THE CADMUS GROUP, INC.

FINAL REPORT

Efficiency Maine Trust Residential Lighting Program Evaluation: Final Report

November 1, 2012

Prepared by:

The Cadmus Group, Inc.
Energy Services Division
100 Fifth Avenue, Suite 100
Waltham, MA 02451
617.673.7100

Prepared for:

Efficiency Maine Trust
151 Capitol Street, Suite 1
Augusta, ME 04330-6262

This page left blank.

Prepared by:
Allison Bard
Josh Keeling
David Korn
Carol Mulholland
Ryan Cook
Brian Shepherd

The Cadmus Group, Inc.

720 SW Washington Street
Suite 400
Portland, OR 97205
Tel: 503.467.7100
Fax: 503.228.3696

An Employee-Owned Company
www.cadmusgroup.com

Corporate Headquarters:
100 5th Ave., Suite 100
Waltham, MA 02451
Tel: 617.673.7000
Fax: 617.673.7001

This page left blank.

Table of Contents

EXECUTIVE SUMMARY

The Efficiency Maine Trust (Efficiency Maine, or the Trust) guides and administers energy-efficiency and alternative energy programs throughout the state of Maine. This report presents results of impact and process evaluations of the Trust's Fiscal Year (FY) 2011 Residential Lighting Program (RLP or the program), conducted by The Cadmus Group, Inc. (Cadmus). The RLP provides financial incentives to encourage the sale, purchase, and use of energy-efficient compact fluorescent lamp (CFL) bulbs, reducing electricity consumption and costs for Maine consumers. The program uses three main strategies to deliver CFLs: markdowns, coupons, and offering CFLs to appliance rebate program participants.

Cadmus' evaluation estimated verified energy savings attributable to the RLP.

To complete the impact evaluation, Cadmus:

- **Investigated lighting purchase and use trends:** Participants' lighting usage included bulb purchases and various aspects of product installation (including but not limited to: installation, removal, storage, placement by room and bulb type, and wattage replaced).
- **Estimated lighting use parameters:** Estimated parameters for calculation of energy and demand savings resulting from CFL use, including: wattage displacement (delta watts), in-service rate (ISR), load shapes, coincidence factors (winter and summer peak), daily and annual hours of use (HOU), and effective useful life (EUL).
- **Verified energy and demand savings:** Verified gross and net energy and demand savings, net-to-gross (NTG) ratios, and freeridership.
- **Evaluated the program's overall impact:** Assessed cost-effectiveness, lifetime savings, and realization rates.
- **Compared results:** Compared impact results to other, recent studies of energy-efficient lighting programs.

Cadmus also completed a process evaluation that examined and offered recommendations regarding the following:

- **Program design and delivery:** Program design, delivery structure, and implementation processes:
  - Product incentives.
  - Retailer and manufacturer relationships.
  - Program marketing and promotion strategies.
- **Consumer awareness, use, and satisfaction:**
  - Demographics.
- **Emerging issues:** Lighting technology, trends and policy changes, including adapting to the Energy Independence and Security Act (EISA).

This evaluation captured and evaluated data from 41 homes, metered from December 2011 through July 2012, during winter (December and January) and summer (June and July) peak periods. Cadmus also conducted telephone surveys, store intercepts, and stakeholder and implementer interviews to better understand: program implementation, participation, and marketing strategies; and consumer purchasing patterns, satisfaction, and demographics.

Key Findings and Recommendations

Impact Evaluation

Lighting Use

Incandescent bulbs still comprise the majority of Maine's lighting load, representing more than half of bulbs installed (34 incandescents installed per home, on average). CFLs, however, have gained ground. A typical Maine household has 15 CFLs installed, equating to CFL installations in 26% of sockets (one in four bulbs in use), on average.

Table 1. Bulb Penetration and Saturation (n=41 homes)

Bulb Type	Penetration	Saturation (Percent of Bulbs)
Other	7.3%	0.1%
LED	2.4%	0.0%
Incandescent	100.0%	58.3%
Halogen	48.8%	5.5%
Fluorescent	82.9%	10.4%
CFL	97.6%	25.6%

Figure 1 compares average numbers of bulbs per home.

Figure 1. Average Bulbs per Home by Type

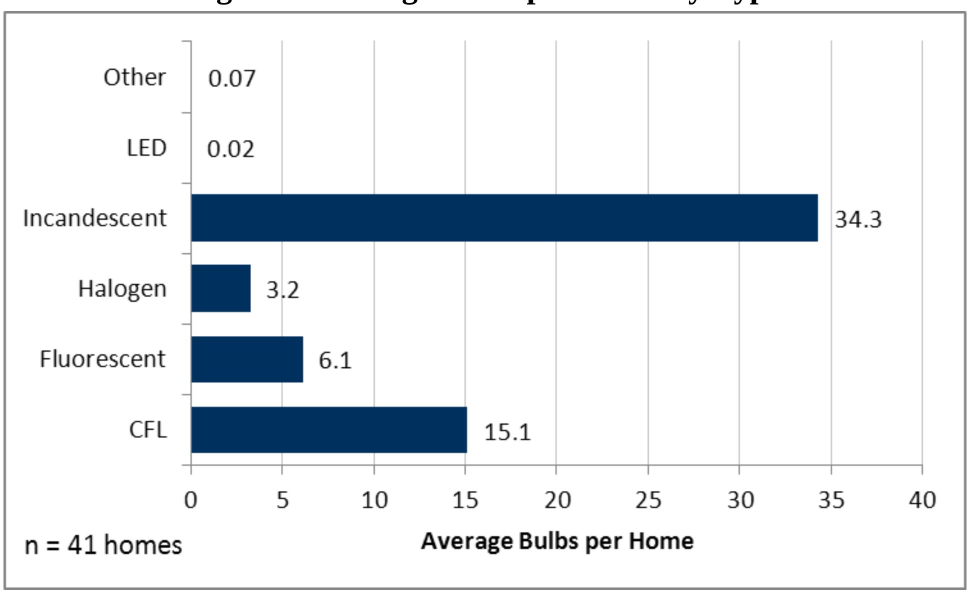
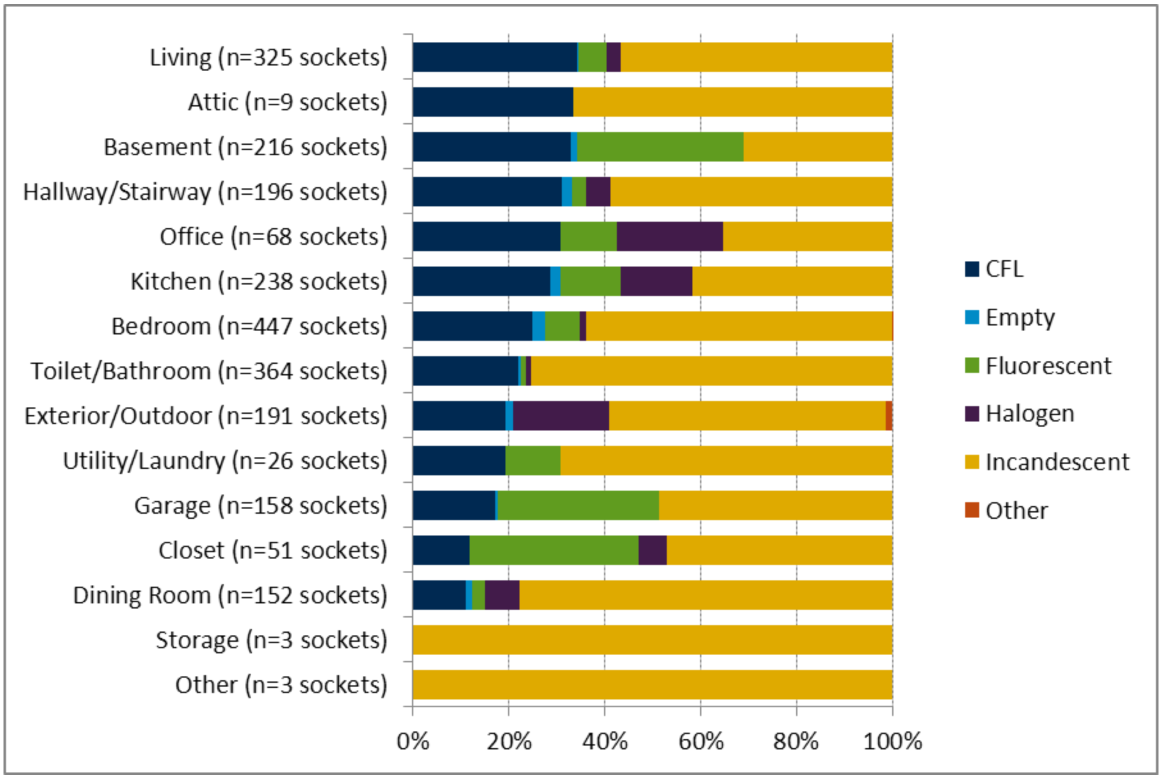


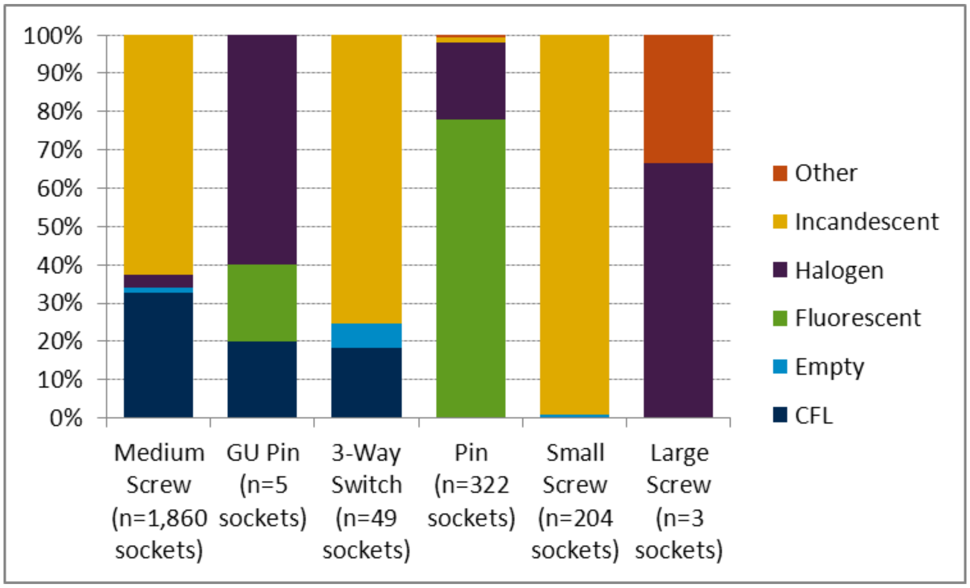
Figure 2 shows bulb distributions by room type.

Figure 2. Bulb Type Distribution by Room Type



As shown in Figure 3, bulb type installations varied considerably, when analyzed by socket type.

Figure 3. Bulb Type Distribution by Socket Type



In-Service Rate

The ISR represents the percent of bulbs installed in the first year. The RLP Program had a first-year estimated ISR of 73% for the standard RLP and 46% for the CFL giveaway associated with the appliance rebate program. The ISR is a factor in calculating first-year savings, but does not impact the calculation of annual or lifetime savings.

Delta Watts

On average, the difference in wattage (delta watts) between CFLs purchased through the program and the bulbs replaced by the newly purchased CFLs (baseline bulbs) was 49 watts.

Hours of Use

Cadmus estimated average annual room-weighted HOU at 2.04 hours per day, with ±9.7% relative precision at the 80% confidence level.[1]

Load Shape and Coincidence Factors

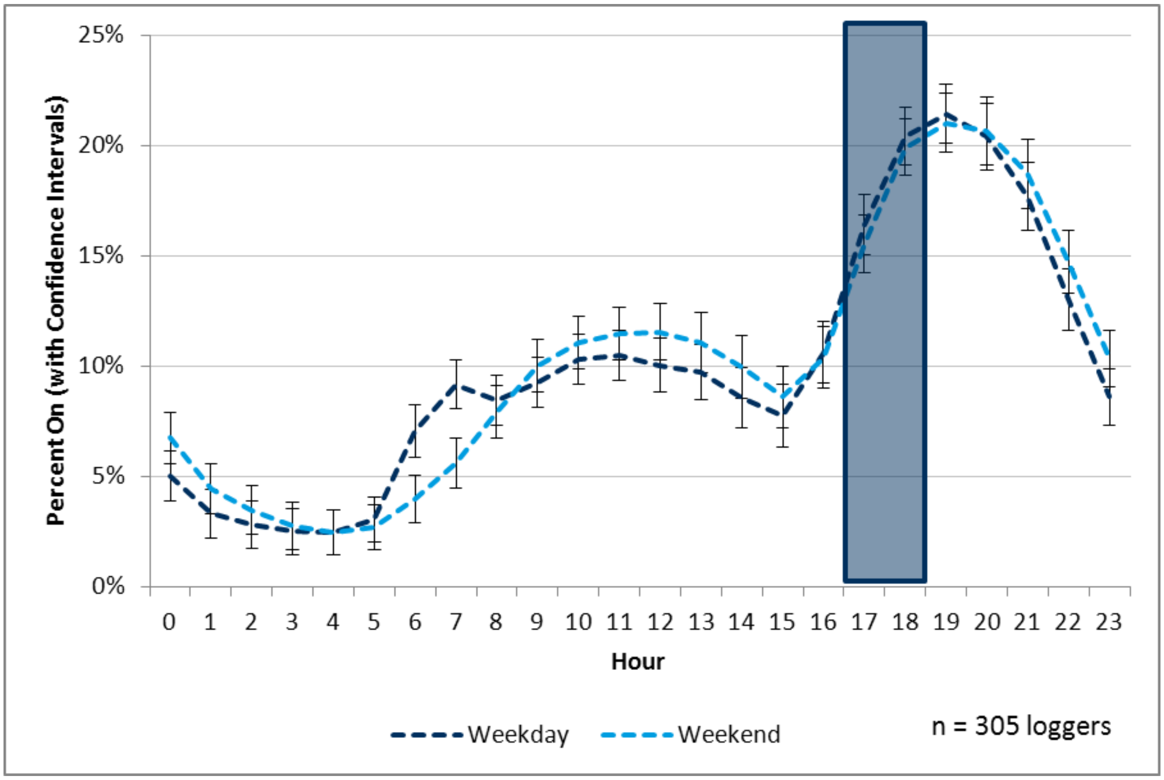
Cadmus estimated daily load shapes to represent the pattern or "shape" of CFL usage (when lights are turned on) over the course of a day. From the load shapes, Cadmus calculated the percentage of CFLs in use coincident with on-peak demand periods, or coincidence factors.

Winter Period

Figure 4 shows Cadmus' estimated daily load shapes for CFLs during December and January, coinciding with Efficiency Maine's measurement of winter on-peak demand reduction. The winter on-peak period had a coincidence factor of 0.184, with a relative precision of ±8.1% at the 80% confidence level.

[1] All precision calculations for the impact estimates in this document are expressed as relative precision with 80% confidence, per ISO-New England guidelines.

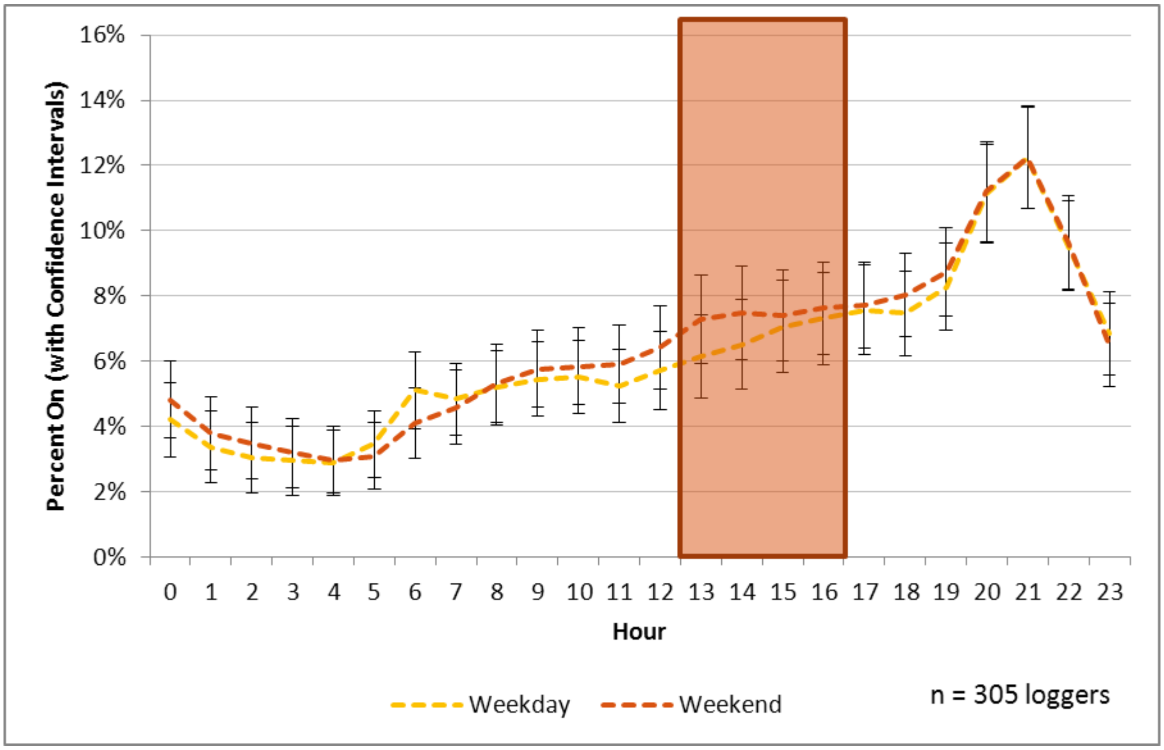
Figure 4. Daily Winter CFL Load Shapes (Peak Period Shaded)



Summer Period

Figure 5 shows Cadmus' estimated daily load shapes during June and July, coinciding with Efficiency Maine's measurement of summer on-peak demand reduction. The summer peak period had a coincidence factor of 0.068, with a relative precision of ±10.1% at the 80% confidence level.

Figure 5. Daily Summer CFL Load Shapes (Peak Period Shaded)



Effective Useful Life

A CFL's EUL reflects how long a bulb can be expected to last. EUL, measured in years, is calculated as the bulb's rated lifetime (hours) from its manufacturer, divided by estimated HOU per day.[2] As shown in Table 2, the estimated EUL ranged from 11.0 to 13.4 years, depending on bulb type and delivery channel.

Table 2. EUL Summary

Bulb Type	Average Rated Lifetime (hours)	HOU	EUL (years)
Standard	9,336	2.04	12.5
Specialty	8,233	2.04	11.0
Giveaway	10,000	2.04	13.4
Program Overall	9,298	2.04	12.5

Savings Metrics

Program savings were measured along several dimensions:

- "Per Unit" savings reflect savings per bulb.
- "Total" savings reflect savings for all bulbs (may be of a certain type).
- "First-year" savings reflect the first-year ISR (percent of bulbs installed in the first year).

[2] The EUL may also include a switching factor: a multiplier adjusting the EUL for impacts from how often the bulb is switched off and on.

- "Annual" savings are typical savings for a subsequent year reflecting 100% installation (annual savings values are not adjusted for the Energy Independence and Security Act (EISA) implementation).
- "Lifetime" savings reflect savings over the lifetime of the bulb, taking into account the EUL. Lifetime savings in this report have been adjusted for the increased efficiency of standard residential lighting over time due to the implementation of EISA.
- "Gross" savings reflect savings associated with all program-promoted bulb purchases, assuming no savings would have occurred in the program's absence.
- "Net" savings represent the portion of gross savings estimated as directly attributable to a program's influence, "removing" savings that would have occurred in the program's absence.

Per Unit Gross Savings

The program had first-year per unit gross savings, adjusting for first-year ISR, of 26.7 kWh/year for standard CFLs, and 26.3 kWh/year for specialty and giveaway bulbs. The program had annual per-unit gross savings of: 36.5 kWh/year for standard bulbs, 35.9 kWh/year for specialty bulbs, and 57.5 kWh/year for giveaway bulbs.

Table 3. Per-Unit Gross Savings

Bulb Type	First Year Per-Unit Gross Savings (kWh/year)	Annual Per-Unit Gross Savings (kWh/year)*
Standard	26.7	36.5
Specialty	26.3	35.9
Giveaway	26.3	57.5
Overall	26.7	36.6

*Annual savings in this table have not been adjusted for EISA implementation.

