparing tested and claimed performance), it is restricted to products which are shown through industry standard tests to meet minimum performance levels. As the Table 1 shows, even in these products there is a trend towards exaggerated claims in product marketing materials:

Table 1. Comparison of Test Data on DLC QPL, as of March 5, 2012

	Average L/W	Max L/W	Min L/W
Tested Efficacy	66.74	115	34
Rated Efficacy	80.36	144	54

Utility or state-run energy efficiency programs have a special stake in LED lighting and claims of performance. A utility program incentive investment which passes cost-benefit at 'claimed' performance may fail to be cost-beneficial if 'actual' performance falls short. Poor performance of LED luminaires can cause the programs to fall short of their savings as well as financial goals.

Utility programs form a critical link to keeping the LED lighting industry moving ahead as this emerging technology takes hold. Incentives such as equipment rebates as well as a utility's stated or implied endorsement of the technology gives customers confidence to take a chance. To support their messages, the utilities use information resources and tools provided by industry, government and other sources. The DOE has built a portfolio of at least eight programs in its effort to commercialize LED lighting. However, there are two sources of specific product

qualifications at utilities' disposal, ENERGY STAR for residential and consumer equipment and the DesignLights™ Consortium for commercial products.

The DesignLights™ Consortium Qualified Products List

The DLC provides specifications and a qualified products list of commercial grade LED luminaires, for utilities to use in operating their energy efficiency incentive programs. As LED lighting became available in 2008, the programs immediately found their customers clamoring for rebates. Program managers quickly recognized the risks inherent in the new technology and sought assurance. ENERGY STAR offered product qualification to help ease this risk, mainly in the consumer market, but that left a void in commercial products.

The 14 utilities making up the DLC, coordinated by the Northeast Energy Efficiency Partnerships (NEEP), decided to step up and create a luminaires Qualified Products List to fill the commercial market void left by ENERGY STAR. NEEP, a regional non-profit energy efficiency organization, had managed the DLC since 1998, promoting quality as well as energy efficiency for commercial lighting in the Northeast region. This became the obvious and preferred brand and venue for the new QPL.

The QPL filled a definite need: within its first year of development, through just word of mouth and networking, DLC attracted more than 20 participating programs from across the continent. By 2012 the DLC covered more than 50 programs in 20 states and four provinces.

The DLC resources are information and tools focused on commercial LED luminaires, but its central resources are the QPL and the DLC Category Specifications. The QPL is available in the form of a downloadable spreadsheet, listing as of April 2012, 10,276 luminaires, specifically recognizable by brand and model number. Program managers can quickly look up products to see whether they have met DLC requirements. Chart 1 shows the rapid growth of products listed on the DLC QPL.

