~~One~~ *Two* Million LEDs and Counting – Experiences of the First Utility to Offer an LED-only Upstream Program

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ABSTRACT

PPL Electric Utilities, which appears to be the first utility to exclusively offer LEDs in its upstream (and other) lighting programs, has provided over two million LEDs, has over two years of experience, and has many exciting stories to share. This paper explores both the utility's and customer's perspectives.

If the CFL market is not saturated and substantial savings are still available at low costs, why would a utility convert a highly successful upstream lighting program from CFLs to LEDs? Changing all upstream lighting discounts to LEDs involves many decisions for the utility, including delivering energy efficiency programs within a cost cap, meeting the energy savings compliance target, and ensuring the cost-effectiveness of a given program. The utility's transition process, preparations, response to stakeholders, product offerings, and marketing and execution of the cost-effective program are instructive to other utilities.

This paper also discusses customers' responses to and experience with the upstream program as it shifted from CFLs to LEDs. Impacts included participation, energy savings, and cost-effectiveness. Longitudinal surveys measuring market progress indicators explored the rapidly changing market for LEDs, demonstrated high levels of awareness and willingness to pay among customers, satisfaction with product characteristics such as brightness and lifetime, and market barriers. Lighting manufacturers also shared their perspectives about current and future sales. Sales and longitudinal shelf stocking studies examined the relationship between price and sales by retailers, and the swift increase in the proportion of LEDs on the shelf within one year.

Introduction

PPL Electric Utilities ("PPL") provides electric delivery services to about 1.4 million customers in central and eastern Pennsylvania. PPL has won 23 J.D. Power and Associates awards for top-quality service to residential and business customers.

PPL has provided energy efficiency programs for its customers since January 2010. Through February 2016, PPL's customers have reduced their usage by more than 2.2 billion kWh per year through these energy efficiency programs, saving approximately $220 million per year. This is equivalent to taking approximately 295,000 cars off the road and the total annual usage of approximately 150,000 homes. PPL's budget is approximately $62 million per year for energy efficiency programs.

Lighting comprised approximately 80% of the total energy efficiency portfolio's savings between 2010 and 2013. Approximately 50% of the lighting savings were from the residential

lighting program where PPL provided discounts for efficient light bulbs at the point of retail sale (the "upstream lighting program"). Upstream lighting includes A-line bulbs, reflectors, and specialty bulbs. Other lighting savings were from low-income direct install programs, energy efficiency kits provided to low-income customers, and lighting retrofits and new construction from non-residential customers.

From January 2010 to 2013, the upstream lighting programs provided discounts for CFLs only. In 2014, PPL started to phase-in LED light bulbs and switched exclusively to LEDs in mid-2014. At that time, PPL also switched exclusively to LED light bulbs in other programs such as the low-income direct install program, the low-income energy efficiency kit program, and the non-residential programs. Figure 1 shows the quantity of bulbs per year.