Net-to-Gross

The NTG ratio indicates the percentage of gross energy savings attributable to a program's influence. Using an econometric model to assess CFL price elasticity, Cadmus calculated an NTG for Maine's RLP of 0.66. Standard bulbs had an NTG of 0.68, while specialty bulbs had an NTG of 0.08. As customers receive giveaway bulbs for free, they have an assumed NTG of 1, indicating the customer would not have received or installed the bulb without the giveaway.

Gross and Net Savings

After estimating relevant parameters, Cadmus calculated the RLP's first-year, annual, and lifetime total gross and net savings.

As shown in Table 4, for FY 2011 (July 2010–June 2011), the RLP achieved first year total net energy savings of 34,628 MWh/year. In subsequent years, measures installed by the program can be expected to save 47,432 MWh annually. Cadmus estimated total annual net savings within ±10.6% relative precision with 80% confidence.

Table 4. Total Gross and Net Energy Savings

Type	Quantity	First-Year		Annual*	
		Total Gross Energy Savings (MWh/year)	Total Net Energy Savings (MWh/year)	Total Gross Energy Savings (MWh/year)	Total Net Energy Savings (MWh/year)
Standard	1,859,155	49,701	33,889	67,767	46,207
Specialty	75,915	1,999	169	2,725	231
Giveaway	22,212	585	585	1,276	1,276
Total	1,957,282	52,284	34,628	71,617	47,432

*Annual savings in this table have not been adjusted for EISA implementation.

In the first year, the RLP achieved net demand reductions of: 3.1 MW for the summer peak period, and 8.6 MW for the winter peak period. The program can be expected to deliver net demand reductions of 4.3 MW and 11.7 MW in summer and winter, respectively, in subsequent years. Cadmus estimated total annual net demand savings within ±11.0% relative precision for the summer peak period and within ±9.4% relative precision for the winter peak period with 80% confidence.

Table 5. Total Gross and Net Demand Savings

Type	Quantity	First-Year				Annual*			
		Total Gross Summer Peak Savings (MW)	Total Gross Winter Peak Savings (MW)	Total Net Summer Peak Savings (MW)	Total Net Winter Peak Savings (MW)	Total Gross Summer Peak Savings (MW)	Total Gross Winter Peak Savings (MW)	Total Net Summer Peak Savings (MW)	Total Net Winter Peak Savings (MW)
Standard	1,859,155	4.50	12.27	3.07	8.37	6.13	16.73	4.18	11.41
Specialty	75,915	0.18	0.49	0.02	0.04	0.25	0.67	0.02	0.06
Giveaway	22,212	0.05	0.14	0.05	0.14	0.12	0.32	0.12	0.32
Total	1,957,282	4.73	12.91	3.13	8.55	6.48	17.68	4.29	11.71

*Annual savings in this table have not been adjusted for EISA implementation.

Table 6 shows estimated lifetime gross and net savings from the program. Lifetime savings estimates are calculated using the EULs estimated above and annual savings values, which are adjusted for increased efficiency of the baseline technology over time, due to EISA.

Table 6. Lifetime Gross and Net Energy Savings*

Type	EUL (years)	Lifetime Gross Savings (MWh)	Lifetime Net Savings (MWh)	Reported Lifetime Gross Savings (MWh)	Gross Realization Rate	Net Realization Rate
Standard	12.5	618,344	421,623			
Specialty	11.0	29,974	2,539			
Giveaway	13.4	10,770	10,770			
Program Overall	12.5	659,088	434,932	614,388	107%	71%

*As lifetime savings have been adjusted for EISA implementation, they may not directly equal the product of annual savings and the EUL.

In its 2011 Annual Report, the Trust reported adjusted gross lifetime savings of 614,388 MWh, slightly lower than gross lifetime savings estimated in this report (659,088 MWh), yielding a gross realization rate of 107%. Net lifetime savings from the evaluation represented 71% of program reported savings in FY 2011.

Cost-Effectiveness

Table 7 shows the cost-effectiveness analysis results, with analysis conducted using the Total Resource Cost (TRC) test. Assessing cost-effectiveness using the TRC involves a valuation of a program's total resource benefits, as measured by electric avoided costs, and its total resource costs, as measured by incremental installed costs and program costs. For the TRC calculation, MWh savings are calculated at the system level (at generation), taking into account line losses (energy lost through transmission and distribution). As noted, lifetime savings have been adjusted to account for increased efficiency of standard residential lighting due to EISA. The final TRC ratio, which was calculated using net savings and participant net costs, passed the TRC test readily, with a ratio of 9.62.

Table 7. Cost-Effectiveness Results*

Category	Reported Savings Scenario
Annual Gross MWh Savings (at generation)	76,433
Annual Net MWh Savings (at generation)	50,816
Lifetime Net MWh Savings (at generation)	463,203
Net TRC Benefits	$29,019,675
Participant Net Incremental Costs	$1,715,503
Technical Support Costs	$1,012,534
Marketing Costs	$34,432
Administrative Costs	$254,883
Net TRC Costs	$3,017,352
TRC Ratio	9.62

*As lifetime savings have been adjusted for EISA implementation, they may not directly equal the product of annual savings and the EUL.

Process Evaluation

Awareness

Ninety-three percent of Maine residents surveyed knew of CFLs. The largest percentage (33%) reported learning of CFLs through television. According to customers interviewed at retail stores, Maine residents have been influenced by sales associates with whom they interact when considering lighting purchases, and received the majority of their education about CFL technologies from retail sales associates.

Store-level managers and sales associates indicated their primary information sources regarding CFLs derived from manufacturer representatives.

Participant and Consumer Satisfaction

The majority of residents surveyed expressed satisfaction with CFLs. All customers interviewed primarily purchased CFLs to save energy and money. Retailers agreed with these motivations. Longer bulb lifetimes and environmental benefits provided secondary motivations.

Reasons for consumer dissatisfaction included bulbs: took too long to reach full brightness; contained mercury; and did not have adequate bulb life.

Design and Delivery

Retailers consistently praised the markdown program, with those participating in the markdown program very satisfied, and planning to continue participation. Those participating in the coupon program want to partake in the markdown program.

Retailer participants consistently reported the markdown program offered a better program implementation strategy than that of coupon delivery. After Efficiency Maine transitioned larger stores to the markdown program, CFL sales increased, and the program operated more smoothly once Memorandums of Understanding had been put in place.

Interviewed retailers also found incentive levels sufficient to increase CFL sales. Retailers reported they would probably stock the same type and quantity of CFLs, but would sell fewer had the program not been in place.

Applied Proactive Technologies (APT) has implemented the program well. APT's knowledgeable field representatives ensured participating retailers remained compliant with the program. Coupon and markdown retailers seemed to rely on field representatives for program management or implementation questions. Field staff conducted in-store events to educate retail sales associates and consumers. These educational efforts provided Efficiency Maine with a presence in the store, and provided customers and staff with educational opportunities on a monthly basis.

Low-Income Participation

In order to help Efficiency Maine understand how the program was reaching low-income customers, Cadmus assessed the percentage of Low-Income Home Energy Assistance Program (LIHEAP)-eligible RLP participants. Cadmus found that 19% of CFL purchasers reported household income levels qualifying for LIHEAP.

Energy Independence and Security Act Impact

With EISA's pending implementation, and the effort to phase out 100-watt incandescent bulbs, consumers have been seeking information about EISA and lighting. Many misunderstand the reasoning behind the legislation, but know they must change. EISA information has not been readily available, and Efficiency Maine has an opportunity to educate consumers about EISA implementation and CFL technology's benefits.

Several new and competing lighting technologies have entered the market, such as EISA-compliant halogens and more efficient CFLs. Manufacturers expect the market will continue to change rapidly, and price, marketing, and consumer preference will decide which technologies dominate. In the near-term, most manufacturers predict halogens, CFLs, and lower-wattage incandescent bulbs will prove most popular with consumers. In the longer-term, they expect LEDs, halogens, and CFLs to maintain a strong market presence.

Recommendations

Based on the impact evaluation findings, Cadmus recommends that Efficiency Maine consider the following:

- Update savings parameters in the Maine Residential Technical Reference Manual (TRM) to incorporate findings from this evaluation.
- Incorporate savings parameter estimates from this evaluation, as appropriate, in demand resource performance reporting calculations for ISO-New England.

Based on the process evaluation findings, Cadmus recommends Efficiency Maine consider the following:

- Maintain a similar incentive level to lower CFL prices for Maine residents.
- Increase its focus on in-store promotion as the next best way to reach customers. The Trust should continue to work with retailers to:
  - Display incentivized CFLs on end caps.
  - Increase signage detail where possible. Improving information contained on the point-of-purchase (POP) materials will help customers understand the RLP is an Efficiency Maine program, and bulbs are "on sale," as both points can help attract consumers.
  - Provide retailers with small, in-store displays to educate consumers about light output levels and CFL energy consumption.
- Address retail sales associates' training needs by enhancing education for retail sales associates through more comprehensive and repetitive sales associate training and increased retailer outreach materials.
- Increase the markdown program's scope by incorporating retailers that are part of a buying group or a larger corporation into the markdown program.
- Position Efficiency Maine as the state's trusted energy advisor on all lighting matters:
  - Add EISA information to its Website, and provide customers with information about energy-saving CFL alternatives and implementation of EISA legislation.

    - Educate Maine consumers about the benefits of installing CFLs in high-use areas.

- Expand on the success of the FY 2012 pilot food bank initiative (distribution of free CFLs), and consider pursuing additional arrangements with other, not-for-profit organizations reaching out to the low-income community.
- Continue to investigate the potential to expand the program to LEDs.
- Expand RLP's presence on the Efficiency Maine Website.
- Consider promoting availability of existing CFL recycling programs.

1. INTRODUCTION

Program Description

The Efficiency Maine Trust (Efficiency Maine or Trust) guides and administers energy-efficiency and alternative-energy programs to reduce electricity and heating fuel consumption and associated costs for Maine residents and businesses. The Trust's Residential Lighting Program (RLP or the program) provides financial incentives to encourage the sale, purchase, and use of energy-efficient compact fluorescent light (CFL) bulbs for the benefit of Maine consumers. In Fiscal Year (FY) 2011, the program utilized three main strategies to deliver CFLs: markdowns, coupons, and a giveaway for Appliance Rebate Program participants.

Under the markdown strategy, Efficiency Maine enters Memorandums of Understanding (MOUs) with retailers and manufacturers to promote CFL sales by reducing the retail price of bulbs. The consumer receives the marked-down price, and, therefore, receives the Efficiency Maine-provided discount price instantly, at the time of purchase. Efficiency Maine reimburses the manufacturer, based on the number of CFLs sold by the retail partner. Efficiency Maine maintains MOUs with approximately 10 retail partners and five bulb manufacturers. Markdown CFL sales have been concentrated among several large retailers, with The Home Depot, Wal-Mart, and Sam's Club accounting for approximately 80% of all markdown CFLs invoiced through the program during FY 2011.

Under the coupon strategy, Efficiency Maine supplies retailers with coupons, which are stocked on shelves next to eligible CFLs or at check-out counters. Customers redeem coupons at the point of sale, and retailers invoice Efficiency Maine for reimbursement. As with markdowns, consumers receive the Efficiency Maine-provided discounts at the time of purchase.

The third strategy, initiated in 2011, drew upon customer involvement in the Trust's Appliance Rebate Program, with Appliance Rebate Program participants electing to receive a free six-pack of CFL bulbs, via a check-off on the Appliance Rebate Program application form.

Evaluation Design

Using a variety of techniques (lighting logger placement and metering; surveys of residents and program participants; interviews with retailers, manufacturers, and stakeholders; and program data), Cadmus conducted an impact and process evaluation of the Trust's RLP. The evaluation reviewed the program's performance during FY 2011. Table 8 shows the evaluation's structure, including research topics, tasks, and tools.

Table 8. Evaluation Topics and Tools

Evaluation Topic	Evaluation Task	Evaluation Tool
IMPACT EVALUATION TOPICS		
Purchase and use analysis	Determine: Installation timing and removal	Site visit
	Failure to install	
	Placement by room	
	Replacement bulb type and wattage	
Parameter estimates	Determine: Wattage displacement (delta watts)	Site visit, telephone survey, program data
	In-service rate (ISR)	
	Load shapes	
	Coincidence factors (winter peak, summer peak)	
	Daily and annual hours of use (HOU)	
	Measure life	
Verified energy and demand savings	Evaluate consistency between program tracking savings values and the assumptions and algorithms included in the Residential Technical Reference Manual (TRM) and Efficiency Maine's Annual Report	Site visit, program data
	Verify gross savings	
	Determine *ex ante* savings	TRM, program data
	Compute net-to-gross (NTG) ratios	
	Determine net energy and demand savings	Program data
	Calculate freeridership	
Program impact	Assess cost-effectiveness	Site visit, program data
	Compute lifetime savings	
	Uncover program realization rate(s)	
PROCESS EVALUATION TOPICS		
Program design, delivery, and implementation	Determine CFLs purchased for business use	Stakeholder, retailer, and manufacturer interview
	Assess retailer and manufacturer satisfaction	
	Gain insight into relationships between stakeholders and participating retailers and manufacturers	
	Review product promotion and marketing strategies	
Consumer awareness, use, and satisfaction	Evaluate: Awareness of program	Telephone survey, intercept survey, stakeholder, retailer, and manufacturer interview
	Awareness of Efficiency Maine	
	Awareness of CFLs	
	Consumer behavior	
	CFL usage	
	CFL general satisfaction	
Emerging issues	Understand: Program changes and enhancements	Stakeholder, retailer, and manufacturer interview, program data
	Product mix	
	Lighting technology, trends, and standards changes (EISA)	
	Specialty CFL, light emitting diode and halogen purchases	
Demographic information	Gain insight into program demographics	Telephone survey, intercept survey
	Understand participation of LIHEAP-eligible residents	Telephone survey

Impact Evaluation

For the impact evaluation, Cadmus collected data through site visits to 41 Maine homes (sites), completed customer telephone surveys, and, to estimate freeridership, conducted an econometric analysis of program tracking data on bulb sales and prices.

At 41 sites, Cadmus installed time-of-use light meters (also referred to as "loggers") in a variety of space types and uses (including outdoor lighting). Loggers were initially placed on 324 unique circuits (defined as a set of bulbs on a given switch/control), with an average of eight loggers per site. During each site visit, Cadmus conducted lighting audits, collecting data on lighting fixtures and usage.

To analyze lighting use for the RLP Program, Cadmus analyzed meter data from the 41 homes. An Interim Report, submitted in April 2012, addressed results obtained from metering a subsample of 20 homes covering the winter peak period (December and January). This Final Report captures and evaluates data from all 41 homes, metered from December 2011 through July 2012, during winter (December and January) and summer (June and July) peak periods. The analysis' final data set utilized data from loggers on 305 unique circuits, installed in the 41 homes.

Gross Savings

Gross energy savings can be determined from energy savings resulting from all purchases of program-incented CFLs. By analyzing data collected from site visit audits and metering, Cadmus determined inputs necessary to calculate RLP gross savings. These included:

- **Saturation:** CFL use hours, by location, and saturations within homes, linking room types and saturations to hours of use (HOU).
- **In-Service Rate (ISR):** Rate that purchased CFLs were installed in homes.
- **Delta watts:** Difference in wattages between purchased CFLs and a baseline fixture (the bulb the purchased CFL replaced).
- **Hours of Use (HOU):** The average hours of use per day for CFLs, installed in various locations within the homes.
- **Load shapes:** CFLs' hourly usage profiles, estimated for weekdays and weekend days.
- **Coincidence factors:** The percent of total demand occurring during a defined peak period, estimated for winter peak and summer peak periods.
- **Effective useful life (EUL):**[3] The estimated measure life of an installed bulb.

Using the above parameters, Cadmus determined verified gross energy and demand savings for the RLP in FY2011. Cadmus compared these values to those of other studies including the 2007 RLP evaluation conducted by NMR Group, Inc. covering the 2003–2006 program period (2007 RLP evaluation), and reported savings and program performance measures.

3 Cadmus used program data and HOUs to determine EUL values.

Net Savings

Net energy savings derive from energy savings resulting from purchases of program-incented CFLs attributed to a program (e.g., CFL bulb purchases that would not have occurred without the program). To estimate net savings, Cadmus conducted an econometric analysis of program tracking data to estimate demand and price elasticity (Maine consumers' responsiveness to price changes in program CFLs).

Analysis compared expected bulb purchases at prices offered under the program (discounted prices) and at original retail prices (prices without the program's discounts) to determine freeridership at the program level and across bulb subtypes. Cadmus estimated an overall freeridership ratio (the portion of CFL purchases that would have occurred without the program's discounts), which could then be used to derive the net-to-gross (NTG) ratio.

Cost-Effectiveness

Cadmus reviewed the FY 2011 program-reported benefit-cost ratio, including the calculation methodology, and inputs and assumptions used in the Trust's calculations. This resulted in calculation of a verified benefit-cost ratio, based on verified net energy savings determined through the impact evaluation.

Process Evaluation

To complete the process evaluation, Cadmus conducted telephone and intercept surveys with Maine residents and CFL purchasers, and completed stakeholder, retailer, and manufacturer interviews.

Consumer Assessment

The customer telephone survey asked respondents about their awareness, purchase, installation, and use of lighting products (particularly CFLs). Cadmus used the customer telephone survey to assess consumer attitudes and behaviors regarding CFLs, and changes in these attributes over the past two years. The survey also provided qualitative insights into the program's influence on purchases (i.e., freeridership).

Cadmus conducted intercept surveys with CFL purchasers at three participating retailers' locations, with participants providing insights into: bulb purchasing patterns; purchasing motivations; and current CFL use and installations.

Stakeholder Assessment

During stakeholder interviews with program managers and implementers, Cadmus staff and stakeholders (program implementers) discussed the program's history, design, vision, and goals. This helped Cadmus establish a greater understanding of the program and its strategies. To better determine the program's influence, stakeholder interviews addressed: marketing and outreach efforts with specific target audiences and market partners; and participation barriers. Finally, stakeholder interviews reviewed: the effectiveness of administrative processes and program delivery (including quality assurance); success of data management efforts; program challenges; and areas for improvements.

Participating Retailer and Manufacturer Assessment

Interviews with participating retailers addressed retailers' motivations for participating in the CFL markdown and coupon program. Interviews provided insights into the program's influence on sales and stocking practices (including changes from previous years' levels, and the levels preceding the program's inception). Retailer interviews also reviewed: marketing and outreach efforts; and satisfaction with the program.

Through manufacturer interviews, Cadmus obtained additional information regarding sales trends and changes in manufacturing priorities as the Energy Independence and Security Act (EISA) takes effect. Cadmus collected information on: CFL sales trends (programmatic and non-programmatic); non-CFL bulbs; and non-programmatic factors influencing pricing decisions (e.g., rare-earth prices, macroeconomic trends).

2. IMPACT EVALUATION

Data Collection and Sampling

For the impact evaluation, Cadmus used several data sources and methods for estimating energy consumption changes resulting from CFLs delivered through the program. Table 9 outlines data collection activities used to estimate savings parameters.

Table 9. Impact Evaluation Data Collection Summary

Parameter	Data Collection Activity
Delta watts	Program tracking data, ENERGY STAR® database
Hours of use	Site visit (metering)
Saturation	Site visit (audit)
Storage rates	Site visit (audit), customer telephone survey

Table 10 shows RLP impact evaluation researchable topics and questions, and tools used to address each question.