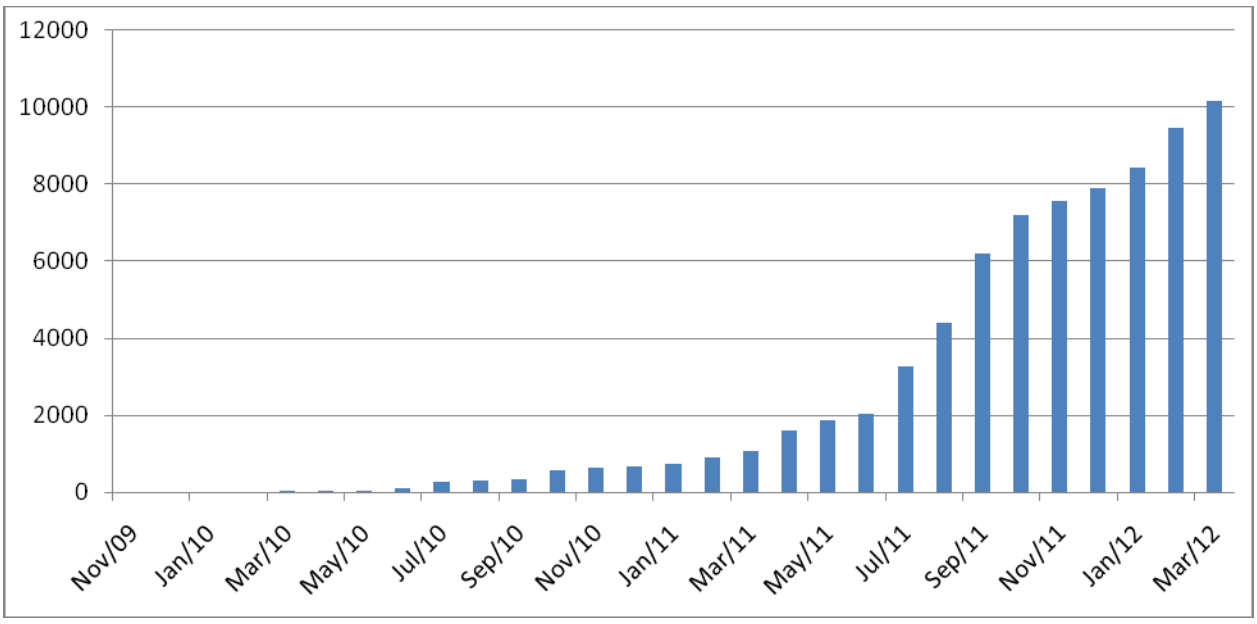

Chart 1. Growth of the DLC QPL since Program Launch

In order for a manufacturer to place its luminaire on the QPL, the product must meet DLC performance, testing and reporting requirements. The DLC application process is based on many of the same principles and resources as those of ENERGY STAR.

- First, an applicant must determine that the product falls within a DLC category and that it meets the required performance levels.
- Applicants must have their luminaires tested at qualified laboratories, as specified in the DOE ENERGY STAR Manufacturer's Guide for Qualifying Solid-State Lighting Luminaires. The laboratories provide data and reports for the applicant to submit to DLC. These cover various properties of the product.
    - LM 79 testing for photometric and electric properties of the luminaire
    - LM 80 testing for lumen maintenance of the light engine
    - ISTMT testing for thermal performance of the luminaire
- Through the on-line DLC application, the manufacturer enters data from these tests and they must upload product data, warranty statement, as well as data files and summary reports from the labs.
- Finally, the applicant provides a $500 processing fee, and submits the application.
- Once everything is complete and correct, DLC analysts pass (or fail) the application and post the product on the list.
- There are powerful provisions for grouping products of similar or scalable performance into "family product groupings." This allows manufacturers to qualify many products by working with DLC to identify worst case performers, then designing testing strategies which demonstrate that the product family meets all requirements.

Quality & Performance in the Commercial LED Lighting Market: Use of the DLC QPL

The DLC QPL is a best attempt to demonstrate quality, performance and endurance in LED luminaires despite of lack of lifetime experience with its products. The process substantiates over 10 years of lumen maintenance in products which were conceived only two years ago! In addition to light output, will efficacy hold up over time? Will color properties endure? Built upon best practices developed by ENERGY STAR, industry standards, and DOE experience, the DLC testing and analysis methods are the best available, and they are solid enough to keep players in the game.

As of mid-2012 there are over 50 energy efficiency programs using the DLC QPL to qualify commercial LED products and over 100 manufacturers with luminaires on the list. The QPL benefits to players are clear: utilities do not have to conduct separate analyses when a customer brings a request for an incentive, they merely look to see whether the luminaire is on the list. For manufacturers, this means submitting just one application, to qualify a product in over 50 programs. And for customers, the QPL takes away some of the fear of the unknown.

Challenges

One might expect the LED lighting industry to mature and settle after a while, but for now, development is still accelerating. So there will be a definite need for DLC (as well as ENERGY STAR) for LED lighting going forward. But this rapidly developing technology presents a number of challenges.