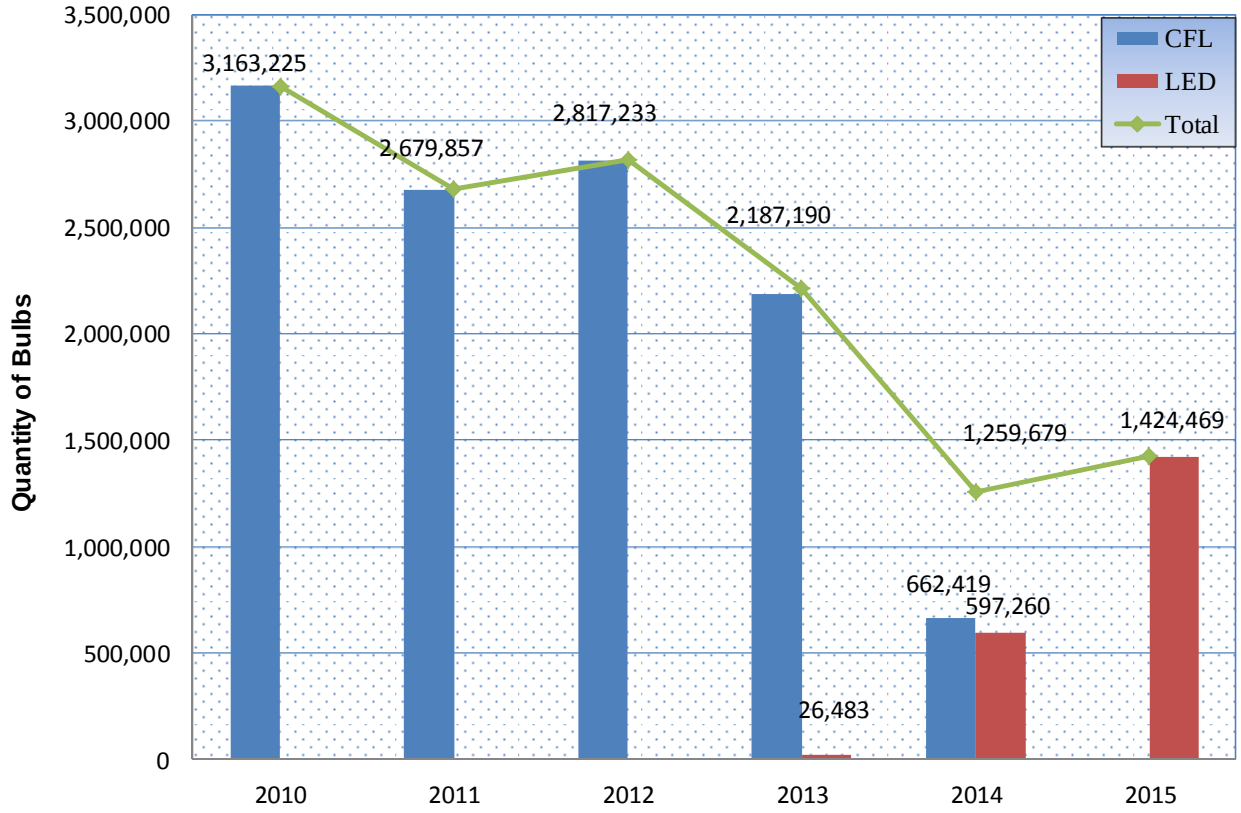

Figure 1. Quantity of CFL and LED light bulbs in PPL's Upstream Lighting Program

Why Switch to LEDs?

As PPL conducted the annual evaluation of its upstream lighting program in 2013 and considered switching from CFLs to LEDs exclusively, some of the things we heard were:

- "You're crazy. Why do this now?"

- "It will cost us five times more per bulb for approximately the same savings per bulb. Where is that money coming from?" (program costs)
- "It will not be cost-effective" (according to the Total Resource Cost Test)
- "Customers are just starting to get used to CFLs. They will not want to switch."
- "Customers will be confused by another new lighting technology."
- "It will cost customers too much. Who will pay $20 for an LED light bulb when they can get a $3 CFL?"
- "LED technology is not ready for the mainstream"
- "Wait until other utilities switch to LEDs. Let them be the guinea pig."
- "CFLs are great. I don't want to switch." (okay, we did not really hear that)
- "Go for it"

So why did PPL consider switching to LEDs, especially since CFLs were such a successful component of PPL's energy efficiency programs from 2010 to 2013? In a nutshell, CFLs were becoming the norm in PPL's service territory and PPL determined it had an opportunity to promote the expanded use of LEDs, which, although more expensive than CFLs, will provide deeper, longer-lived savings with much better operational performance for customers.

The 2012 Pennsylvania Statewide Residential End-Use and Saturation Study reported residential socket saturation of 21% for PPL (2012 Pennsylvania Statewide Residential End-Use and Saturation Study, page 46).[1] This was a relatively high saturation rate considering PPL had been discounting CFLs for less than two years at the time the study data were obtained. Further, PPL's internal residential lighting study in 2013 estimated that residential CFL saturation was a relatively consistent 30% for the last three years, indicating that even with a strong marketing push and incentives, the saturation of CFLs had largely reached its maximum. A maximum saturation of 30% is similar to the saturation levels achieved by electric utilities in other states, which have promoted CFLs over a longer period of time than PPL.

In addition, PPL's 2013 market research determined that 70% of customers would select a CFL bulb type if they needed to purchase an indoor 60 watt equivalent bulb for their home and 77% said they planned to purchase CFLs in the next 12 months. Seventeen percent said they would purchase an incandescent and 13% would purchase an LED. The rate at which CFLs replaced other CFLs was another indicator that CFLs were becoming the norm. PPL's 2013 market research determined that 76% of customers would replace a burned-out CFL with another CFL. Only 18% would replace the burned-out CFL with an incandescent and 11% with an LED.

Another important factor considered in 2013 was PPL expected the LED bulb market to expand very rapidly, with or without utility incentives. There was obviously a "race to market" by LED bulb manufacturers. PPL realized this was a great opportunity to spur an emerging market and to bolster the competiveness of higher quality ENERGY STAR® bulbs.