Table 10. Impact Evaluation Researchable Issues

Evaluation Topic	Evaluation Task	Evaluation Tool
Verified energy and demand savings	Evaluate consistency between program tracking savings values and assumptions and algorithms included in the Residential TRM and Efficiency Maine's Annual Report	Site visit, program data, TRM
	Verify gross savings	
	Determine *ex ante* savings	
	Compute NTG ratios	
	Determine net energy and demand savings	
	Calculate freeridership	
Purchase and use analysis	Determine: Installation timing and removal	Site visit
	Failure to install	
	Placement by room	
Parameter estimates	Determine: Wattage displacement (delta watts)	Site visit, telephone survey, program data
	ISR	
	Load shapes	
	Coincidence factors (winter peak, summer peak)	
	Daily and annual HOU	
	Measure life	
Program impact	Assess cost-effectiveness	Site visit, program data
	Compute lifetime savings	
	Uncover program realization rate(s)	

Sampling for Metering

The telephone survey also recruited customers for the metering study. Recruitment included offering incentives of up to $125 to those agreeing to participate. Of 200 telephone survey respondents, 41 participated in the metering study.[4] Hence, in December 2011, Cadmus installed meters in 41 Maine homes to determine HOU for CFLs installed in various locations within the homes. Participants were asked to use lights as they would without loggers. This allowed normal lighting practices to be determined. Cadmus sampled 41 sites as this is the number of sites necessary to achieve estimates with ±10% relative precision with 80% confidence, assuming a coefficient of variation of 0.5.[5] This is consistent with the guidelines for M&V presented in ISO-NE's M-MVDR. For more detail on this evaluation's compliance with ISO-NE guidelines, see Appendix A.

Cadmus installed an average of eight loggers per site, in various space types and uses (including outdoor lighting), yielding approximately 324 loggers, each on a unique circuit. As some CFL fixtures contained more than one bulb (e.g., a three-lamp ceiling light), and others were switched together (e.g., a three-lamp bathroom vanity), the 324 loggers covered 351 CFLs.

If participants had more than seven CFL fixtures, Cadmus used an online random number generator to select which fixtures to meter within homes. If technically feasible, each house also had its front porch light metered, whether or not the porch light had a CFL. If a home had fewer than seven CFL fixtures, incandescent bulbs were chosen for remaining meters in room types not covered by CFLs. Cadmus investigated data consistency not only by room type, but by factors such as bulb types and saturation levels. To account for differences in average CFL installation rates in the metered sample, Cadmus weighted collected data back to the metered sample (addressing unmetered CFLs in some homes).

Lighting Use Findings

When installing lighting meters, Cadmus technicians also conducted lighting audits to better understand the state of lighting in Maine homes. Room and fixture data collected included:

- Room types (e.g., living area, kitchen, bedroom).
- Fixture types (e.g., table lamp, ceiling fixture, recessed fixture).
- Bulb types (e.g., CFLs, incandescents, light-emitting diodes [LED]).
- Bulb shapes (e.g., twister, A-lamp, globe).
- Bulb wattages.
- Specialty features (e.g., three-way functionality, dimmable).
- Socket types (e.g., medium screw base, candelabra, pin-based).

The site visits provided a portrait of CFL (and other lighting product) use in Maine homes. Table 11 shows various bulb penetrations, defined as the proportion of homes with at least one bulb of a given type installed, and bulb saturations, defined as the proportion of total installed bulbs

[4] Telephone survey respondents who indicated interest and reported having at least one CFL installed were re-contacted by Cadmus for the on-site study (on a first-come, first-served), until 41 had enrolled.

[5] This is equivalent to ±10% relative precision with 90% confidence (one-tailed).

attributable to particular bulb type. Most homes had incandescent, CFL, and fluorescent bulbs present, and nearly one-half of homes had at least one halogen. Incandescents represented more than half of bulbs installed, with an average of 34 incandescents installed per home. CFLs were installed in 26% of sockets, for an average of 15 CFLs per home.

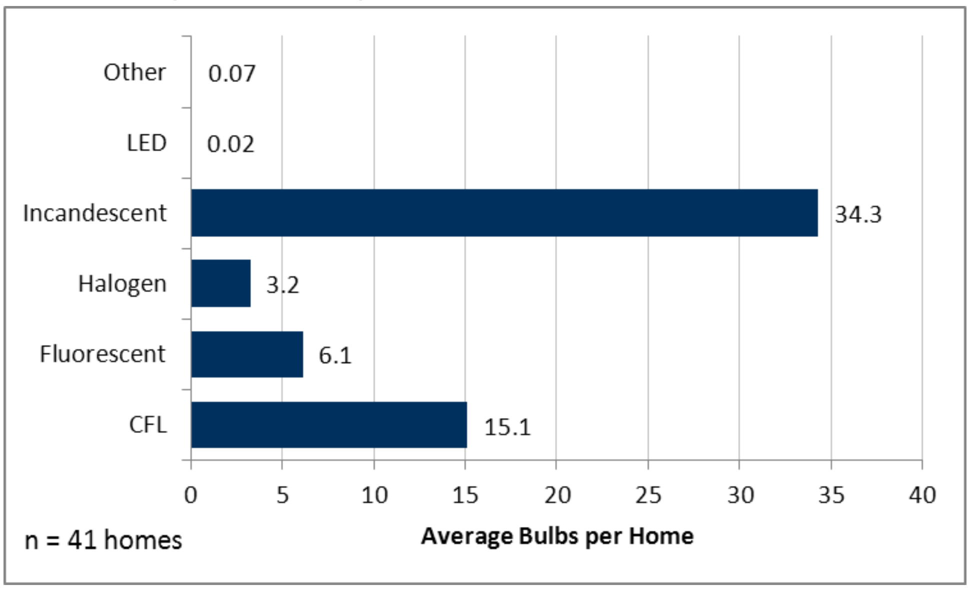
Table 11. Bulb Penetration and Saturation (n=41 homes)

Bulb Type	Penetration	Saturation (Percent of Bulbs)
Other	7.3%	0.1%
LED	2.4%	0.0%
Incandescent	100.0%	58.3%
Halogen	48.8%	5.5%
Fluorescent	82.9%	10.4%
CFL	97.6%	25.6%

In terms of saturation, incandescent bulbs still comprised the majority of Maine's lighting load, but CFLs have gained ground, averaging one in four bulbs in use.

Figure 6 compares average numbers of bulbs per home. A typical Maine household has 15 CFLs and approximately twice as many incandescents installed.

Figure 6. Average Bulbs per Home by Type (n=41)



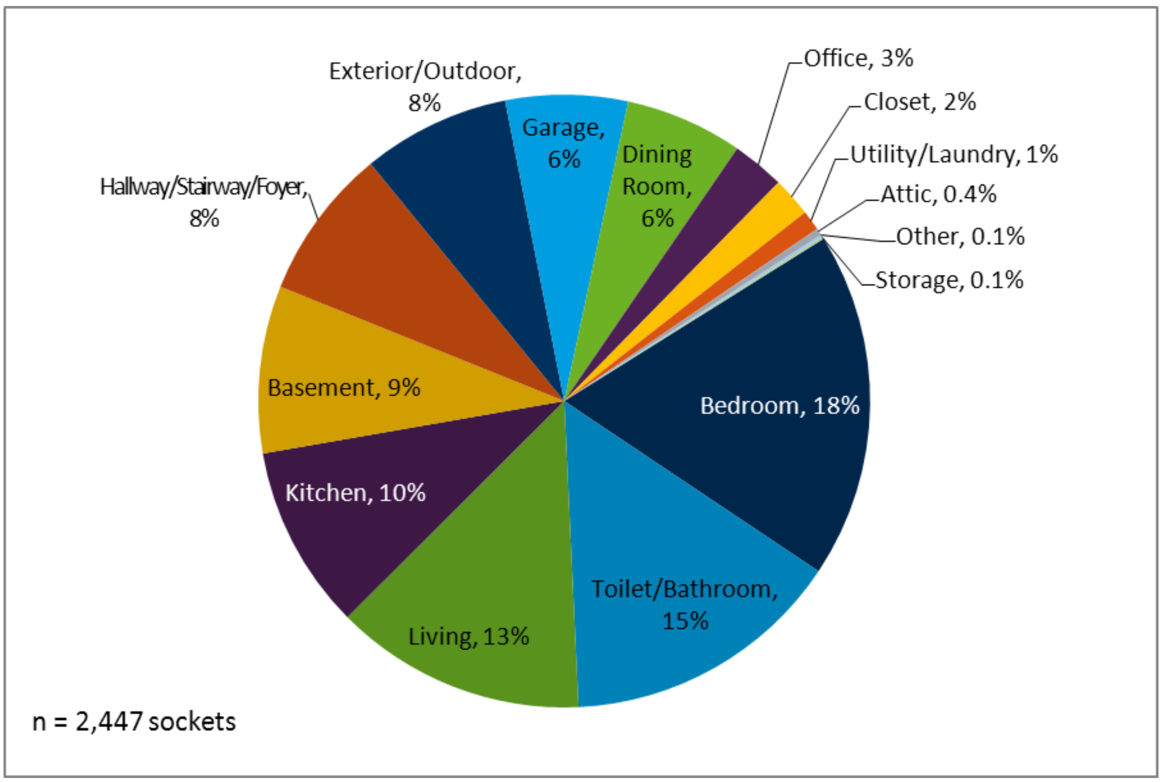
As shown in Table 12, for the 41 audited homes, technicians found an average of 36 fixtures and 60 individual sockets per home. In total, they found 2,447 sockets, and 2,415 bulbs installed in those sockets, plus 32 empty sockets.

Table 12. Socket and Fixture Summary (n = 41 homes)

Socket and Fixture Summary	Total
Total Sites	41
Total Fixtures	1,471
Average Fixtures/Site	36
Total Sockets	2,447
Average Sockets/Site	60
Sockets/Fixture	1.7
Total Bulbs Installed	2,415
Bulbs/Fixture	1.6
Empty Sockets	32

As shown in Figure 7, more than one-half of 2,447 sockets were in high-use rooms,[6] such as: bedrooms (18%), bathrooms (15%), living areas (13%), and kitchens (10%). In contrast, low-use rooms (such as attics, closets, and storage rooms) contained very small percentages of total sockets.

Figure 7. Percent of Sockets by Room Type



Of 1,374 high-use sockets identified during lighting audits, CFLs comprised 27%, as shown in

6 Classification of rooms as high-use has been based on multiple lighting studies, conducted by Cadmus for utilities in the Midwest, Mid-Atlantic, and Great Lakes regions.

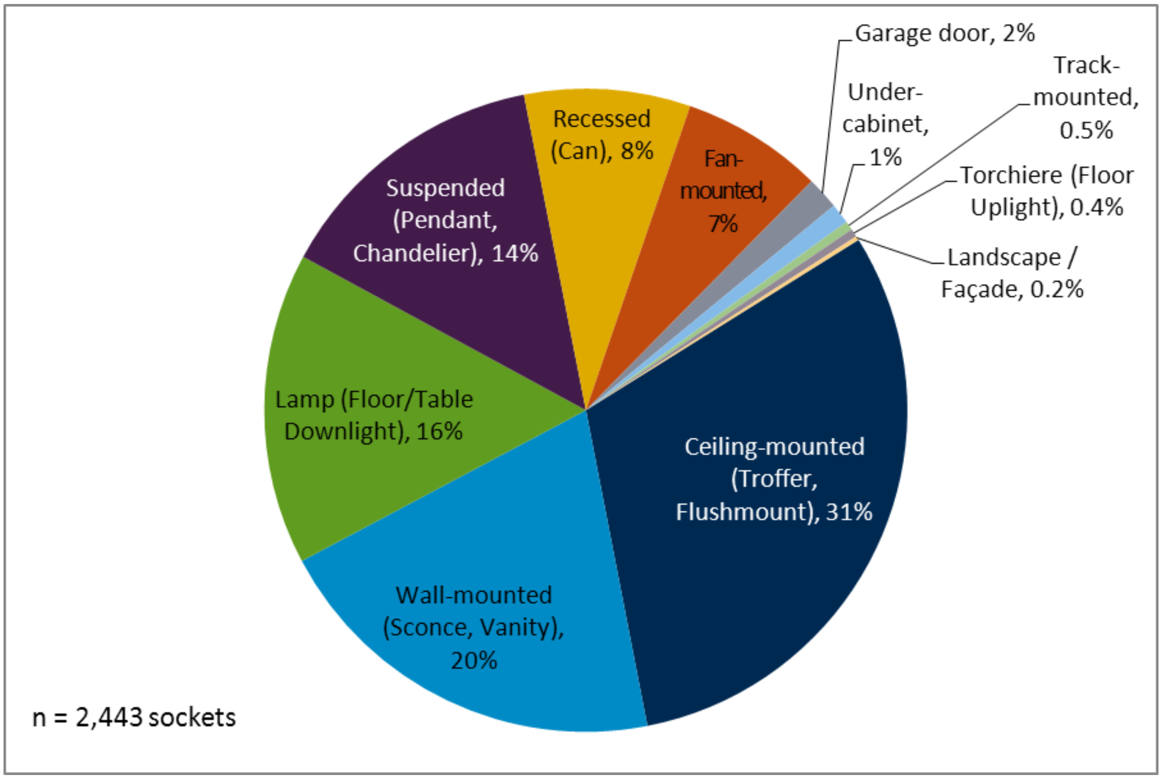
Table 13.

Table 13. CFLs in High-Use Areas

Room Type	Total Sockets	CFLs	CFLs as % of Sockets Per Room (CFL/Total Sockets by Room)	CFLs by Room as % of Total High-Use Sockets (CFL/1,374)
Bedroom	447	112	25%	8%
Toilet/Bathroom	364	80	22%	6%
Living	325	111	34%	8%
Kitchen	238	68	29%	5%
Totals	1,374	371	27%	27%

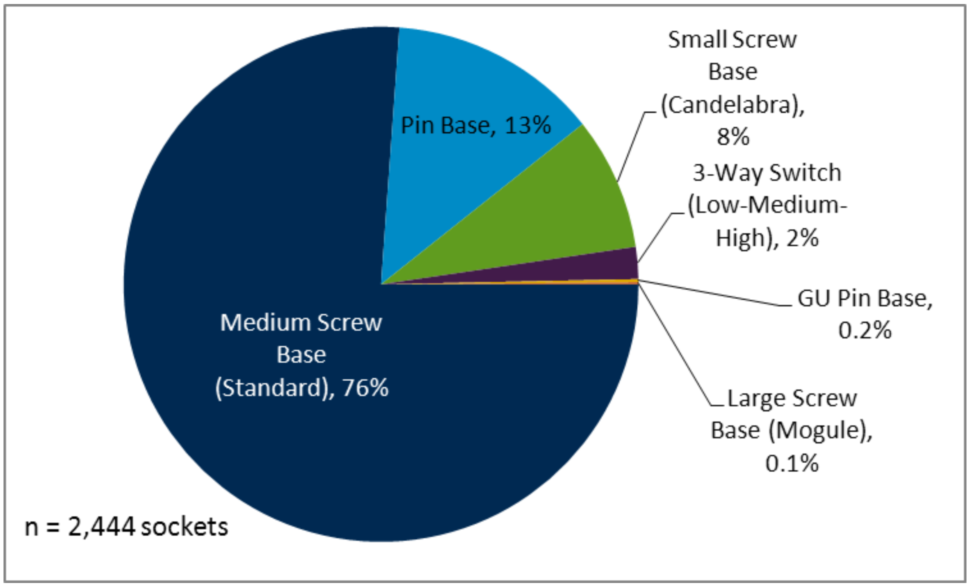
During lighting audits, field technicians noted fixture types for each socket, with ceiling fixtures, found in all 41 audited homes, containing about 31% of total sockets. As shown in Figure 8, wall-mounted fixtures (such as wall sconces or bathroom vanity fixtures) made up about 20% of sockets, with another 16% found on table/floor lamp fixtures.

Figure 8. Fixture Types



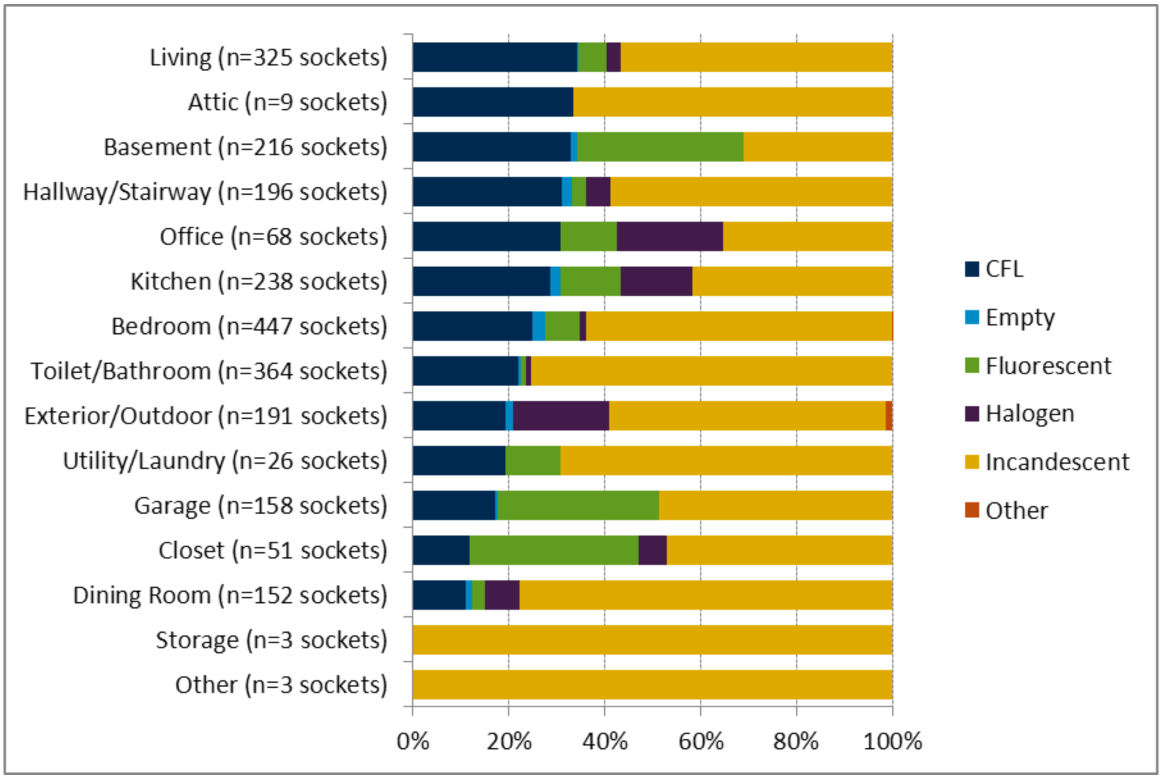
Medium screw base or standard sockets made up 76% sockets. Pin-based sockets made up 13% (used for linear fluorescent tubes, halogen linear lamps, or circline fluorescent tubes). Candelabra or small-screw based sockets accounted for about 8% of total sockets. The remaining sockets included: 3-way sockets; GU pin sockets (interchangeable base to accommodate multiple pin-based bulb types); and large screw-base sockets, as shown in Figure 9. On average, each home had: 45 medium screw base sockets, eight pin-based sockets, and five small-screw-base sockets.

Figure 9. Socket Types



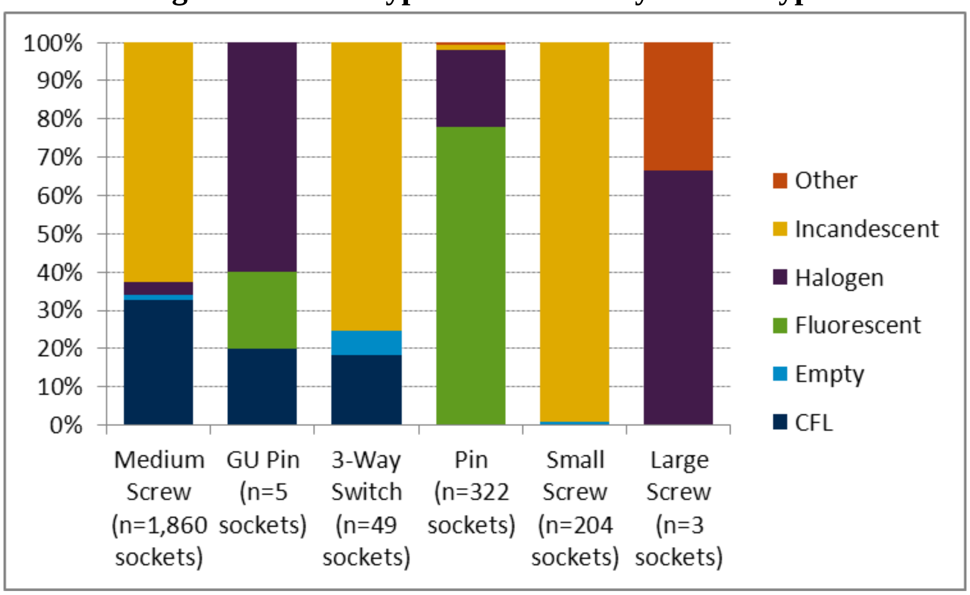
Incandescents, overall, were most frequently installed bulbs, as a percentage of total bulbs for each room type, as shown in Figure 10. Incandescents represented at least 50% of installed bulbs in all rooms, except offices, kitchens, closets, and basements. Fluorescents and CFLs also comprised significant distributions of bulbs installed in each room type. Distributions of incandescents, fluorescents, and CFLs were most consistent in basements, with each bulb type representing about one-third of bulbs found.