- How should the QPL deal with products which develop quicker than the application process? By the time some products are developed, produced, tested, qualified and marketed, some of their components may become obsolete. DLC needs to figure out how to track and then update its qualified luminaires.
    - DLC has adopted ENERGY STAR successor LED device policies, as well as developed its own successor luminaire policies, in efforts to reduce required testing and remove barriers to bringing products to market without backsliding on quality.
- LED development is yielding higher performance, thus raising the bar for the industry. When average or standard LED luminaire performance significantly exceeds DLC specifications, how should DLC adjust the QPL requirements? And, then happens to products which passed at lower levels but fail at higher ones?
    - DLC underwent a thorough review of all existing criteria during the summer of 2011. In that process, DLC raised efficacy requirements and tightened Correlated Color Temperature (CCT) allowances, in an effort to keep pace with improving technology. DLC will is undergoing a similar review during the summer of 2012.
    - Products that do not meet revised criteria levels are allowed to stay qualified for 270 days, following standard procedures again developed by ENERGY STAR, in an effort to not punish manufacturer partners who had tested and qualified their products. After that grace period, all products on the QPL are required to meet the new standards.
- How do users take more complete advantage of LED lighting's current capabilities? For instance, DLC requires luminaire light output amount and distribution, but the objective of a system is characterized by the amount of light delivered to the work surface, not light emitted from the luminaire. This drives toward requirements of uniformity both at the luminaire level and at the system design level.
- At some point in time, will LED lighting technology mature and will the industry shake out to only a few luminaire manufacturers? If so, will the industry police itself and obviate the need for DLC?
- How do program managers respond to developments in further capabilities in LED lighting? Solid-state lighting poses control, communication or other benefits which we can't even imagine at this time. DLC qualification will have to remain nimble and able to scramble as these future developments pose risk and uncertainty yet again.

It is certain that future developments in LED lighting technology are uncertain. However, the cooperation and relationships among utilities, manufacturers and customers under the DLC process will equip parties to better meet the next challenges in commercial lighting.

Utility Programs: Support of Market Transformation

An illustrative example of a utility program serving to advance LED lighting technology is Pacific Gas and Electric Company (PG&E). PG&E is one of the largest utilities in the US, provides electricity and natural gas to over 15 million California residents. Early on PG&E responded to the importance of helping customers manage their energy use. Demand-side management benefited both the customer and the utility by reducing the long-term growth in electric bills and mitigating the impact of demand growth on the utility infrastructure.

PG&E's publicly-funded programs support energy efficient technologies at every point of the technology's lifecycle. The emerging technology assessment projects provide valuable feedback to the public and industry on the feasibility of products in their introductory stage. Next, PG&E's incentive programs provide much needed financial support to enable these new products to compete effectively in the marketplace. Finally, PG&E's support in development of statewide codes and standards enables products to achieve mass adoption.

Although energy savings potential is a major driver for PG&E to support a particular technology, they take into account other factors into consideration including quality and overall performance against incumbent technologies. Lighting has continually provided the majority of energy savings for PG&E and its customers; therefore, it is no surprise that PG&E chose to support LED technology early on.

PG&E launched its LED streetlight program in 2009. To ensure that products installed under the program would perform well and consistently over time, PG&E had developed stringent performance criteria. The state of California does not have a standard specification for LED lamps or luminaires and qualifying products can be resource intensive; therefore, PG&E chose to extend support to the Design Lights Consortium when it stepped out to provide meaningful qualification standards for commercial applications. More recently, California is in the process of developing a minimum performance standard for LED lamps and luminaires that leverages the specification structure developed by DLC. California utilities expect that DLC will continue to lead the industry with setting more stringent standards for LED manufacturers that the utilities can support.

Today, PG&E provides incentives for a majority of categories listed by the Design Lights Consortium as well as ENERGY STAR. Their LED programs include a calculated incentive based on projected first year energy savings and load shed at $0.05/kwh and $100/kw respectively. Also, prescriptive rebates (meaning a flat amount per unit purchased; also called deemed) include LED recessed downlighting, refrigerated case lighting, signage lighting, and exit signs. Many PG&E customers take advantage of its deemed rebates; therefore, PG&E plans to expand its deemed catalog to include other high impact LED applications like PAR and MR replacement lamps, 2x2 and 2x4 recessed fixtures, outdoor area fixtures, wallpacks, high bay fixtures, and canopy fixtures.