Based on these factors, PPL determined that incentives for CFLs were no longer necessary as the market (customers and retailers) appeared to have adopted CFLs as normal

[1] Please note that the data for this study were obtained in late 2011. Also, the CFL saturation rate is statistically valid at the statewide level but not for a specific utility such as PPL.

practice. Therefore, PPL decided it was prudent to shift the current focus of its lighting programs from CFLs to LEDs beginning in mid-2014.

Implementation

Deciding that it no longer made sense to provide incentives for CFLs was the easy part of the decision. However, it was more difficult to determine how to accommodate the higher cost LEDs in a portfolio of energy efficiency programs with a fixed budget ($61.5 million per year), how the higher cost of the LEDs would impact cost-effectiveness (Total Resource Cost Test), and whether customers would accept LEDs, especially since PPL previously touted CFLs for their energy efficiency and "long life" (compared to an incandescent bulb). "I just bought a bunch of CFLs and now you (PPL) are asking me to buy more expensive LEDs."

PPL was confident customers would accept LED technology because LEDs offer considerable technical and performance advantages compared to CFLs. Specifically, LEDs: (a) offer greater energy savings and a much longer life; (b) provide full brightness instantly; (c) operate much better in dimming applications; (d) do not have the spiral shape that many consumers dislike; and (e) do not contain mercury, therefore negating the need for special handling when being disposed. PPL believed these operational disadvantages prevented CFLs from achieving higher socket saturations.

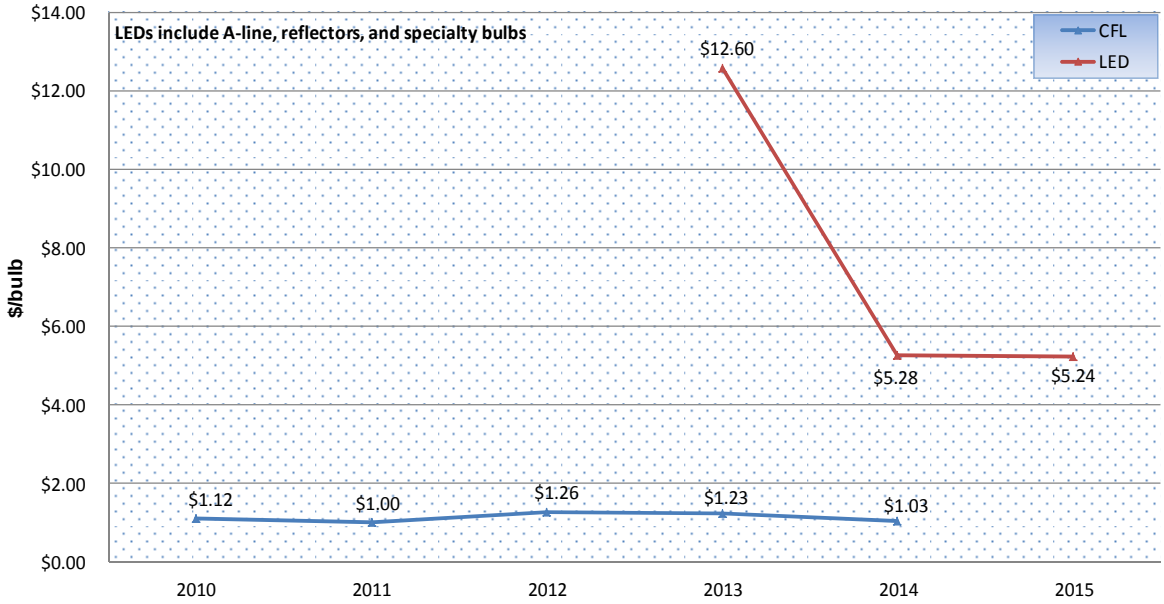

Figure 2. Average incentive per light bulb.

The program costs (primarily incentives) are much higher for LEDs than CFLs as shown in Figure 2. If PPL had converted from 2.2 million CFLs per year to 2.2 million LEDs per year, the additional program costs would have been $9 million per year. To mitigate this cost impact, PPL reduced the number of bulbs (and savings) per year by approximately 35%, from 2.2 million in 2013 to 1.4 million in 2015 (see Figure 1). As shown in Figure 3, this resulted in a net increase

in upstream lighting incentives from approximately $2.7 million in 2013 to approximately $7.5 million in 2015.