Figure 10. Bulb Type Distribution by Room Type



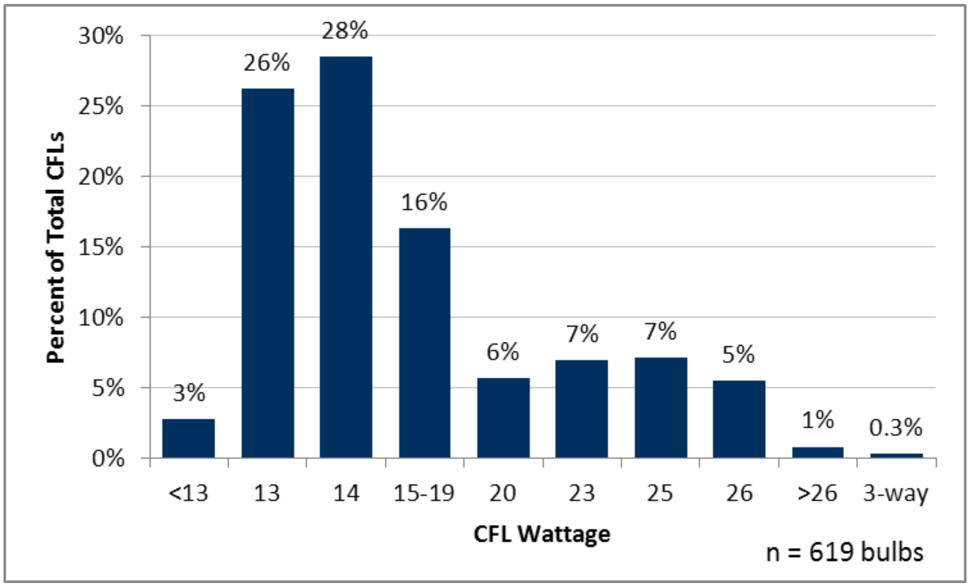
Bulb type installations varied considerably, when analyzed by socket type. Nearly all small-screw base sockets contained an incandescent bulb, with no CFLs found in small-screw base, large screw base, or pin-based fixtures. About one-third of all medium-screw base sockets contained CFLs, with the remainder containing incandescents.

Figure 11. Bulb Type Distribution by Socket Type



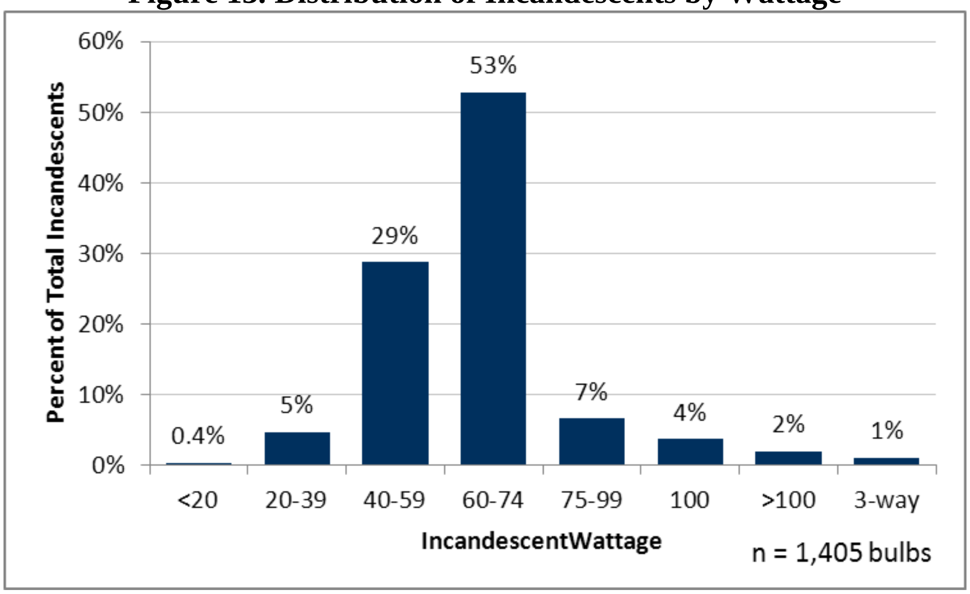
The following figures show distributions of bulb wattages for each bulb type. As shown in Figure 12, 13 watt or 14 watt bulbs made up more than one-half the CFLs in use, with most of the remainder between 15 to 26 watts.

Figure 12. Distribution of CFLs by Wattage



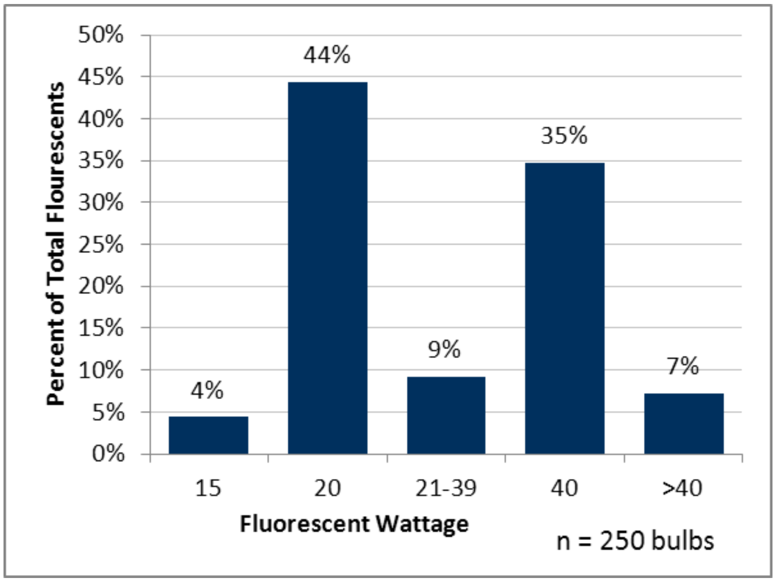
As shown in Figure 13, 40 watt or 60 watt bulbs made up about three-fourths of incandescent bulbs.

Figure 13. Distribution of Incandescents by Wattage



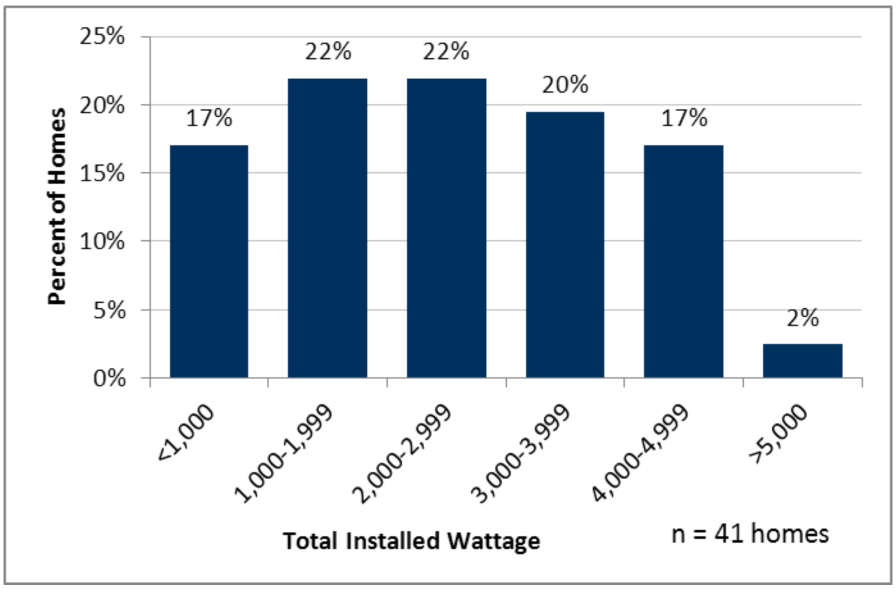
As shown in Figure 14, 20 or 40 watt bulbs made up about three-fourths of fluorescent bulbs, with only about 7% of fluorescents more than 40 watts.

Figure 14. Distribution of Fluorescents by Wattage



The total wattage of installed lights varied from less than 1,000 watts to more than 5,000 watts per home, averaging 2,564 watts per home. When analyzed in 1,000 watt increments, distributions of installed wattages appeared fairly uniform. As shown in Figure 15, only one home had more than 5,000 watts installed.

Figure 15. Distribution of Installed Wattage per Home



Gross Savings Analysis

Methodology

In energy-efficiency programs, gross savings can be defined as estimated savings for a measure delivered through the program, assuming a standard efficiency baseline.[7] Cadmus determined verified first-year and annual gross energy and demand savings associated with the RLP, using measurements and calculations based on full-year retailer data, lighting audit and logger data from 41 sites during the study period. First-year savings accounted for the ISR (not all purchased bulbs would be initially installed), while annual savings take an ongoing value, assuming 100% installation. The analysis used following gross savings algorithms for per unit (bulb) energy and demand savings:

$$\text{First} - \text{year kWh savings/year} = \frac{\Delta W}{1000} * ISR * (HOU * 365.25)$$

$$\text{First} - \text{year kWsavings} = \frac{\Delta W}{1000} * ISR * CF$$

$$\text{Annual kWh savings/year} = \frac{\Delta W}{1000} * (HOU * 365.25)$$

$$\text{Annual kWsavings} = \frac{\Delta W}{1000} * CF$$

Where:

ΔW	=	the average difference in wattage between the CFL installed and baseline wattage (the bulb replaced, delta watts).
ISR	=	the ISR, or the percentage of bulbs installed and operating.
HOU	=	the average number of hours CFLs are used per day.
CF	=	the proportion of demand occurring during the peak period (the coincidence factor).

Per-unit lifetime savings could then be calculated as:

$$\text{Lifetime kWh savings} = (Annual\ kWh\ savings/year) * EUL$$

Where:

EUL	=	the effective useful life of the CFL.

In-Service Rate and Placement

The ISR represents the proportion of program CFLs installed during the program period. For the standard upstream program (markdown and coupon), Cadmus estimated an ISR based on data

7 Standard efficiency refers to the minimum efficiency required by state or federal standard.

collected during site visits, with Cadmus field staff counting numbers of CFL bulbs in storage, and comparing these to the total number of CFLs in homes to determine the ISR. During site visits, field staff also collected data on locations of installed CFLs, which were used to weight HOU estimates to the population distribution of bulbs, by space type.

Cadmus estimated a separate ISR for the Appliance Rebate Program CFL giveaway participants, accounting for differences in installation rates often seen between upstream and giveaway programs. ISR estimation used self-reported installation rates from the telephone survey for giveaway participants.

Delta Watts

Delta watts represent the wattage difference between a baseline fixture and an equivalent efficient CFL fixture. To compute delta watts, Cadmus used program tracking data, provided by Efficiency Maine, on CFL sales by Stock Keeping Unit (SKU)[8] number (model number and bulb type) for the 269 eligible CFL products sold by the nine participating RLP retailers.

Sales data for the 1.9 million incented CFLs sold during FY 2011 included CFL wattages, but not lumen data or light outputs for bulbs.

To estimate the equivalent baseline wattage of each CFL product, Cadmus mapped each CFL to a discrete lumen range. Cadmus developed groups of lumen ranges (bins) based on the 2007 EISA lumen requirements.[9] For each range, EISA provides an incandescent wattage equivalent. Difference between this wattage and the actual rate wattage of a given CFL represent delta watts for that product.

The program tracking database did not include lumen outputs. Therefore, Cadmus used a secondary source—a list of eligible ENERGY STAR CFL products from the ENERGY STAR Website—to determine appropriate lumens for each product.[10] For a small subset (36 of 268 SKUs), this was done through direct matching of SKUs. These 36 matched SKUs, however, accounted for 69% of total bulbs sales. Where direct matching could not be used, Cadmus estimated lumens using a trend line of CFL wattage and median lumens, calculated from ENERGY STAR data.

Hours of Use

Cadmus calculated the average daily HOU for each fixture as the average time "on" across the entire metering period (daily, from 12:00:00 a.m. to 11:59:59 p.m.). The average HOU by room type across all days and households could be estimated using a set of regression models,

[8] SKU represents the unique make and model indicator for a specific retailer.

[9] Congress signed EISA into law on December 19, 2007. The new law contains provisions for phasing in more efficient incandescent lamps, based on rated lumens. For example, a 100 watt incandescent lamp with a rated lumen range of 1,490 to 2,600 must have a minimum of 72 watts, effective nationally by January 1, 2012.

[10] This analysis used a downloaded list of ENERGY STAR-qualified CFL bulb products, last updated on May 24, 2011. The database consisted of 5,245 CFL products, and their associated wattages and lumens. The list required data cleaning to remove or update the following: database inconsistencies; missing values; decimal places; outliers; and incorrect entries. Cleaning removed or updated nine entries, resulting in a "cleaned" database of 5,243 CFL products. The most recent version of these data can be found at: downloads.energystar.gov/bi/qplist/Lamps_Qualified_Product_List.xls?bb82-57af.

providing daily HOU as a function of daylight hours. The population average HOU was estimated using CFL saturations by room type from the full audit population as weights. This ensured the overall HOU estimate represented the distribution of CFLs during the program period.

The following guidelines assigned “on” intervals to each light logger:

- If a light logger did not record any light for an entire day, that day has an HOU of 0.
- If a light logger registered a light turned on at 8:30 p.m. on Monday, and registered the light turned off at 1:30 a.m. on Tuesday morning, 3.5 hours were added to Monday’s HOU, and 1.5 hours were added to Tuesday’s HOU.

Residential CFL usage partly serves as a function of daylight hours. Lamps used in rooms without access to daylight (closets, basements, and other windowless rooms), along with lamps with usage independent of daylight (lights on timers or lights turned on when home from work), can be classified as “baseload” lights. Overall, the baseload usage provides the basis for home HOU, combined with usage dependent on hours of daylight. Therefore, overall usage fluctuates over a year’s course, given fluctuations in daylight hours.

To account for this effect, Cadmus fit regression models for each room type, expressing HOU as a function of average daylight hours. Appendix D provides a detailed discussion of this approach.

Coincidence Factor

The coincidence factor can be defined as the percentage of total demand actually occurring during a given peak period. To determine the coincidence factor, Cadmus used lighting logger data to estimate daily load shapes for weekday and weekend days. Efficiency Maine uses winter on-peak and summer on-peak definitions, prescribed for participation in the ISO-NE Forward Capacity Market. This defines winter on-peak as non-holiday weekdays, from 5:00 to 7:00 p.m., during December and January, and summer on-peak as non-holiday weekdays from 1:00 to 5:00 p.m., during June, July, and August.[11] Cadmus calculated the average percent of bulbs on during the specified on-peak period as the coincidence factor.

Effective Useful Life

EUL can be calculated using the rated lifetime of bulbs in combination with estimated hours of use. In some evaluations, an included switching factor accounts for degradation CFLs incur due to different switching times (the average duration of a bulb left on continuously), compared to that assumed in determining a rated lifetime.

Through reviewing available literature, however, Cadmus found consensus has not been achieved regarding this issue, with available estimates for switching factors either out of date or based on a small number of data points. Consequently, the analysis excluded this from the current evaluation. Nevertheless, switching most likely presents an issue, and current EULs should be considered optimistic. Appendix D presents further discussion of this issue.

---

11 Per ISO-NE transmission, markets, and services tariff: http://www.iso-ne.com/regulatory/tariff/sect_1/sect_i.pdf

The analysis used the following algorithm:

$$EUL = \left(\frac{Rated\ Lifetime\ hrs}{Daily\ HOU * 365.25\ days}\right)$$

Where:

Rated Lifetime Hours = rated hours of operation for the CFL, provided by the manufacturer.

Cadmus used daily HOU from the metering study, and rated lifetimes taken from program data.

Findings

In-Service Rate and Placement

Based on bulb installation and storage data collected from the site visits, Cadmus found an ISR of 73% for the standard RLP, indicating approximately three out of four CFLs in homes presently installed. Based on phone survey results, giveaway participants had a substantially lower ISRs, with fewer than half (46%) of bulbs installed. Giveaway programs typically have lower ISRs, as the program initiates the transaction, not the customer (as in upstream programs). ISR values, only applied to first-year savings, do not affect annual savings.

Table 14 shows distributions of CFLs by room types, findings which were used to weight HOU estimates by room type for metered bulbs to the CFL population. To determine room-based weights, Cadmus calculated CFL distributions by room as a percentage of CFLs observed in all 41 metered households (including both metered and non-metered CFLs). As shown in the table, bedrooms, living rooms, and bathrooms had the highest CFL placement rates.

Table 14. CFL Placement by Room Type

Room	Count	Weight
Basement	71	11%
Bedroom	112	18%
Dining Room	17	3%
Exterior/Outdoor	37	6%
Garage	27	4%
Hallway/Stairway/Foyer	61	10%
Kitchen	68	11%
Living	111	18%
Office	21	3%
Other	14	2%
Toilet/Bathroom	80	13%
Total	619	100%

Delta Watts

Table 15 represents all eligible CFL wattages purchased through the RLP (along with associated baselines). Cadmus calculated, on average, approximately 49-watt difference between program and baseline CFLs.

Table 15. Baseline Wattages and Delta Wattage of CFLs

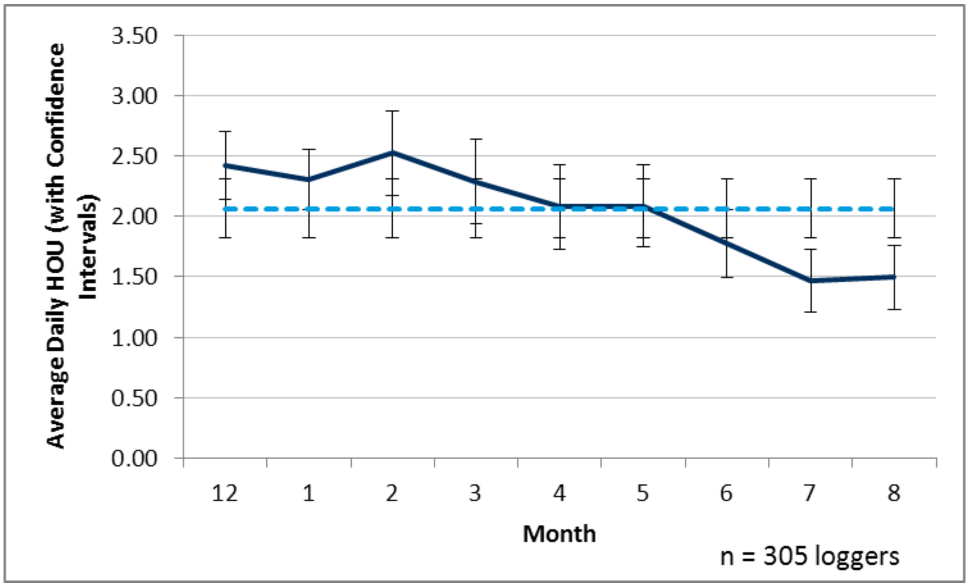
CFL Wattage (W_{eff})	Average Baseline Wattage (W_{base})	Average Delta Watts (ΔW)	Proportion of Total Bulb Sales
5	25	20	0
7	40	33	0.1%
9	40	31	2.5%
10	40	30	2.1%
11	40	29	0.5%
12	60	48	0.1%
13	60	47	50.9%
14	60	46	28.6%
15	60	45	1.7%
16	60	44	0.2%
18	75	57	0.2%
19	75	56	1.3%
20	75	55	2.1%
23	97	74	5.0%
24	100	76	0.0%
26	100	74	3.9%
27	100	73	0.4%
28	100	72	0.1%
29	100	71	0.0%
30	100	70	0.0%
32	100	68	0.1%
33	100	67	0.0%
40	150	110	0.0%
42	150	108	0.1%
55	200	145	0.0%
65	200	135	0.0%
Weighted Average		49	

Cadmus recommends using this approach to determine an equivalent baseline by equivalent lumens of each lamp, due to its consistency with the 2007 EISA. For program evaluations in 2012 and beyond, the 2007 EISA established an equivalent baseline to follow.