Commercial SSL: Market Transformation from a Manufacturer Perspective

To manufacturers of LED luminaires utility program rebates are essential in keeping products moving through the market and DLC qualification is essential in distinguishing them and their products as good values for their customers. An example of leadership in the LED lighting market and partnership with utility programs is, Cree, Inc. of Durham, NC. Cree views its participation in DLC and utility programs as important components of its market strategy, including increasing sales and adoption of LED technology in the lighting market.

Cree has been an industry leader, bringing the blue LED to market in 1989. Through its, XLamp® chips Cree paved the way to LED general illumination through innovations in brightness and efficiency. XLamp LEDs were the first "lighting-class" LEDs – LEDs bright enough to be used in general-illumination applications, such as desk lamps, ceiling fixtures and street lights. Recognizing the revolutionary potential of LED lighting, in 2008 Cree expanded its product lines into LED-lighting applications, such as reflector lamps, ceiling, and down light

luminaires. After gaining a solid footing in the LED indoor-lighting market, Cree expanded into outdoor lighting in 2011 with the acquisition of Ruud Lighting, Inc., also a US based manufacturer of outdoor LED lighting.

Cree recognizes that quality and performance are critical factors in maintaining their leadership position and in transforming the market for speedy adoption of LED lighting. Cree also looks to create a variety of product lines in order to maximize their ability to meet customers various lighting needs. This offers the chance to show that LED lighting, and Cree's products can deliver performance and quality in a majority of commercial lighting applications.

In their analysis of the LED lighting market, Cree sees growing potential in the near and long-term future Recent success in multiple sectors across the lighting market has demonstrated to Cree that current opportunities in LED lighting are in upgrades to existing lighting systems as well as in new construction projects.

Cree looks to the new construction installations as well as the upgrade project installations as opportunities to transform lighting. Each sector has unique characteristics which provide opportunities for development and installations of new products which is further emphasized by the creative ways LEDs can be configured. Each sector also has budgetary complications. In new construction, where the specification of efficient lighting is a standard, the opportunity to design to the highest efficiency is possible because funds are already allocated to the project, and specifications point to efficient systems. The steps to highest efficiency products are small, but the savings over the life of those products can be immense. In upgrade markets, the opportunity for highest efficiency lighting requires evaluation of payback calculations which include maintenance and energy savings. Utility funding plays a critical role in these calculations.

Coordination between industry and utilities allows for a greater market lift and speedier adoption. While quality is an essential benchmark, not all LED lighting companies necessarily take this path. Leaders look to the certification or qualification organizations to set standards that give confidence to the utilities in their investments. This helps to ensure they will provide a satisfactory experience for their rate payers and reduce the risk of LED savings being questioned by their regulators.

It is important to consider how rapidly products and technology are changing, and how this change affects the approval of product by utilities. Should there be tiers of product quality? What would those tiers reflect? Perhaps it requires a look at what it takes to transform the market. A luminaire manufacturer must start with the challenge of providing illumination, consider potential form factors, and then look for an appropriate fit for LEDs.

CONCLUSION

It is critical that quality and performance is addressed early in the adoption of a new lighting technology to avoid souring the market for years to come. Solid-state lighting represents too big an opportunity in energy reduction and cost savings to allow low-performing early entrants to spoil the market. The DesignLights Consortium, which seeks to act as a screening tool for utility programs across the country in product categories not recognized by ENERGY STAR, has gained tremendous importance in the market place in the last 18 months. Product qualification has exploded, and manufacturers increasingly rely on DLC listing to qualify for incentives. It has effectively reduced program administration burden on utility partners, and provided manufacturers and way of indicating their product meets quality performance metrics.

In the ever-changing solid-state lighting market place, DLC seeks to continue to be nimble and adjust to new demands. It plans to continue to serve member and industry need, and assure expeditious adoption of LED technology in the commercial, industrial, and outdoor markets.

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