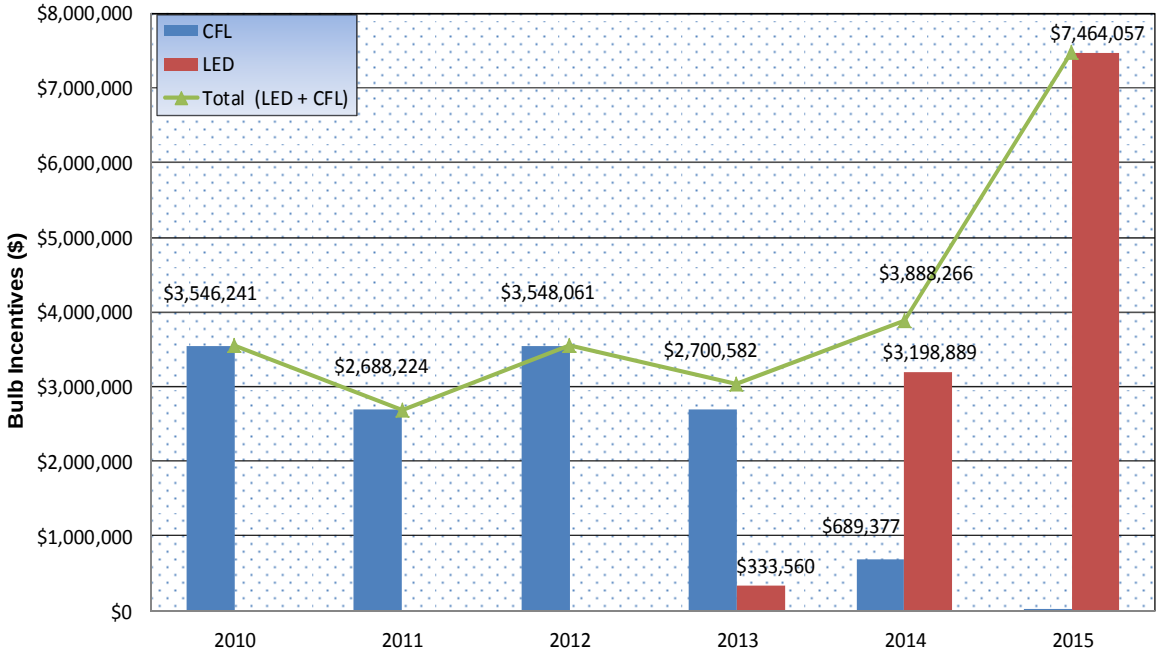

Figure 3. Total incentives for upstream light bulbs.

Results

The transition to the LED-only upstream lighting program was very successful and was completed by mid-2014 as planned, over a six month transition period from late 2013. Retailers and bulb manufacturers supported the change as did customers who purchased the quantity of LEDs that PPL projected, within budget, and reported high levels of satisfaction with LEDs.

PPL achieved the desired energy savings for this program after the switch to LEDs. Figure 4 shows the energy savings from the upstream lighting program. The benefit-cost ratio of the program decreased but remained cost-effective when PPL switched from CFLs to LEDs. Retailers embraced the LEDs and the percentage of shelf space occupied by LEDs more than doubled in one year. The impact on the program's cost-effectiveness and retailer's stocking practices are summarized in Table 1 below.

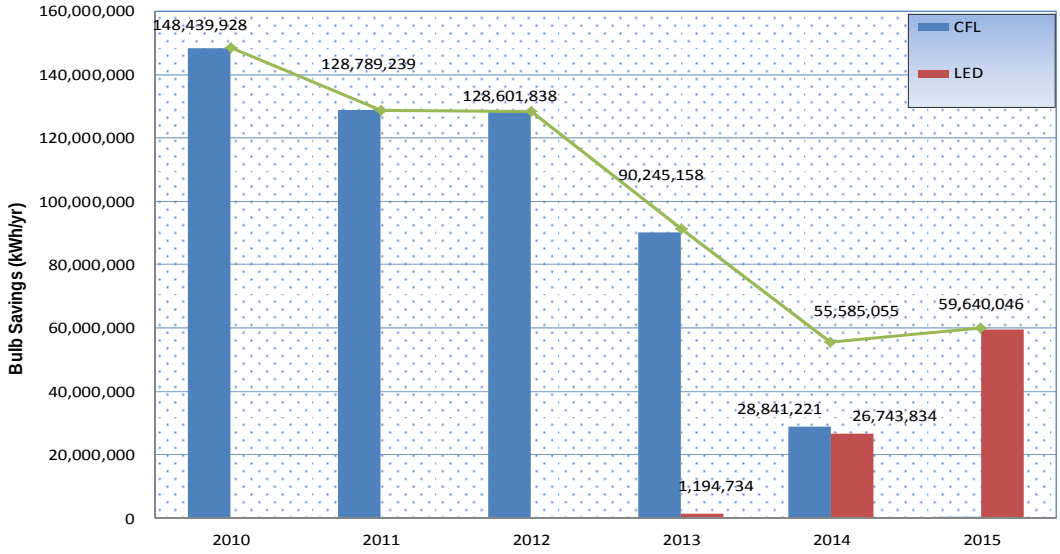

Figure 4. Energy savings from the upstream lighting program.