Hours of Use

The meter sample had an unweighted, average daily HOU of 2.07 hours per day. As shown in Figure 16, the average HOU followed a downward trend, from winter to summer.

Figure 16. Unweighted Average HOU by Month



To annualize meter data collected in Maine, while accounting for effects of daylight hours on usage, Cadmus fit a series of regression models to the data. This required estimating HOU for each room type, and then calculating a weighted average HOU using the full distribution of CFLs in the audit sample (including metered and unmetered bulbs). Table 16 shows the modeling effort's results, and Appendix D provides a detailed account of this approach.

Table 16. Seasonally-Adjusted Average HOU per Day by Room Type

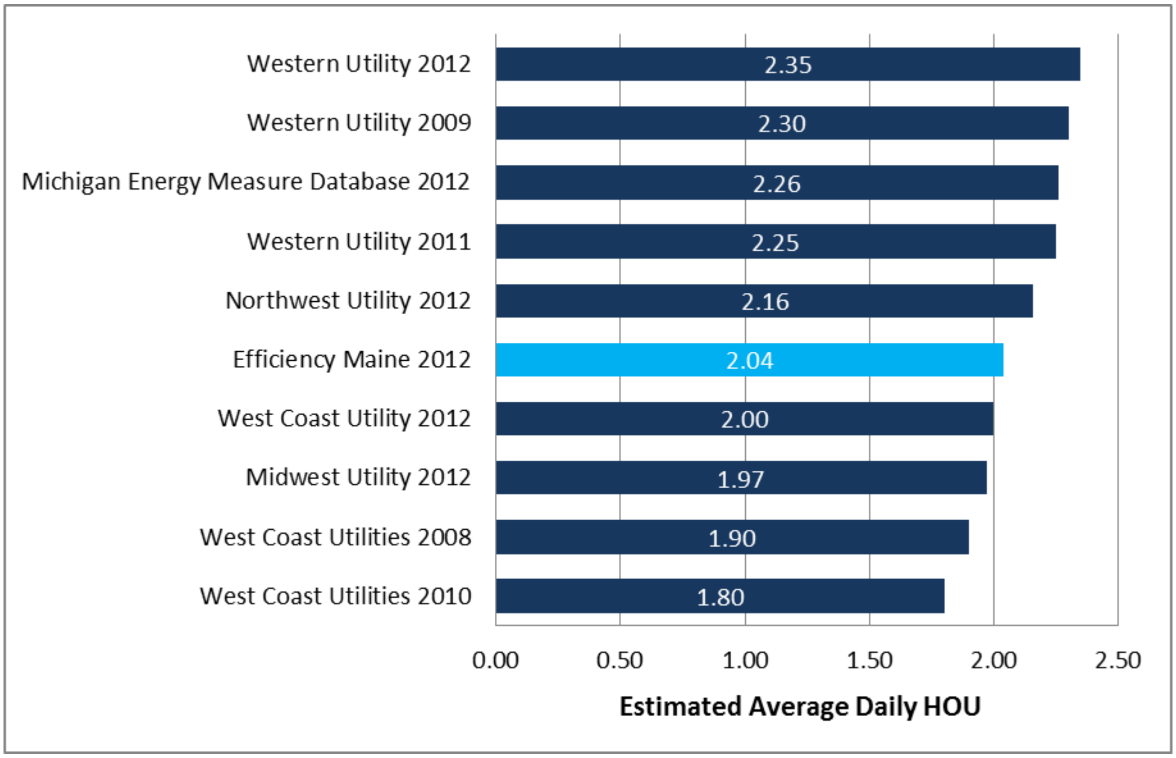
Room	Proportion of Audited CFLs (n = 619 bulbs)	Overall	Relative Precision
Basement	11%	1.29	±15%
Bedroom	18%	1.35	±17%
Dining Room	3%	2.72	±7%
Exterior/Outdoor	6%	2.76	±12%
Garage	4%	0.96	±43%
Hallway/Stairway/Foyer	10%	2.14	±14%
Kitchen	11%	3.96	±9%
Living	18%	2.65	±9%
Office	3%	1.66	±12%
Other	2%	0.37	±59%
Toilet/Bathroom	13%	1.42	±7%
Weighted Average		2.04	±10%

* "Other" rooms encompass those with especially low usage, such as laundry/utility rooms and closets.

Benchmarking

The estimated HOU per day often serves as a function of the scale and maturity of an energy-efficient lighting program. As a CFL program begins to fully saturate a market, bulbs begin to be installed in low-use areas, such as closets and utility rooms, reducing the HOU estimate. Such effects remain consistent with the finding of a lower HOU in the present study, compared with the 2007 RLP evaluation, which found an HOU of 3.2 hours per day. As shown in Figure 17, the Trust's program had an HOU in the middle of the spectrum, compared to findings from other metering studies of residential lighting programs.

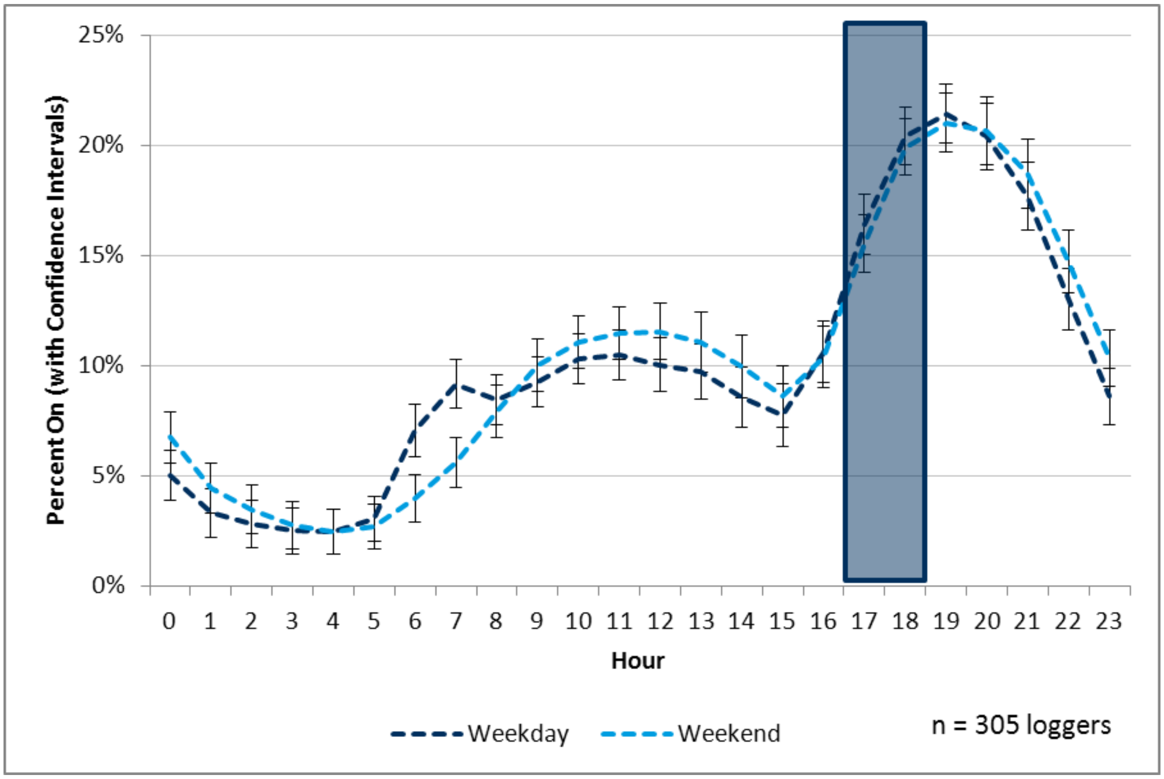
Figure 17. Comparison of Daily HOU



Load Shape and Coincidence Factor

Figure 18 shows Cadmus' estimated daily load shapes for lighting, based on metered data collected during the winter peak months of December and January.

Figure 18. Daily Winter Load Shapes (Peak Period Shaded)

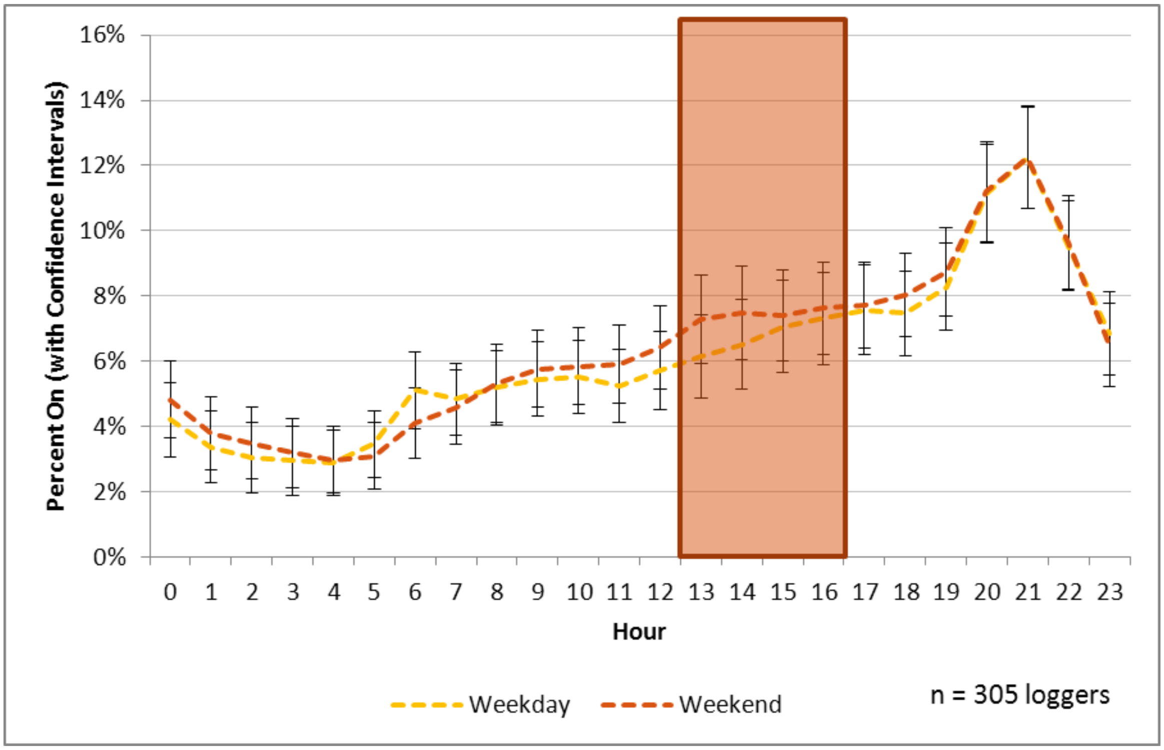


Using these load shapes, Cadmus estimated a winter on-peak coincidence factor of 0.184, with a relative precision of ±8.1% at the 80% confidence level. This indicates, on average 18.4% of lighting demand (bulbs on) occurs during winter on-peak hours (5:00 to 7:00 p.m., non-holiday weekdays in December and January).

Figure 19 shows Cadmus' estimated lighting daily load shapes for metered data, collected during summer peak months of June and July.[12]

[12] August also was a summer peak period, but, due to the evaluation's timeline, the metering period ended before the month's end.

Figure 19. Daily Summer Load Shapes (Peak Period Shaded)



Using these load shapes, Cadmus estimated a summer on-peak coincidence factor of 0.068, with a relative precision of ±10.1% at the 80% confidence level. This indicates, on average, 6.8% of lighting demand (bulbs on) occurs during the summer on-peak hours (1:00 to 5:00 p.m., non-holiday weekdays in December and January).

Effective Useful Life

As shown in Table 17, program CFLs have an estimated EUL by bulb type between 11.0 and 13.4 years, based on manufacturer-rated lifetimes and average HOU from the metering study. The 2007 RLP evaluation estimated an EUL of 7.5. The difference between the reports largely arose from differences in daily HOU, an important input in EUL calculations.

Table 17. EUL Summary

Bulb Type	Average Rated Lifetime (hrs)	HOU	EUL (years)
Standard	9,336	2.04	12.5
Specialty	8,233	2.04	11.0
Giveaway	10,000	2.04	13.4
Program Overall	9,298	2.04	12.5

Per-Unit Gross Savings

Combining the metrics discussed above, Table 18 shows first-year and annual gross energy and demand savings per unit (bulb) by lumen bin, respectively.

Table 18. First-Year Per-Unit Gross Savings Summary

Type	Lumen Bin	HOU	Average CFL Wattage	Baseline Wattage	Delta Watts	ISR	Gross Energy Savings (kWh/year)	Gross Summer Peak Savings (kW)	Gross Winter Peak Savings (kW)
Standard	3,301–4,815	2.04	55.0	200.0	145.0	73%	79.3	0.007	0.020
	2,601–3,300	2.04	41.6	150.0	108.4	73%	59.3	0.005	0.015
	1,490–2,600	2.04	24.5	100.0	75.5	73%	41.3	0.004	0.010
	1,050–1,489	2.04	19.5	75.0	55.5	73%	30.4	0.003	0.007
	750–1,049	2.04	13.4	60.0	46.6	73%	25.5	0.002	0.006
	310–749	2.04	9.5	40.0	30.5	73%	16.7	0.002	0.004
	0–309	2.04	5.0	25.0	20.0	73%	10.9	0.001	0.003
	Weighted Average	2.04	14.4	63.2	48.9	73%	26.7	0.002	0.007
Specialty	3,301–4,815	2.04	65.0	200.0	135.0	73%	73.9	0.007	0.018
	1,490–2,600	2.04	26.5	100.0	73.5	73%	40.2	0.004	0.010
	1,050–1,489	2.04	19.6	75.0	55.4	73%	30.3	0.003	0.007
	750–1,049	2.04	14.5	60.0	45.5	73%	24.9	0.002	0.006
	310–749	2.04	10.1	40.0	29.9	73%	16.4	0.001	0.004
	Weighted Average	2.04	16.1	64.2	48.1	73%	26.3	0.002	0.006
Giveaway	1,490–2,600	2.04	23.0	100.0	77.0	46%	26.3	0.002	0.007
Program Overall	Weighted Average	2.04	14.6	63.7	49.2	73%	26.7	0.002	0.007

Net Savings Analysis

Methodology

Net savings result from purchases of program-incented CFLs attributed to the program. To compute net savings, one adjusts gross savings to account for the likelihood that some participants would have purchased a high-efficiency measure (e.g., CFL) without the program incentive. The equation below shows the ratio of NTG savings:

$$NTG = \frac{Net\ Savings}{Gross\ Savings}$$

This section describes Cadmus' approach for estimating net impacts and, subsequently, NTG.

Data

NTG analysis primarily utilized program data provided by Applied Proactive Technologies (APT), Efficiency Maine's RLP implementer. This dataset included package and bulb sales for each retailer, by model number and week. For each unique combination of retailer, model number, and incentive level, the dataset contained the following fields relevant to this analysis:

- Original retail price;

- Incentive provided by Efficiency Maine;
- Target retail price;
- Number of bulbs per package;
- Rated wattage;
- Rated lifetime in hours; and
- Specialty/standard designation.

Not all records were complete across all categories. For instance, 22% of records did not include the original retail price. As this field was necessary to predict the counterfactual (prices faced by consumers in the program's absence), this required restricting analysis only to bulbs with complete data. This did not, however, largely affect the results, assuming data were missing at random.

Cadmus estimated a consumer demand model using APT-provided sales tracking data, predicting demand levels in the program's absence. As outlined in the National Action Plan for Energy Efficiency, econometric methods of estimating net savings provide this option when comprehensive and detailed data are available,[13] an approach possible as APT tracked original retail prices of program bulbs, and stringently enforced sales at targeted program prices. Thus, Cadmus had sufficient information on prices consumers would face in the program's presence and absence.

Freeridership

To determine the freeridership ratio (the portion of savings associated with CFL purchases that would have occurred in the absence of program discounts), Cadmus estimated expected bulb purchases (and associated savings) at prices offered under the program and at original retail prices. The basic framework of this analysis can be described as:

$$Freeridership\ Ratio = \frac{\sum_i^n \left(E\left[bulbs_{NOPROG\,i}\right] * W_i\right)}{\sum_i^n \left(E\left[bulbs_{PROG\,i}\right] * W_i\right)}$$

Where:

$E(bulbs_{PROGi})$	=	the expected number of bulbs of type, i, purchased given prices dictated by the program (as predicted by the model).
$E(bulbs_{NOPROGi})$	=	expected number of bulbs of type, i, purchased given the original retail prices by the program (as predicted by the model by setting price to original retail levels).
W_i	=	rated wattage for bulb type, i.

This basic freeridership estimation approach remains consistent with other econometric methods, such as willingness-to-pay and discrete choice modeling.

13 "National Action Plan for Energy Efficiency." 2007. Model Energy Efficiency Program Impact Evaluation Guide. www.epa.gov/eeactionplan.

Spillover

The study also considered examined evidence for market effects spillover. Market effect spillover occurs when a program causes price pressure on competing, nonparticipating measures (e.g., non-qualifying bulbs) in the marketplace, the installation of which can lead to savings outside of the program. These nonparticipating measures could be CFLs sold at participating retailers (but not marked down by the program), or CFLs sold by nonparticipating retailers.

After conducting the stakeholder interviews, however, Cadmus concluded the program likely experienced very small market effect spillover, and incorporating other spillover would prove inaccurate. The implementer noted very little indication existed of price pressures for nonparticipating CFLs sold at participating stores. Multiple stakeholders also noted the program covered a substantial number of bulbs sold in Maine.[14] Given the difficulty and cost associated with tracking this effect, Cadmus chose to exclude market effects spillover from the NTG analysis. It should be noted, though, that market effects spillover most likely remains a minor small factor, and the NTG estimate should be considered conservative.

The analysis excluded participant and nonparticipant spillover as such spillover typically occurs through customer education. Strong customer outreach typically does not take place in strictly upstream programs, and did not play a large role in the recent RLP Program. In the past evaluation, the lighting markdown program included significant marketing and customer interaction, which warranted inclusion of such spillover.

The following equation provided final NTG for the program:

$$NTG = 1 - Freeridership\ Ratio\ (FR) \mp Spillover\ Ratio = 1 - FR$$

Estimation

Cadmus estimated CFL demand using econometric estimations of a “revealed-preference” model, based on detailed tracking data on actual CFL purchases and prices. This estimation method has rarely been used in upstream lighting program evaluations, as such data generally have been unavailable. As Efficiency Maine and APT tracked these data and shared them for this evaluation, Cadmus found such econometric demand estimation provided the best method for estimating the program’s freeridership. Appendix C provides further technical details.

Findings

Freeridership

Cadmus estimated freeridership using coefficients from estimation of the revealed preference model to predict sales, if the prices had remained at their original retail price levels, and promotional events had not taken place. The difference in sales (weighted by CFL wattage) between this hypothetical scenario and actual sales produced net sales attributable to the program (sometimes called “program lift”). The ratio of these sales to the total program incented sales provided the NTG.

[14] If participating retailers compose 90% of the market, even in the unlikely scenario that nonparticipating retailers matched participating retailers’ prices exactly, the spillover ratio would equal the 10%*FR ratio.

The analysis found program-wide freeridership within values expected for mature upstream lighting programs (as shown in Figure 21). As shown in Table 19, the core program (markdown and coupons) had freeridership of 0.34, a value implying approximately 34% of the gross CFL savings taking place during the program period would have occurred in the program's absence.

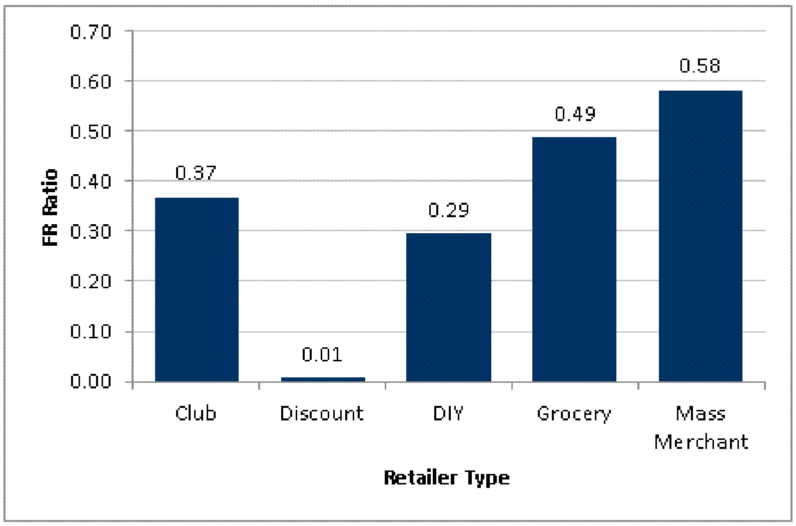
Cadmus assumed there was no freeridership for Appliance Rebate Program participants—a common practice for giveaway and direct-install programs, as customers do not shop for lighting products, but simply are offered CFLs without prompting.

Table 19. Program NTG

RLP	Freeridership	NTG
Upstream	0.34	0.66
Giveaway	0.00	1.00

Looking at freeridership by retailer types, discount, club, and do-it-yourself (DIY) stores appeared to experience lower freeridership levels, and mass-merchant and grocery stores experienced higher levels.

Figure 20. Freeridership by Retail Channel



Specialty Bulbs

Upstream lighting programs sometimes ignore differences in program impacts between specialty and standard bulbs. Cadmus' model allowed freeridership values to be estimated separately for these groups.

Standard CFLs (0.32) experienced much lower freeridership levels than specialty CFL bulbs (0.92), probably due to differences in incentive levels and a lower price elasticity of demand for specialty bulbs. As shown in Table 20, specialty bulbs had lower incentives, relative to their original retail prices, than those for standard bulbs. Specialty bulbs had an average per-bulb incentive of $1.33, representing 20% of its retail price. By contrast, the average standard bulb received an incentive of $1.02, or 28% of its retail price.

Table 20. Retail Price and Incentive by Bulb Type

Bulb Type	Average Retail Cost per Bulb	Average Incentive per Bulb	Percent of Original Retail
Standard	$3.65	$1.02	28%
Specialty	$6.77	$1.33	20%

Findings reported during the process evaluation stakeholder interviews corroborated these impact findings. As specialty bulbs proved hardest to move, the number of bulbs could not be moved cost-effectively. During FY 2011, Efficiency Maine began offering a lower incentive for specialty products ($1.25 per CFL, rather than $1.50) as it decided lowering the incentive level by $0.25 would not negatively impact already low sales.

Benchmarking

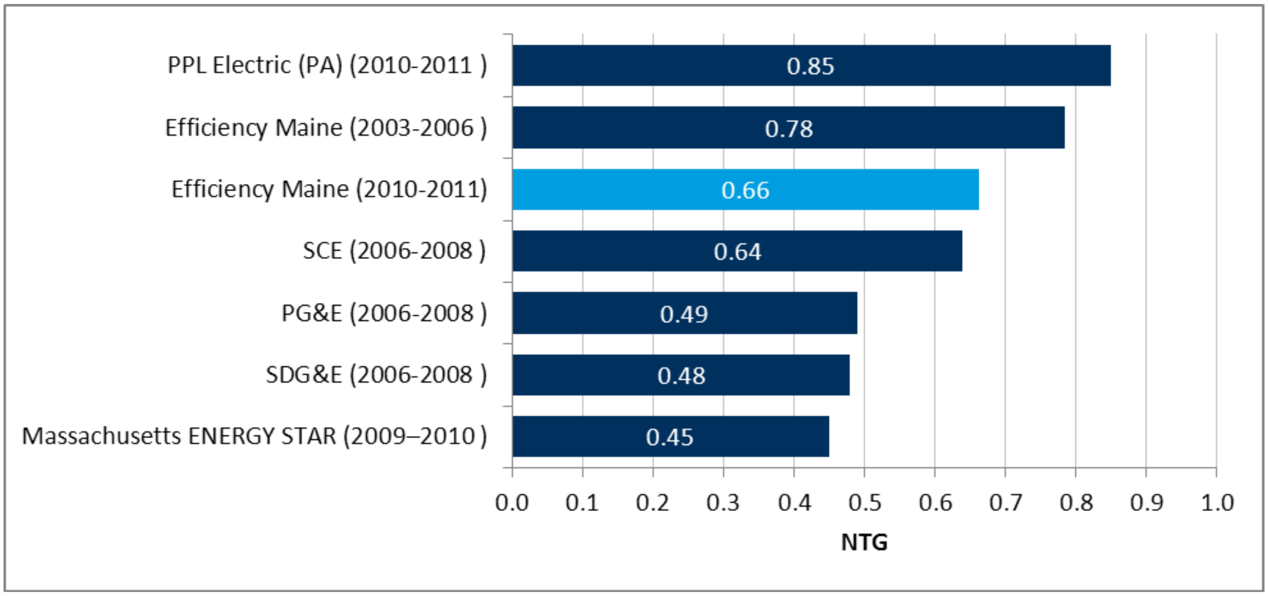
NTG values can be difficult to compare between upstream lighting program evaluations, as estimation techniques (such as self-report or econometric) and measured components (such as spillover) vary widely.

For example, spillover may be measured along several dimensions, including participant/nonparticipant, like/non-like, and market effects.[15] As the current RLP places very little emphasis on marketing and outreach, non-like spillover was not expected to significantly factor in program impacts. By computing NTG values only based on freeridership (not spillover) for several other programs, Cadmus could ascertain NTG values for comparison.

Figure 21 compares these values. In the present study, Efficiency Maine's has a lower NTG value than that found in the Efficiency Maine study covering the 2003–2006 program period—the 2007 RLP evaluation—but this remains above the median value in the comparison group.

15 Non-like spillover can be defined as: savings from purchases of efficient equipment not incented by a program, and of a wholly different type, but in some way induced by the program. For example, marketing a lighting program may make customers more likely to purchase efficient appliances. Non-like spillover most commonly occurs in programs with substantial marketing or energy education components.

Figure 21. Comparison of Upstream CFL Program NTG Ratios*



*To allow comparison, NTG values in this figure have been calculated as NTG= (1 – freeridership), and do not include spillover.

The Efficiency Maine (2003-2006) 2007 RLP evaluation and the PPL Electric (2010-2011) evaluation were conducted using self-report methods. The other studies shown in Figure 21 were conducted using a combination of methodologies; including market share, econometric, and self-report.

Program-Level Savings

First Year and Annual Savings

Table 21 presents values of various parameters factoring into CFL savings calculations, and compares Cadmus' 2012 evaluation findings with those from Efficiency Maine's 2009 TRM[16] and the 2007 RLP evaluation.

Table 21. Comparison of Savings Parameters

Parameter	2012 Evaluation	2007 Evaluation	2009 TRM
HOU	2.04	3.26	2.70
Coincidence Factor	0.18	0.36	0.11
Delta Watts	49.2	45.2	39.5
EUL	12.5	7.5	6.8
NTG	0.66	1.11	1.20

Cadmus' findings for individual parameters differed from those found in other Maine-specific sources, particularly in the estimated HOU, EUL, and NTG. Such change can be expected as residential lighting programs mature, and CFLs spread to lower-usage areas. The HOU reduction primarily affects annual savings, and has little impact on lifetime savings or cost-effectiveness, aside from indirect effects arising from the EISA standard. NTG went down considerably, though this only affects net savings.

[16] The TRM documents key parameters and algorithms for program savings calculations.

Once relevant savings parameters had been estimated, Cadmus calculated first-year total gross and net program savings. As shown in Table 22, verified, first-year total gross savings of 52,284 MWh, and first-year net savings of 34,628 MWh. After the first year, the program will likely save 71,617 gross MWh, and 47,432 net MWh annually.

Table 22. Total Gross and Energy Net Savings

Type	Quantity	First-Year		Annual*	
		Total Gross Energy Savings (MWh/year)	Total Net Energy Savings (MWh/year)	Total Gross Energy Savings (MWh/year)	Total Net Energy Savings (MWh/year)
Standard	1,859,155	49,701	33,889	67,767	46,207
Specialty	75,915	1,999	169	2,725	231
Giveaway	22,212	585	585	1,276	1,276
Total	1,957,282	52,284	34,628	71,617	47,432

*Annual savings in this table have not been adjusted for EISA implementation.

The program achieved net demand reductions of 3.1 MW for the summer on-peak period and 8.6 MW for the winter on-peak period in the first year; and is expected to maintain net reductions of 4.3 MW and 11.7 MW in summer and winter, respectively, in subsequent years. Cadmus estimated total annual net demand savings within ±11.0% relative precision for the summer peak period, and within ±9.4% relative precision for the winter peak period with 80% confidence.

Table 23. Total Gross and Net Demand Savings

Type	Quantity	First-Year				Annual*			
		Total Gross Summer Peak Savings (MW)	Total Gross Winter Peak Savings (MW)	Total Net Summer Peak Savings (MW)	Total Net Winter Peak Savings (MW)	Total Gross Summer Peak Savings (MW)	Total Gross Winter Peak Savings (MW)	Total Net Summer Peak Savings (MW)	Total Net Winter Peak Savings (MW)
Standard	1,859,155	4.50	12.27	3.07	8.37	6.13	16.73	4.18	11.41
Specialty	75,915	0.18	0.49	0.02	0.04	0.25	0.67	0.02	0.06
Giveaway	22,212	0.05	0.14	0.05	0.14	0.12	0.32	0.12	0.32
Total	1,957,282	4.73	12.91	3.13	8.55	6.48	17.68	4.29	11.71

*Annual savings in this table have not been adjusted for EISA implementation.

Lifetime Savings

Table 24 estimates verified lifetime gross and net savings from the program, with lifetime savings based on annual savings values (including the assumption that CFLs in storage will eventually be installed) and estimated EUL. They have also been adjusted for EISA's implementation of EISA, which Table 25 also describes in further detail.

Table 24. Lifetime Gross and Net Savings

Type	EUL (years)	Lifetime Gross Savings (MWh)	Lifetime Net Savings (MWh)
Standard	12.5	618,344	421,623
Specialty	11.0	29,974	2,539
Giveaway	13.4	10,770	10,770
Program Overall	12.5	659,088	434,932

EISA Adjustments

With certain provisions, launched in January 2012, EISA[17] sets mandatory maximum wattages for light bulbs, depending on bulb lumen outputs. In evaluating energy-efficiency programs, this proves significant, as it raises the efficiency of the assumed baseline unit, substantially lowering savings an installed high-efficiency CFL would achieve over the baseline. Table 25 shows pre- and post-EISA baselines for each category of lumen output, and years in which mandates become effective.

Table 25. EISA Adjustments

Lumen Range	Assumed Original Baseline	New Maximum Wattage	Effective Date	Average CFL Wattage	Calculated Savings Reduction
310-749	40	29	2014	9.51	36.10%
750-1049	60	43	2014	13.41	36.50%
1050-1489	75	53	2013	19.52	39.70%
1490-2600	100	72	2012	24.51	37.10%

As the entire program period occurred before EISA became effective, this analysis assumed availability of pre-EISA bulbs at the time of purchase, and used these bulbs as the baseline in calculating incremental costs. To incorporate EISA into calculations of program benefits over time, Cadmus calculated annual savings values for installed bulbs by lumen group and bulb type (specialty and standard) for each year of the bulbs' expected life. Annual savings in years affected by EISA were reduced to reflect the increased baseline.

For example, standard bulbs in the 1,490–2,600 lumen range were attributed one year of full savings, before reducing savings to reflect EISA requirements for the remainder of the measure's life. This assumed that regular incandescent bulbs would be replaced on an annual basis. As specialty bulbs have been excluded from EISA requirements, adjustments were not necessary.

Realization Rates

In its 2011 Annual Report, the Trust reported annual gross savings of 90,351 MWh. Using Cadmus-verified annual gross savings and the Trust's reported savings yielded a 79% gross realization rate for annual savings, with verified gross annual savings lower than reported, primarily due to the reduction in HOU.

[17] 2007 Energy Independence and Security Act. Section 321: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_bills&docid=f:h6enr.txt.pdf

In its 2011 Annual Report, the Trust reported lifetime gross savings of 614,388 MWh. Using Cadmus verified lifetime gross savings and the Trust's reported savings yielded a 107% gross realization rate for lifetime savings. Reported and verified lifetime savings were relatively close, due to trade-offs between EUL and HOU. The Trust used a lower EUL, but a higher HOU. Therefore, lifetime savings were not dramatically affected. Other factors included differences in per-unit savings values and in applications of baseline efficiency adjustments due to EISA.

Comparing the Trust's reported lifetime savings (614,388) to net savings estimated in this evaluation (434,932 MWh), 71% of reported lifetime savings can be attributed to the program. Part of the difference between reported savings and net evaluated savings resulted from application of the NTG factor (0.66) in this analysis.

Table 26 compares major inputs in calculation of lifetime savings in the Trust's 2011 Annual Report and in this evaluation.

Table 26. Comparison of Lifetime Savings in Annual Report and Cadmus Evaluation

Value	Trust Annual Report	Cadmus Evaluation	Realization Rate
Gross Annual MWh Savings*	90,351	71,617	79%
Weighted Average NTG	N/A	66%	
EUL	6.8 years	12.5 years	
Gross Lifetime MWh Savings	614,388	659,088	107%
Net Lifetime MWh Savings	614,388	434,932	71%

*Annual savings in this table have not been adjusted for EISA implementation.

Cost-Effectiveness Analysis

Methodology

Cadmus calculated RLP cost-effectiveness using a modified Total Resource Cost (TRC) test, which serves as an industry-standard metric for evaluating program cost-effectiveness. Outlined in the California Standard Practice Manual,[18] the TRC compares energy savings benefits (avoided costs) to program administrator and customer costs. The Trust uses a modified version of the TRC test when reporting its programs.[19]

Cost-effectiveness assessment using the TRC test involves a valuation of a program's total resource benefits, as measured by electric avoided costs, and its total resource costs, as measure by incremental installed costs and program costs. In applying the TRC, costs and benefits are analyzed in Net Present Value (NPV), which considers program lifetime effects, discounted to their current values. A program can be deemed cost-effective if it has a ratio of total resource benefits to costs greater than 1, calculated as:

---

18 California Public Utilities Commission (CPUC). 2001. *California Standard Practice Manual Economic Analysis of Demand-Side Programs and Projects*. Sacramento, CA: Governor's Office of Planning and Research, State of California.

19 For details of the modified test, see: http://www.efficiencymaine.com/docs/AgencyRules/Chapter%20380.pdf

$$\frac{Total\ Resource\ Benefits}{Total\ Resource\ Costs} \geq 1$$

Where,

$$Total\ Resource\ Benefits = \text{NPV}\left(\sum_{\text{year}=1}^{\text{measure life}}\left(\sum_{\text{i}=1}^{8{,}760}\left(\text{Net Impact}_{\text{i,j}} \times \text{Avoided Cost}_{\text{i,j}}\right)\right)\right)$$

And,

$$Total\ Resource\ Costs = \text{NPV (Net Incremental Measure Costs + Program Administrator Costs)}$$

Data

To calculate the RLP's cost-effectiveness, Cadmus used the verified net savings results, detailed in the previous section and adjusted to account for changing baseline consumption, associated with federally mandated increases (EISA) in standard lighting efficiency.

Cadmus calculated participant cost inputs from retail price information included with sales tracking data provided by the program implementation team, combined with Cadmus baseline research. The resulting total cost differed from that used in the 2011 Annual Report (which utilized deemed incremental cost figures, by wattage, from the 2009 Residential TRM). Incremental costs, calculated from pricing data, were substantially lower than those assumed in the TRM. The average incremental cost based on the TRM assumptions was $4.73, while the incremental cost calculated by Cadmus based on the retail pricing data, and used in the cost-effectiveness analysis for the evaluation, was $1.40.

The Trust provided administrative cost information as well as certain model inputs and assumptions from the cost-benefit model the Trust used for program reporting, as shown in Table 27.

Table 27. Model Inputs and Assumptions

Category	Value
Discount Rate	4.51%
Line Loss	6.50%
2011 Avoided Costs by Fuel	**Value**
Electric Energy, Winter Off Peak ($/kWh)	$0.05
Electric Energy, Winter On Peak ($/kWh)	$0.05
Electric Energy, Summer Off Peak ($/kWh)	$0.04
Electric Energy, Summer On Peak ($/kWh)	$0.05
Electric Demand, Winter ($/KW)	$0.00
Electric Demand, Summer ($/KW)	$52.62
Transmission and Distribution ($/KW)	$80.00

Findings

Table 28 shows TRC results and key ratio components for the RLP in FY 2011. The program easily passed the TRC cost-effectiveness test, with a value of 9.62.

Assessing cost-effectiveness using the TRC involves a valuation of a program's total resource benefits, as measured by electric avoided costs, and its total resource costs, as measured by incremental installed costs and program costs. For the TRC calculation, MWh savings are calculated at the system level (at generation), taking into account line losses (energy lost through transmission and distribution). As noted, lifetime savings have been adjusted to account for increased efficiency of standard residential lighting due to EISA.

Net savings and net costs were the basis for TRC results. Cadmus' impact evaluation served as the basis for savings values and participant net incremental costs. Efficiency Maine provided technical support, marketing, and administrative costs. The inputs and results are shown in Table 28.

Table 28. Cost-Effectiveness Results*

Category	Reported Savings Scenario
Annual Gross MWh Savings (at generation)	76,433
Annual Net MWh Savings (at generation)	50,816
Lifetime Net MWh Savings (at generation)	463,203
Net TRC Benefits	$29,019,675
Participant Net Incremental Costs	$1,715,503
Technical Support Costs	$1,012,534
Marketing Costs	$34,432
Administrative Costs	$254,883
Net TRC Costs	$3,017,352
TRC Ratio	9.62

*As lifetime savings have been adjusted for EISA implementation, they may not directly equal the product of annual savings and the EUL.

In its 2011 Annual Report, the Trust reported a 4.42 TRC. The disparity between the estimates primarily resulted from the Trust using much higher incremental costs in its cost-effectiveness calculations. In addition, the Trust used gross (not net) savings in calculating program benefits.

3. PROCESS EVALUATION

The RLP process evaluation investigated: program delivery structures; implementation processes; participation by retail partners; product incentives; and promotion and marketing strategies.

Data Collection and Sampling

Cadmus' process evaluation of the Trust's lighting program collected data through interviews with program staff and program stakeholders, including program implementers, participating retailers, manufacturers, and residential consumers. Table 29 provides more detail on Cadmus' research and data collection activities.

Table 29. Process Evaluation: Methods for Data Collection

Target Population	Quantity
End-Use Customer Survey for CFL Purchasers	200
End-Use Customer Survey for Appliance Program Participants	41
Intercept Surveys	44
Retailer (Store Managers and Corporate-Level)	5
Manufacturer Interviews	9
Stakeholder Interviews (Trust Staff, APT)	3

Table 30 shows the RLP process evaluation's researchable topics and tasks, along with the tools used to address each question.

Table 30. Process Evaluation Researchable Topics and Indicators

Evaluation Topic	Evaluation Task	Evaluation Tool
Consumer awareness, use, and satisfaction	Evaluate:	Telephone survey, intercept survey, stakeholder, retailer, and manufacturer interview
	Awareness of program	
	Awareness of Efficiency Maine	
	Awareness of CFLs	
	Consumer behavior	
	CFL usage	
	CFL general satisfaction	
Program implementation process	Determine CFLs purchased for business use	Stakeholder, retailer, and manufacturer interview
	Assess retailer and manufacturer satisfaction	
	Gain insights into relationships between stakeholders and participating retailers and manufacturers	
	Review product promotion and marketing strategies	
Planned program changes and enhancements	Understand:	Stakeholder, retailer, and manufacturer interview, program data
	Program changes and enhancements	
	Product mix	
	Lighting technology, trends, and standards changes (EISA)	
	Specialty CFL, LED, and halogen purchases	
Demographic information	Gain insights into program demographics	Telephone survey, intercept survey
	Understand participation of LIHEAP-eligible residents	Telephone survey

Methodology

End-Use Customer Telephone Surveys

Random-Digit-Dial Respondents

Telephone surveys provided the best, unbiased method for understanding residents' perspectives and habits. Cadmus selected RDD Field Services, a survey research firm, to conduct 200 random-digit-dial (RDD) customer surveys across Maine participants and nonparticipants (CFL users and non-users). Under Cadmus' supervision, RDD Field Services used a computer-assisted telephone interviewing system to complete the telephone surveys. Two-hundred residents, located south and west of Orono, Maine, completed the telephone surveys,[20] with each survey call completed in November 2011, and lasting approximately 20 minutes. This report refers to RDD telephone survey respondents as RDD respondents. Since the process evaluation focused on the program's most recent two years, survey questions only covered that period.