Table 1. Summary of program and portfolio impacts

	2014 with CFLs only	2015 with LEDs only
Upstream Lighting TRC benefit-cost ratio (excluding program admin costs)	15.7	2.9
Residential Retail Program (includes upstream lighting and other residential products)	7.47	2.48
Portfolio TRC benefit-cost ratio	2.20	1.52
Shelf-stocking study (% of LED shelf space)[2]	15%	37%

Evaluation Methods

Cadmus, PPL's program evaluation contractor, conducted both impact and process evaluations of the upstream lighting program from 2009 through 2015 (program years [PY] 1 through 6). These evaluations included surveys of three populations assumed to represent the program participants: (1) General-population residential customers (since PY2); (2) General-population small[3]-business customers (since PY5); (3) Participants in other PPL residential DSM programs, (a subset of the residential population).

[2] See Figure 8.

[3] Multiple evaluations have demonstrated that small-business customers purchase light bulbs for their businesses directly from retailers. PPL and Cadmus assumed that large commercial and industrial customers are unlikely to purchase a significant number of general-purpose light bulbs from retailers.

Cadmus used these survey data to track market progress indicators such as LED awareness, willingness to pay for LEDs, satisfaction with LEDs vs. CFLs, and general bulb-purchasing patterns. Cadmus estimated the number of program bulbs purchased by the small-commercial segment. Bulbs installed in commercial settings are subject to higher hours-of-use and coincident peak assumptions, producing greater savings than in residential settings. Lastly, Cadmus compared answers from the general residential and commercial survey populations to similar questions regarding LED usage and willingness to pay. Cadmus conducted a 2-year shelf-stocking study, and interviews with lighting manufacturer representatives.

Evaluation Findings

Recent customer survey data indicates that awareness of LEDs is high (around 90% over the past 2 years) and that customers are much more satisfied with LEDs than with CFLs. In a 2015 customer survey, 70% of customers who had used LEDs said they were "very satisfied" with them, versus only 37% of customers who had used CFLs.

Data regarding a change in year-over-year residential purchasing patterns are unclear, but small business customers are definitely buying more LEDs (twice as many reported recent purchase of an LED for their business as in the previous year) and fewer halogen or incandescent bulbs. Residential customers were more likely to report purchase of halogen or incandescent bulbs than LEDs, even though fewer are purchasing CFLs.

Table 2- Percentage of Respondents Purchasing Bulbs in the Six Months Preceding April, 2015

Customer Base	N	Year	LEDs	CFLs	Incandescent or Halogens	Any Screw-In Bulb
Small Business General Population	385	PY6	23%	20%	12%	49%
	392	PY5	11%	21%	21%	44%
Residential General Population	301	PY6	16%	29%	26%	65%
	301	PY5	17%	45%	Unknown	
DSM Programs	300	PY6	45%	33%	21%	79%

Cadmus found that at least 12% of the bulbs purchased through the upstream-lighting program were for commercial installations. Because of the higher per-bulb savings for commercial installations to these bulbs, this finding resulted in attributing almost one-third of the upstream lighting program savings to the small commercial segment.

Customers who had used LEDs reported they were more likely to buy at various hypothetical price points than those who had not yet tried LEDs. Figure 4 shows residential customers' reports, highlighting the steep jumps in overall likelihood ("very" plus "somewhat") between the price points. Non-users show the largest increase in willingness to pay, when the hypothetical price point dropped from $10 to $7.

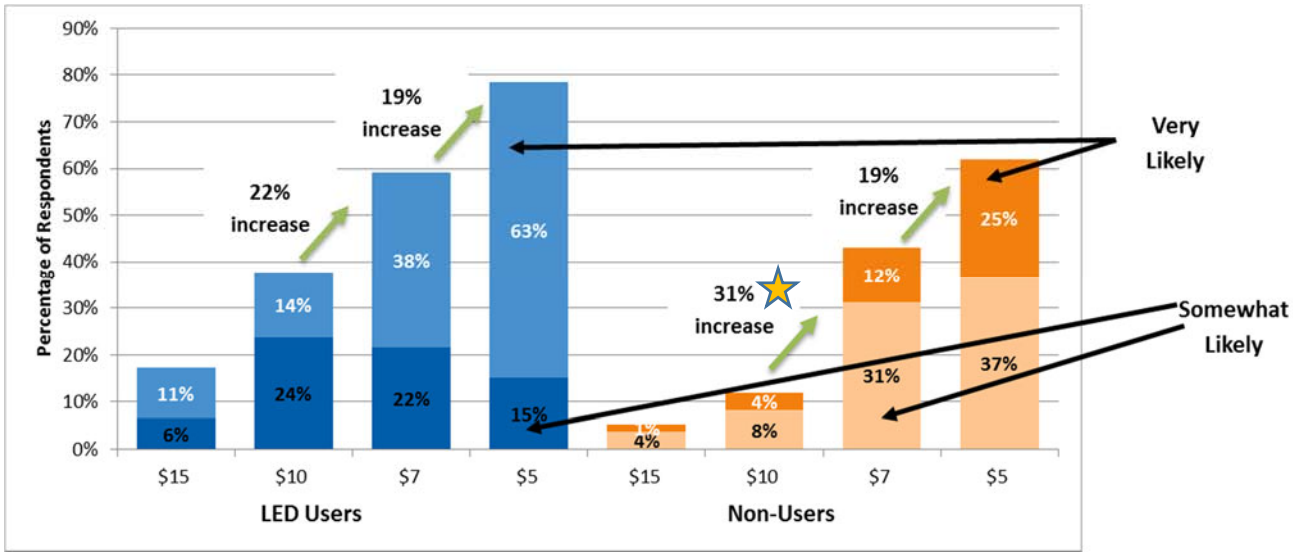

Figure 4. General Residential LED Users vs. Non-Users Willingness to Pay

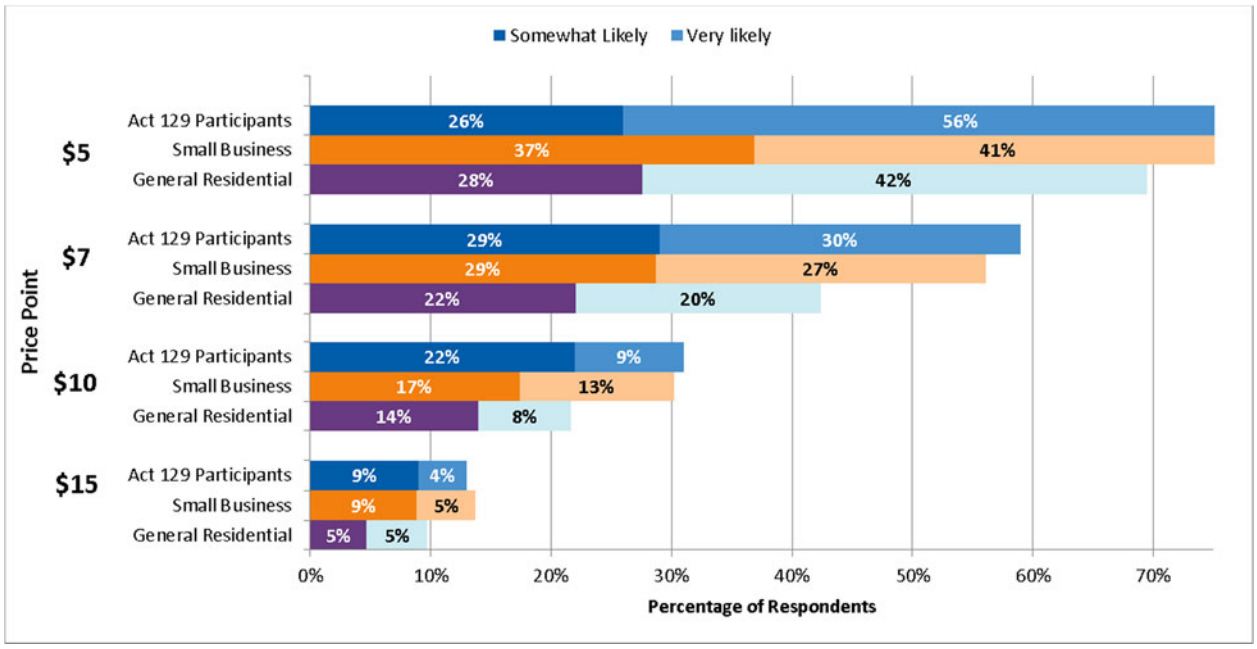

Figure 5. Willingness to Pay by Respondent Group

The pattern between users and non-users is similar for small commercial customers. However, commercial customers, as well as DSM program participants, indicated a higher likelihood to purchase LEDs at all price points, as shown in Figure 5. Cadmus hypothesized that small business customers are more willing to pay for LEDs because these customers will save more energy (because of their higher daily usage) than residential customers will, and possibly, because they are more aware of the cost-effectiveness of LEDs. Survey data supports this conclusion; small business customers ranked energy use as more important than cost by a small