The survey instrument examined respondents' attitudes and behaviors regarding CFLs as well as changes in these attributes over the last two years. Survey questions asked respondents about:

- Awareness of energy-saving light bulbs (CFLs, LEDs, and halogens);
- Where they purchased lighting products (CFLs and incandescents);
- Current use and general satisfaction with CFLs;
- Whether they changed lighting use since installing CFLs;
- Storage tendencies;
- Awareness of Efficiency Maine programs; and
- Demographic information.

CFL Giveaway—Appliance Rebate Program Participants

A pilot program, the CFL giveaway to Appliance Rebate Program participants, accounted for a small percentage of overall lighting savings. The Trust provided Cadmus with a list of Appliance Rebate Program participants choosing to receive a free CFL six-pack, along with their appliance rebates. Cadmus randomly selected and contacted residents participating in the program, utilizing the RDD survey instrument. The survey asked these residents about the following issues:

- Satisfaction with CFLs received through the giveaway;
- Whether and where free CFLs had been installed;
- Whether giveaway recipients knew of CFLs before participating; and
- Whether and where giveaway recipients purchased additional CFLs;

[20] The survey targeted this area of Maine to monitor and limit evaluation expenses, travel costs, and drive times for site visits (audits) conducted with a subset of survey respondents.

- Whether giveaway recipients took additional energy-efficiency actions after participating in the program; and
- Familiarity with Efficiency Maine and its programs.

Giveaway recipient surveys provided important insights into installation versus storage rates as well as planned bulb replacement practices.

Intercept Surveys

Cadmus conducted in-store intercept surveys[21] with customers at three participating retailers, completing an average of 15 intercept surveys per store, and collecting data from 44 customers. Table 31 breaks down intercept survey participation by store.

Table 31. Intercept Survey Participation

Store	Location	Participants
Maine Hardware	Portland	15
Home Depot	Portland	15
Wal-Mart	Bangor	14
Total		44

Customer intercept surveys, administered in February 2012, addressed:

- Bulb purchasing patterns;
- Motivations behind purchases;
- Current CFL use and storage rates; and
- Demographics.

Stakeholder Interviews

Cadmus completed three interviews with the Trust and APT, its program implementation contractor, to better understand the program's implementation and strategy. Interviews focused on the following:

- Program history and design;
- Vision and goals;
- Marketing and outreach;
- Target audiences and market partners;
- Participation barriers;
- Effectiveness of administrative processes and program delivery (including quality assurance);
- Data management;

[21] The evaluation defined an intercept survey as: an in-person survey, conducted with customers about to purchase a lighting product (e.g., CFL, incandescent, halogen) at a participating retail location.

- Program challenges; and
- Areas for improvements.

Cadmus completed the interviews in January and February 2012.

Retailer Interviews

Cadmus completed five lighting retailer interviews, which offered additional insights into the program's effect on Maine's lighting market. Cadmus targeted retail store managers at local and corporate levels. Retailer interviews addressed the following issues:

- Retailer motivations for participating in the CFL markdown program;
- Retailer motivations for participating in the CFL coupon program;
- The program's influence on stocking practices (including changes from previous years' levels, and levels prior to the program's inception);
- Retailer pricing decisions;
- Retailer satisfaction and experience with the program;
- Retailer perception of consumer awareness and purchasing patterns; and
- Retailer recommendations for program improvements.

Cadmus conducted five interviews with corporate and store-level employees of local and national retailers participating in the RLP. Table 32 provides additional detail on retailers interviewed through the process evaluation.

Table 32. Retailer Survey Participation

Retailer	Interviewee	Responsibilities	Year Participation Began	Approximate Annual CFL Sales
Big Box #1	Utility Liaison	Setting up and executing rebate programs nationwide	2010	N/A
Local Retailer #1	Inventory Controller	Purchasing/Receiving, store operations	N/A	N/A
Local Retailer #2	General Manager	Purchasing/Receiving, store operations	2005	12,000
Local Retailer #2	Controller	Finances, program paperwork	2005	N/A
Local Retailer #3	Owner	Oversees entire store	2005	1,000

Manufacturer Interviews

Prior to initiating the RLP process evaluation, Cadmus completed interviews with nine CFL manufacturers as part of ongoing research into changes taking place in the lighting market. Interviews included sales trends and changes in manufacturing priorities as EISA takes effect, collecting information on CFL sales trends (programmatic and non-programmatic), on non-CFL bulbs, and non-programmatic factors influencing pricing decisions (e.g., rare-earth prices, macroeconomic trends). This information informed the RLP evaluation at no additional cost to the Trust.

Findings

This section describes Cadmus' process evaluation findings, drawn from the previously outlined research.

Program Implementation

Efficiency Maine has offered the RLP since 2003. The program began with coupons for bulbs and fixtures, adding the markdown component in 2005. In FY 2011, the Trust's first Triennial Plan (covering 2011–2013) guided the RLP. The Triennial Plan set the RLP's FY 2011 energy-savings goal about 80% higher than actual program energy savings in FY 2010. Efficiency Maine adapted and modified the RLP to meet the increased goals.

Markdown Incentive Structure

Retailers participating in RLP markdown program had to accept Efficiency Maine's incentive amounts. None requested decreased incentives. Interviewed retailers indicated the current RLP incentive was effective, and did not conclusively consider a higher incentive more effective. Two of the five retailers interviewed did not believe a higher incentive level would be beneficial or lead to more CFL sales. Two other retailers thought a higher incentive level would lead to more bulb sales and be more helpful to customers. The remaining retailer (and two others) thought that, if the incentive increased enough to drop the sales price below a certain level, customers would hoard CFLs, not effectively achieving energy savings.[22]

Program Design

Markdown Program vs. Coupon Program

Participating retailers preferred the markdown program due to its simplicity and speed, both to retailers and customers. Retailers participating in the markdown program found it efficient and successful. Store managers favored the program, and maintained positive relationships with APT and Efficiency Maine. "It's a win-win for everyone, really," one store manager said.

All retailers interviewed preferred a markdown over a coupon. A few of the interviewed retailers who had previously participated in the markdown program had changed to the coupon program at the request of Efficiency Maine, but wanted to return to the markdown program.[23] Those remaining on the coupon program wanted to join the markdown program, but did not always have a point-of-sale computing system sophisticated enough to accommodate the markdown program's requirements (reporting sales by store or SKU, and prices associated with each purchase).

[22] Increased incentive levels could drop CFLs' ultimate retail price below the product's wholesale price, which would negatively affect companies' revenue figures. If the ultimate retail price fell below the wholesale price, transactions would result in revenue losses as the incentive amount would not count toward revenue (i.e., a product's retail price would be less than a product's wholesale/purchased price). This accounting difference would decrease many companies' profit margins, presenting a disincentive for their participation.

[23] APT requires all MOUs specify per-product and SKU incentive amounts, and quantities allocated to each retailer. In 2010, Efficiency Maine and APT terminated a two-party MOU, covering about 100 retailers as it did not meet APT's requirements, thus placing all affected retailers on the coupon program.

Retailers who were able to create the point-of-sale transaction (a necessary prerequisite for participation in the markdown program) noted that it could be set up easily. Most retailers built incentive markdowns into prices when scanned; others applied discounts manually at the register.

Retailers reported customers preferred the automatic markdown, which did not require them to fill out coupons. The markdown program also did not require retailers to mail in physical coupons, which could be confusing to track or otherwise document. The markdown allowed for easier bookkeeping.

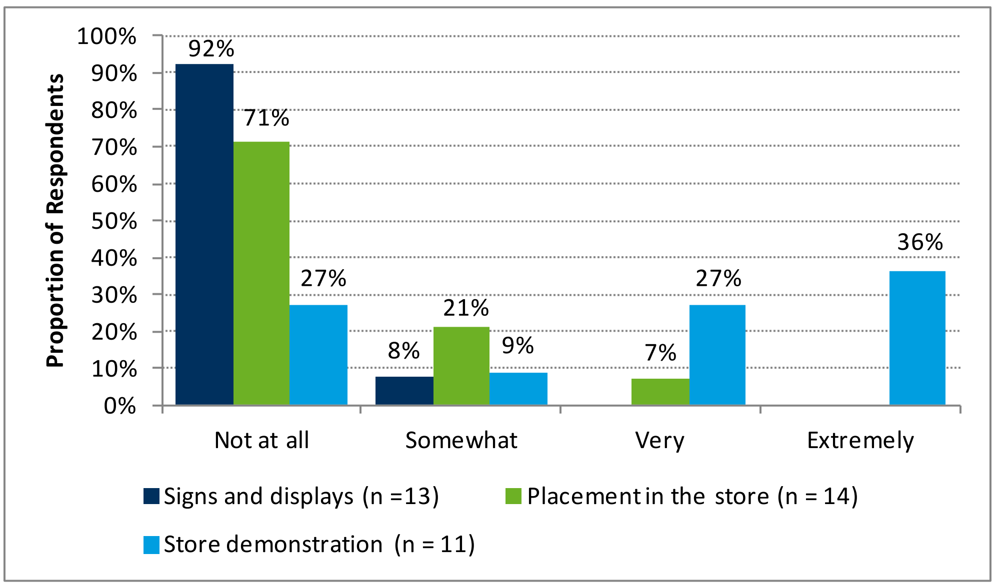
Retailers switching from the coupon to markdown reported requiring about 50% more shelf space for CFLs after the switch, due to increased demand. One retailer, participating in the markdown program for a time, but transitioning back to the coupon program in June 2011, reported a decline in CFL sales following the transition.

Program Marketing

Influencing Factors

Intercept survey participants purchasing CFLs (n=17) cited store demonstrations or sales associates as more influential on their purchasing decisions than point-of-purchase (POP) displays or CFL placements in stores, as shown in Figure 22.

Figure 22. Influence of Marketing on Decision to Purchase CFLs

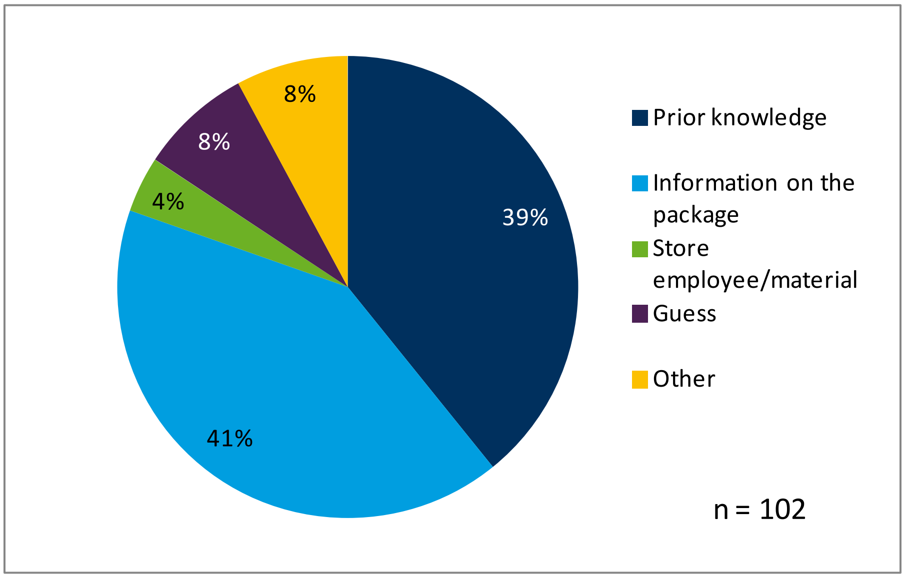


Note that, while intercept survey respondents discounted POPs and store locations, RLP program staff reported sales only increased dramatically after the program increased POP and worked with stores to place CFLs on aisle end-caps.

Selecting Wattage

The RDD survey asked residents how they chose CFL wattages for purchase. Figure 23 shows methods RDD respondents reported using to determine appropriate wattages. Though a large proportion relied on prior knowledge, 45% either relied on packaging or store-supplied information.

Figure 23. How Respondents Determine CFL Wattages to Purchase, RDD Survey



Marketing Technique

Advertising

At one point, the RLP CFL incentive offered about $1.00 per bulb. Concurrently, Efficiency Maine spent about $0.50 per bulb on a television advertising promotional campaign. Program management staff believed it would be difficult to influence CFL store purchases through in-home television commercials, given lighting does not represent a major purchasing decision. Management expressed concerns that the television campaign proved neither cost-effective nor drove sales needed to meet the program's higher goals.

To increase CFL sales during FY 2011, Efficiency Maine chose to move program funds from television advertising into incentive dollars; eventually eliminating TV advertising. The program using money saved to increase the CFL incentive by 25%, from $1.00 to $1.25 per bulb, bringing CFL prices in line with (and, in some cases, making them lower than) traditional incandescent bulb prices. Higher incentives translated into lower CFL prices as well as reduced administrative dollars per bulb sold.

However, the funding shift from television advertisements to incentives decreased the RLP program's marketing effort to residents. While some program staff maintained reservations about changing methods for program promotion, they recognized they could not meet program goals without adjustments and innovation. Other staff did not express reservations about eliminating television advertising because it allowed Efficiency Maine could focus on additional sales of CFLs.

While the elimination of television advertising lead to a decrease in the customer-facing aspect of the program, the Trust and APT moved the television advertising money not set aside for incentives to in-store promotions, helping to maintain the program's presence in stores. After this adjustment to incentive levels and in-store promotion, CFL sales increased. Per stakeholders, the change proved: "spectacularly successful"; further, reducing high-cost television advertising did not result in negative sales impacts.

In-Store Education

APT field work produced RLP's primary marketing and outreach. APT's field staff regularly visited all participating retailers, which reported appreciating APT's appearances in the stores. Program staff believed this implementation strategy aspect proved critical for a successful program as it helped retailers and customers better understand the program and methods for participation.

POP Materials

APT's field staff placed POP materials on qualified products, and maintained POP's proper placement and physical quality (precluding shop-worn materials). The POP material included signs and stickers highlighting CFL prices discounted by Efficiency Maine (as shown in Figure 24).

Figure 24. In-Store POP Example

APT established MOUs with retailers, specifying APT staff would visit stores to put up POP materials. BJ's, Sam's Club, and Big Lots all have used additional POP materials negotiated with manufacturers.

Most retailers did not promote the program independently, but used material provided by Efficiency Maine and APT. Some independent retailers, however, decided to develop their own educational and marketing materials, including signage further highlighting discounted prices and attributing discounts to Efficiency Maine. Those retailers believed their additional signage increased CFL sales. All retailers interviewed indicated they preferred signage better highlighting RLP discounts.

In-Store Consumer Training

APT field staff offered in-store training for consumers, varying from small gatherings of store personnel and consumers to one-on-one training between an APT field representative and a customer. At in-store events, APT staff discussed different technologies and answered customers' questions.

In-store training usually included store displays, showing different RLP lighting products, and comparing lumen outputs, colors, temperatures, electricity usage, and styles. APT also provided additional written information to customers attending these events.

One retailer maintained a permanent CFL display, showing color rendering indexes (CRI) and lamp lumen output levels to educate customers about differing technologies. The retailer attributed some sales to this display. Cadmus' intercept survey results confirmed in-store demonstrations helped customers decide types of light bulbs to purchase.

Sales Associate Training

Cadmus' customer intercept survey found sales associates played an important role in consumers' decisions about types of light bulbs to purchase. The RLP did not have a retailer training manual, but APT offered a comprehensive training program to retailers and sales associates. APT field staff taught and trained store associates and department leads about: the RLP program; why Efficiency Maine offered discounts; and which lighting products qualified. As most of APT's training modules took five minutes or less, store associates could be trained incrementally, over a number of store visits. APT also encouraged its field staff to attend store meetings, soliciting program feedback from sales staff, and ensuring the program remained in the forefront of sales associates' minds when speaking with customers. Program staff would like sales associates to act as RLP sales representatives by discussing CFLs' energy and technology benefits with customers.

Some independent retailers expanded APT's training by providing their own training to sales associates, who then were expected to educate consumers about different lighting technologies. All retailers interviewed reported their sales associates had been educated about CFLs, either by the store managers, manufacturers, or APT representatives.

Off-Shelf Merchandizing

When Efficiency Maine ended its television advertising, the program began to place a greater emphasis on CFL positioning within stores. APT worked with retailers to offer CFLs on end caps for longer times. An end cap would be a prime product shelving location, or prime retail space (generally at the end of a product aisle, on a main thoroughfare within the store). Figure 25 shows an end cap in a participating store.

Figure 25. End Cap Example

Interested parties usually must pay to have their products featured on end caps, but the RLP could secure free end caps by increasing incentives offered on bulbs (leading to lower prices), and promising increased sales. When implemented, end cap promotions dramatically increased CFL sales.

Program retailers did not originally believe increased incentives would impact sales to such an extent, but many ran out of light bulbs after advertising less expensive CFLs on end caps. The program increased its credibility with retailers as RLP staff predicted higher sales. The stores increasingly paid greater attention to APT's advice regarding CFL stocking and merchandising, and offered additional free end caps to the RLP program.

Per RLP staff, the revised marketing strategy placed more bulbs into Maine homes and sockets with the program's lowest-ever, per-bulb cost. Program staff described this strategy as a *"perfect storm."* They indicated lowering bulb prices or putting bulbs on end caps independently would not have achieved the same success as that seen when employing both strategies simultaneously.

Through retailer interviews, Cadmus learned one retailer placed discounted CFLs on a permanent end cap, ensuring continued high CFL sales. Slightly more than one-quarter of intercept survey respondents told Cadmus they found end cap store placements effective.

Other Retailer Promotional Efforts

Other successful RLP promotional efforts included:

- Placing advertisements about CFLs in a store's flyers or circulars;
- Highlighting the RLP discount on a receipt or invoice customers receive after purchasing a qualifying bulb;

- Highlighting Efficiency Maine provided the discount; and
- Using the phrase “instant savings” in the store-specific POP.

Program Management

Efficiency Maine did not communicate directly with retailers or manufacturers. Rather, APT facilitated those relationships on the Trust’s behalf. After the RLP established the markdown option, APT coordinated and negotiated with manufactures and retailers to provide the required sales reports.

Efficiency Maine and APT reviewed lighting and appliance program statistics regularly, with Efficiency Maine receiving a weekly report from APT, showing RLP progress. APT also sent a monthly field report, which outlined: APT and program updates; markdowns in place; numbers of bulbs reported through each markdown; numbers of site visits conducted; and amounts of training taking place. Field reports provided a snapshot of information field representatives collected in stores during their weekly visits.

The full APT/Efficiency Maine team met once per quarter for program performance strategy reviews, examining current sales rates, with APT offering recommendations about whether to change, add, or remove any MOUs. APT also recommended money amounts Efficiency Maine should allocate toward each program delivery channel.

RLP Program Support

Cadmus asked retailers about feedback received from APT. All interviewed reported receiving appropriate program support levels. APT field representatives helped with all program areas, going so far as to show retailers how to run reports necessary for maintaining compliance with Efficiency Maine’s data requests. Retailer staffs reported timely communications with APT and Efficiency Maine. One store retailer described APT as: “very helpful and supportive during store visits.”

While markdown retailers expressed pleasure with the program, coupon retailers described APT’s support as: “inconsistent and sometimes inadequate.” One retailer complained their staff did not receive training, and noted APT visited every other month or so.

Some retailers wanted APT to better understand their internal implementation cycles and timelines. As retailers may require several business days to make pricing and SKU changes, they wanted APT’s field staff to allow sufficient time for retailers and their systems to adjust and incorporate program changes.

Retailer Satisfaction

All interviewed retailers expressed satisfaction with the RLP, reporting they joining the program to increase CFL sales—a goal all had met.

Retailers reported minimal problems associated with RLP participation. All retailers participating in the markdown program did not find it challenging to set up the MOUs and start markdown programs, and each could adapt to subsequent program changes. All retailers participating in the coupon program experienced much lower sales volumes (around one to two bulbs per day), but did not report frustrations with the coupon program—only their desire to participate in the markdown program. All retailers interviewed indicated the program met their expectations, and they planned to continue participation.