margin, whereas more residential customers ranked the cost of bulbs as “very important” versus energy use (62% versus 57%, respectively). However, the typically cost-conscious residential customers still placed more importance on bulb quality characteristics such as brightness and longevity than on cost, suggesting that price sensitivity is a surmountable obstacle to increased adoption.

Although the majority of PPL’s customers say they are willing to pay $5 for an LED, and PPL’s program bulbs, especially the most common general-service bulbs, sold around this price point, the average price customers recalled paying for the most recent bulb purchased was over $10.

In addition to achieving savings goals and maintaining adequate program cost-effectiveness, PPL indicated that being a forerunner in the move toward LEDs helped the market transition toward this technology. In interviews with Cadmus, lighting-manufacturer representatives lauded utility programs for both their incentives and education efforts, and were adamant that utility programs have had a profound effect on the market for emerging technologies in lighting. They reinforced the notion that utility incentives contribute to both competition and economies of scale and support the competitiveness of ENERGY STAR®-certified bulbs, which are superior in quality and preferred by some major retailers. These factors contribute to market transformation in the long run, but in the short run, incentives are making LEDs competitive with EISA-compliant halogens, still the cheapest bulbs, thus likely to be the market leader in the absence of subsidies. Manufacturers agreed that CFL saturation is not likely to increase, and predicted that CFLs will be replaced by LEDs as LEDs come down in price.

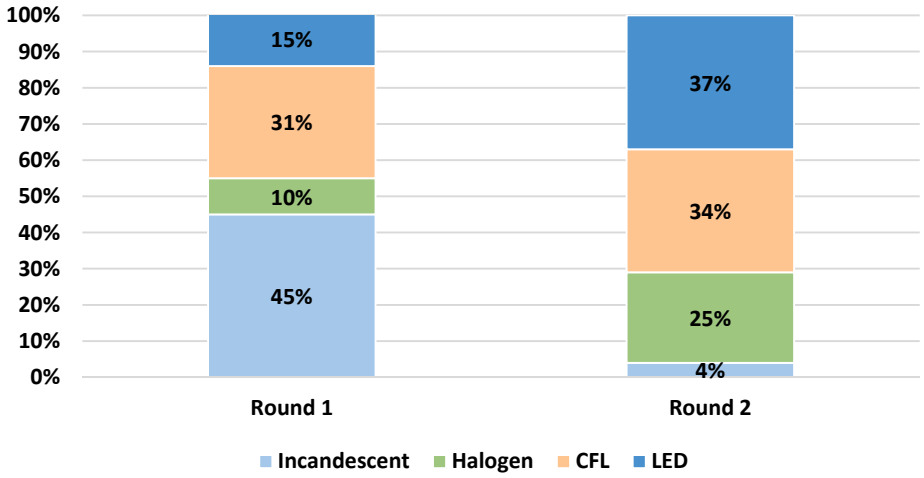

Figure 8. Percentage of Pack Faces of GSL Bulbs by Technology Type

The longitudinal shelf-stocking study and analysis illustrated an increase in the presence of LEDs on retailer shelves. Figure 8 compares the number of “pack faces”[4] (bulb package facing the consumer (i.e., the visible pack[s] adjacent to the aisle) between Round 1 (2014) and

[4] Pack faces offer the best available proxy for shelf space (area) dedicated to each bulb type. The number of pack faces by bulb pack is a good indication of available products and proportion of anticipated sales; store managers decide which bulbs to market and dedicate shelf space accordingly.

Round 2 (2015) of this longitudinal study. LEDs increased from 15% of shelf space to 37% of shelf space in just one year, as incandescent bulbs virtually disappeared.

Comparing year-over-year changes in the proportion of shelf space dedicated to various bulb technology types at retailers that participate in PPL's upstream lighting program vs. those that don't shows that LED presence increased in both, but that LED shelf space is still small in nonparticipating stores.

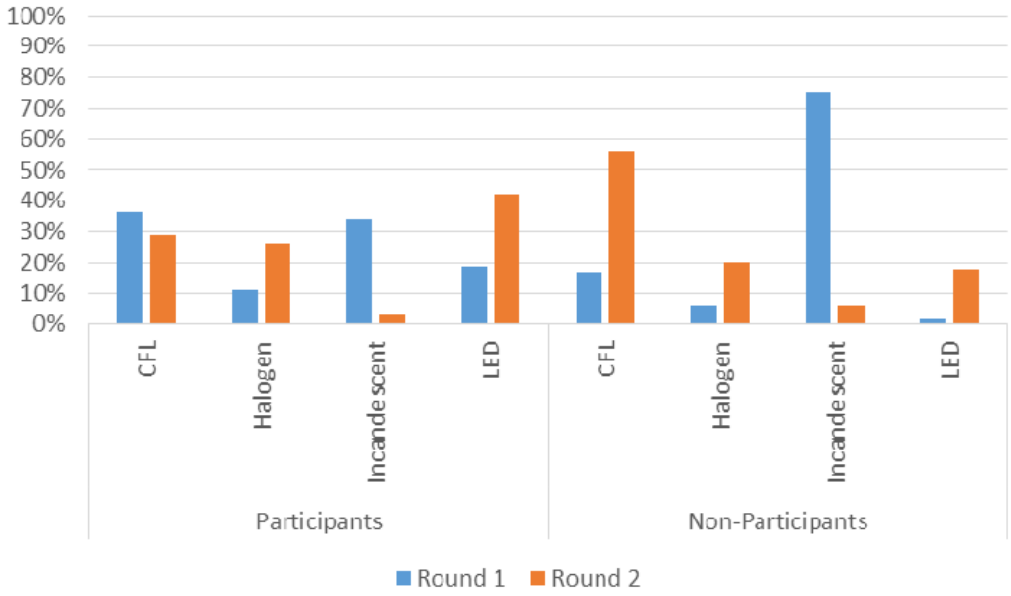

Figure 9. Percentage of Weighted Pack Faces of GSL Bulbs by Technology, and Participation

Increases in shelf space correspond to a significant drop in prices of LEDs, at both participating and nonparticipating retailers. Between 2014 and 2015, we observed that LED prices, as expected, were lower at participating retailers, but the drop in prices between the years was actually more dramatic at nonparticipating retailers. Still, the average price of a general-service LED at a nonparticipant store, at over $14, was still out of the range most respondents indicated a willingness to pay.

Conclusions

Based on the variety of quantitative and non-quantitative evaluation activities conducted over the past two years (such as shelf stocking studies, market effects studies, interviews with lighting manufacturers, demand/price elasticity studies, and participant self-report surveys), Cadmus concluded that the upstream lighting program is contributing to the transformation of the lighting market and consumers' increased adoption of LEDs. In addition to bringing down prices overall, incentivizing only ENERGY STAR® rated LEDs, which are superior in quality and longevity, is likely to prevent some of the consumer dissatisfaction issues that occurred during the initial introduction of CFLs. This is important because, as consumers begin to view

lighting purchases as investments rather than simply incidental costs, poor consumer experiences can make a lasting impression, creating barriers to further adoption.

While LED prices have dropped significantly and rapidly over the past year, they are still considerably more expensive than the EISA-compliant halogen bulbs. From a consumer standpoint, LEDs are cost effective, based on both energy savings and avoided replacement costs; so much so that payback time on the initial investment of a 60W equivalent LED bulb (11W) vs. a 43W halogen equivalent, after PPL's incentive, is less than one year[5]. However, there are still consumers who will gravitate toward the cheaper upfront cost of these inefficient bulbs. Therefore, educational efforts highlighting lifecycle costs, in conjunction with incentives and maintaining retail-channel diversity may hasten increased market adoption of LEDs.

Survey data collected by Cadmus in 2016 will include answers to questions regarding where customers purchase general-purpose light bulbs as well as their perceptions of LED pricing.

References

2012 "Pennsylvania Statewide Residential End-Use and Saturation Study." Prepared by GDS Associates, Inc. for the PA PUC. Available at: http://www.puc.state.pa.us/electric/pdf/Act129/PA_Residential_Baseline_Report2012.pdf.

PPL Electric Utilities Act 129 PY6 Annual Report: https://www.pplelectric.com/~/media/pplelectric/save%20energy%20and%20money/docs/act129_phase2/py6annualreport20151115.pdf?la=en

ES calculator: http://www.energystar.gov/sites/default/files/asset/document/light_bulb_calculator_0.xlsx

[5] Using the ENERGY STAR bulb savings calculator: http://www.energystar.gov/sites/default/files/asset/document/light_bulb_calculator_0.xlsx