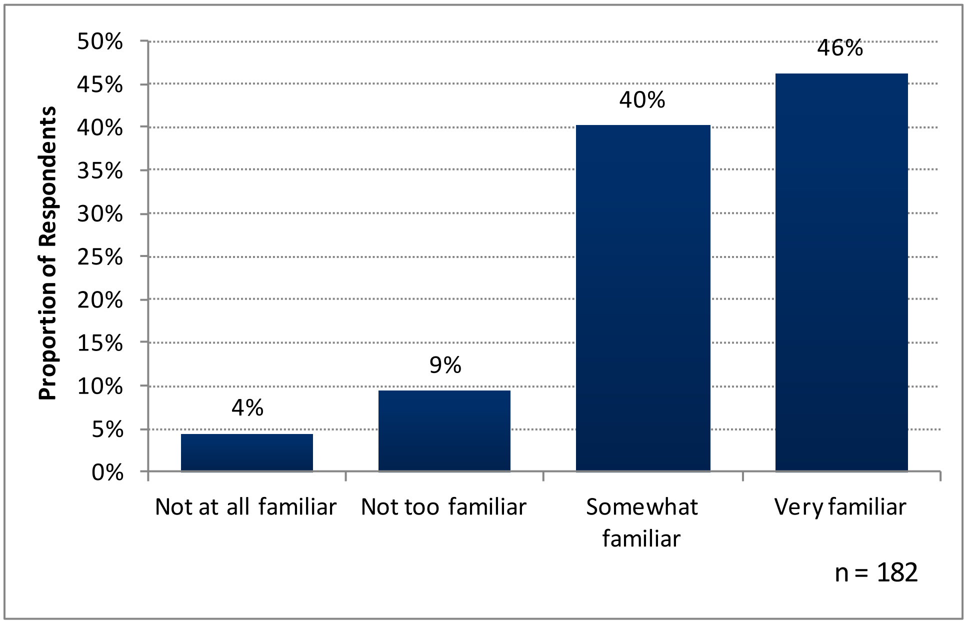
Program and Bulb Awareness

CFL Awareness

Cadmus assessed the program implementation strategy's overall effect on consumer awareness for both CFLs and the RLP.

In 2011, 93% of RDD respondents surveyed reported knowing of CFLs. Even after the survey interviewer described their shape and function, 4% of customers reported unfamiliarity with CFLs. Surveys asked respondents aware of CFLs to rank their awareness levels. As shown in Figure 26, most of these respondents (86%) had some familiarity with CFLs. The 2007 RLP evaluation reported 85% of all surveyed residents expressed familiarity with CFL bulbs after being read a description.[24]

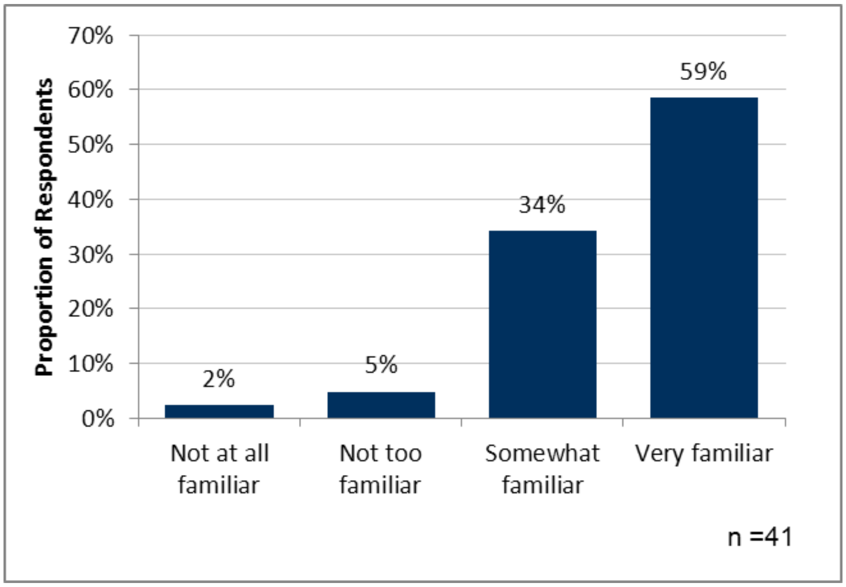
Figure 26. RDD Survey Respondent Familiarity with CFLs



Surveys also asked Appliance Rebate Program CFL giveaway respondents about their familiarity with CFLs. As shown in Figure 27, more than 90% of giveaway respondents interviewed expressed at least some familiarity with CFLs (even though, considering all giveaway respondents received a free CFL six-pack, one would expect 100% would express some familiarity with the technology).

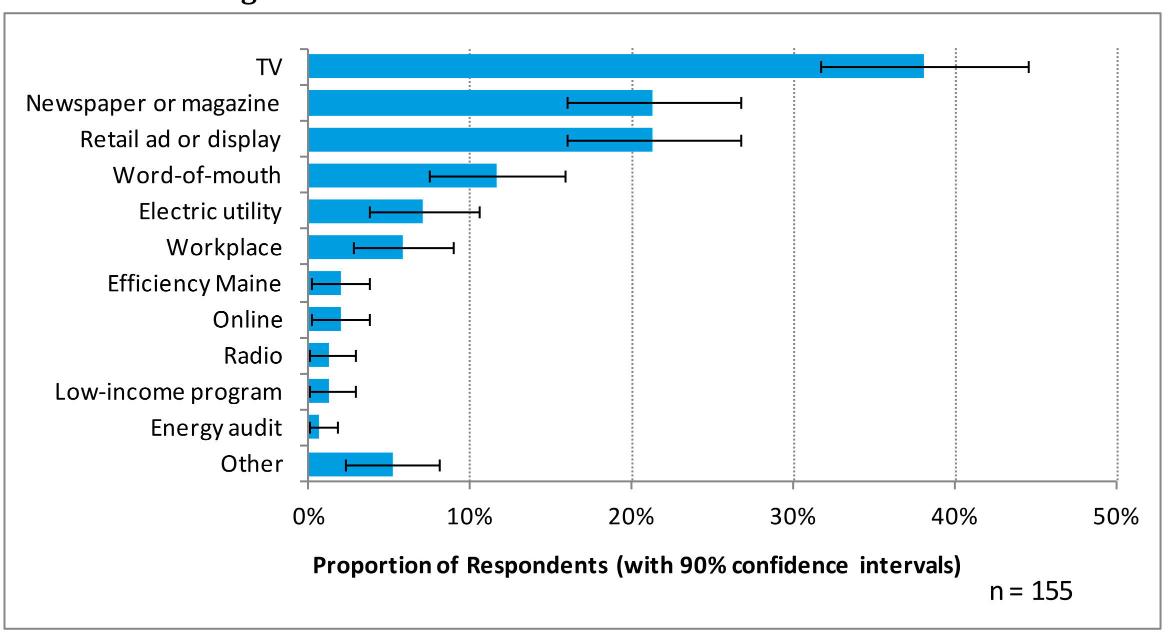
[24] NMR Group, Inc. April 2007. *Process and Impact Evaluation of the Efficiency Maine Lighting Program*.

Figure 27. Giveaway Respondent Familiarity with CFLs



As shown in Figure 28, 38% of respondents reported they first learned about CFLs through an advertisement or story on television. While RLP television advertising ended nearly two years ago, this figure suggests viewers remembered the advertisements. Other awareness sources included: newspapers and magazines (21%); retail store displays or advertisements (21%); and friends or family members (12%).

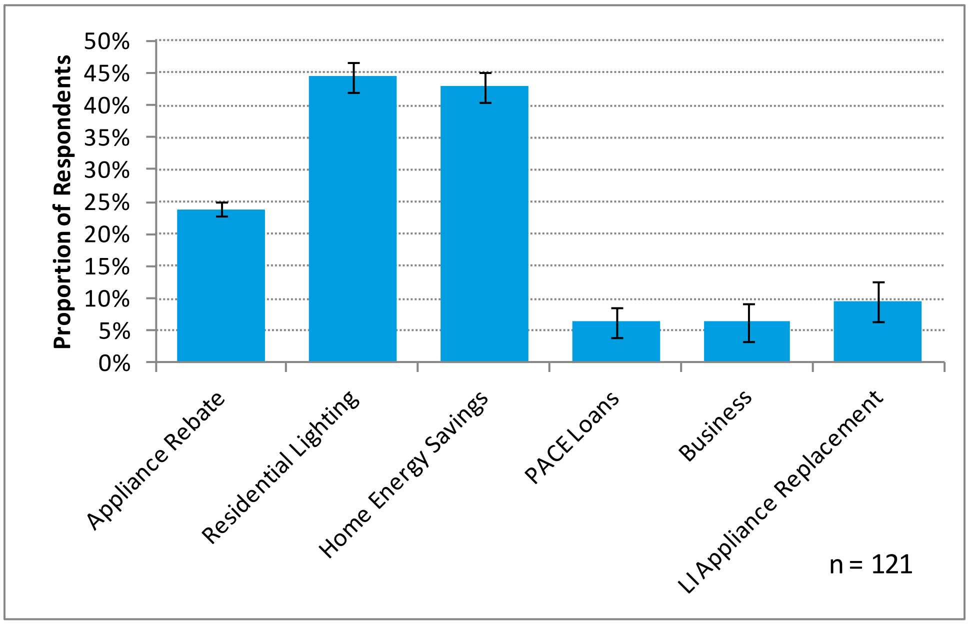
Figure 28. How Customers First Learned About CFLs



Efficiency Maine Program Awareness

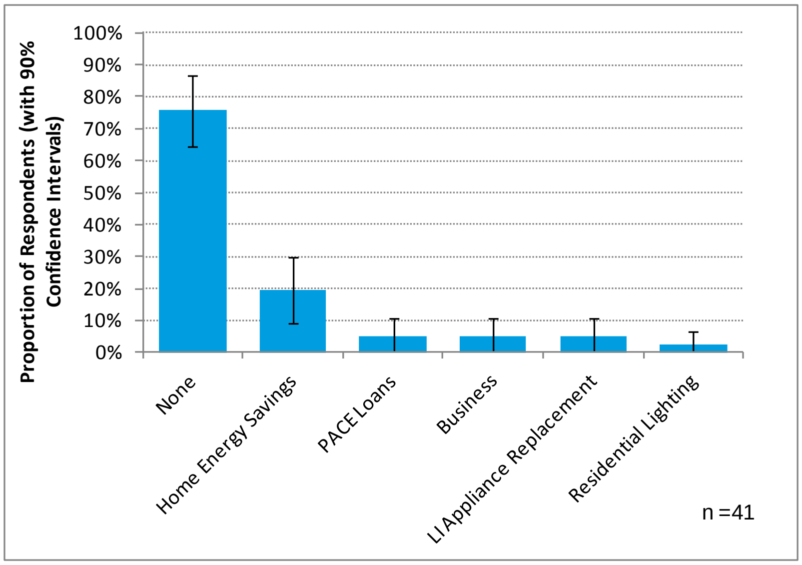
After being introduced to Efficiency Maine and its goals, approximately 71% of RDD respondents said they knew of the organization. When asked to name specific programs Efficiency Maine offered, over one-half named: the RLP; the Home Energy Savings Program; or both (as shown in Figure 29). One in four RDD survey respondents knew of the Appliance Rebate Program.

Figure 29. General Awareness of Efficiency Maine Programs



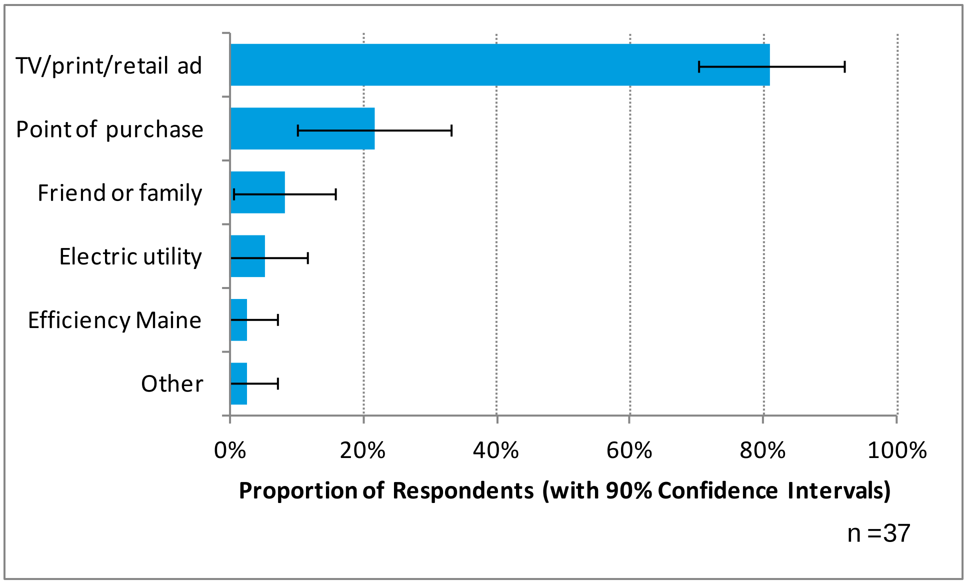
Few giveaway respondents knew of other Efficiency Maine Programs (aside from the Appliance Rebate Program). Figure 30 shows 75% of giveaway respondents had not heard of other programs, while 19% knew of the Home Energy Savings Program.

Figure 30. Giveaway Respondent Awareness of Other Programs



Giveaway respondents first reported learning about the Appliance Rebate Program (and then the CFL giveaway) through retail, television, or print advertisements, as shown in Figure 31. Only one respondent learned of the Appliance Rebate Program through Efficiency Maine.

Figure 31. How Giveaway Respondents Learned of the Appliance Rebate Program

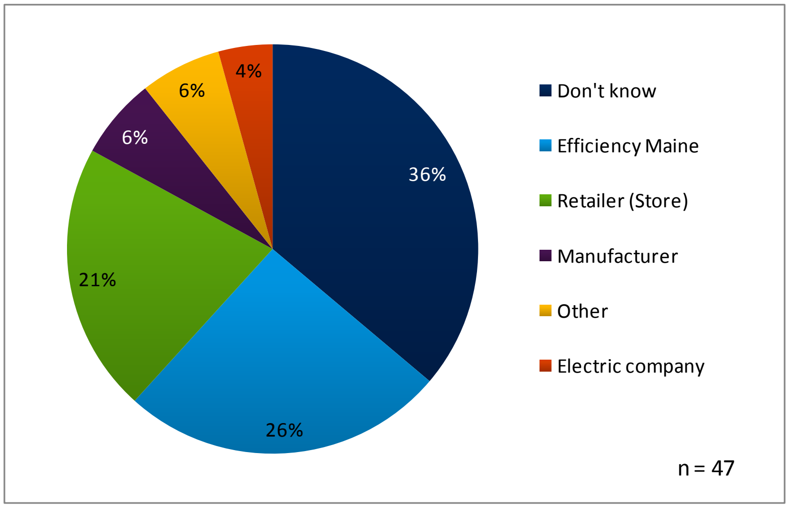


Many retailers learned of the program through APT field staff or through existing relationships with APT. When other store managers or corporate-level employees stepped into their current roles, the program had already been put in place.

Awareness of Incentives

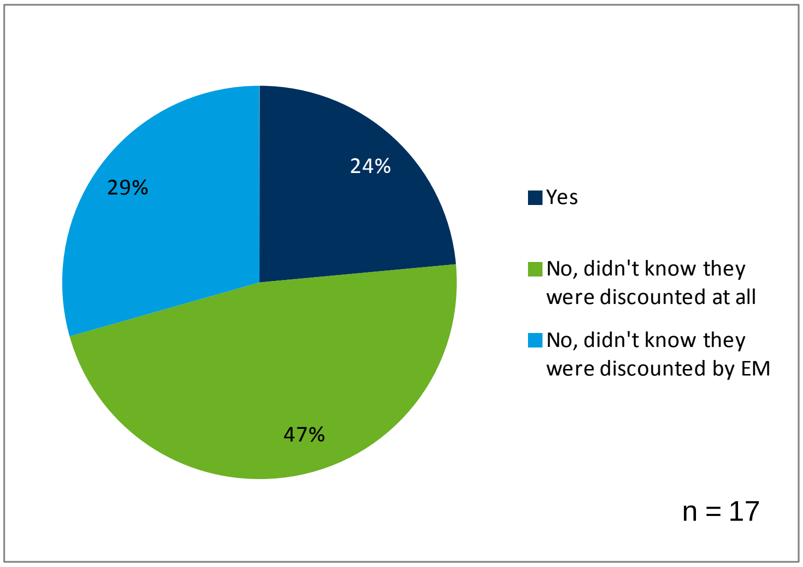
The majority (61%) of RDD respondents purchasing CFLs in the past two years said they did not know of discounts, markdowns, or coupons offered on those bulbs. Figure 32 shows respondents' reported sources of incentive information. Over one-third (36%) could not be sure who provided the incentives; about one-fourth (26%) knew Efficiency Maine provided it.

Figure 32. RDD Respondents: Who Provided the Incentive?



As shown in Figure 33, only 24% of intercept survey respondents knew Efficiency Maine discounted CFL bulbs in stores, while 47% did not know of discounting. Of 10 intercept survey respondents saying they knew Efficiency Maine offered discounted CFLs before entering the store, six knew they could find Efficiency Maine discounted CFLs at the exact store they visited.

Figure 33. Intercept Respondents' Awareness of Discounts/Incentives



As noted, low reported RLP awareness levels may have resulted from removal of marketing campaigns, targeted to educate consumers about the program and product.

Bulb Use and Purchasing

Purchasing Patterns and History

CFL Purchasing Patterns

As shown in Figure 34, 81% of RDD respondents reported previously purchasing CFLs, and 64% had purchased CFLs within the past two years.

Figure 34. CFL Purchasing History

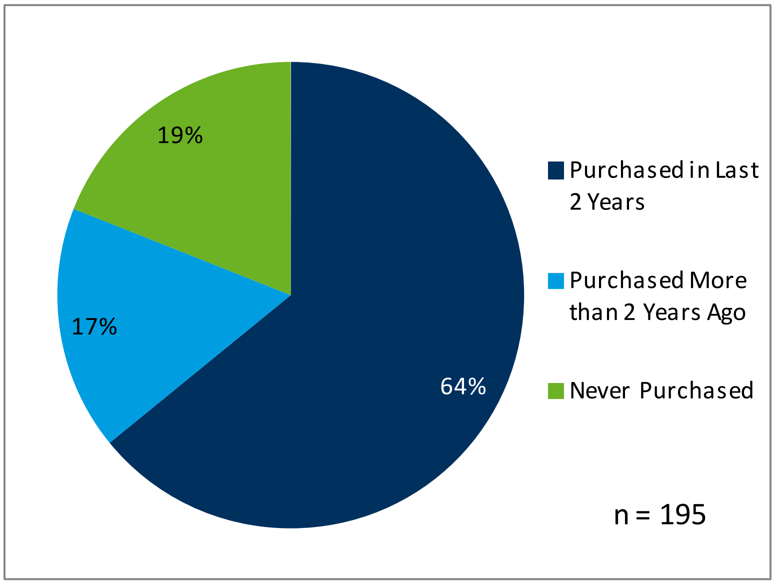
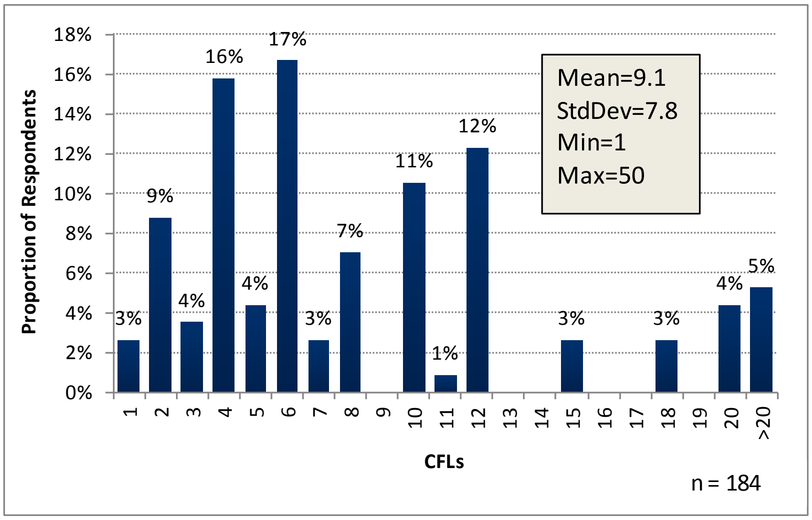


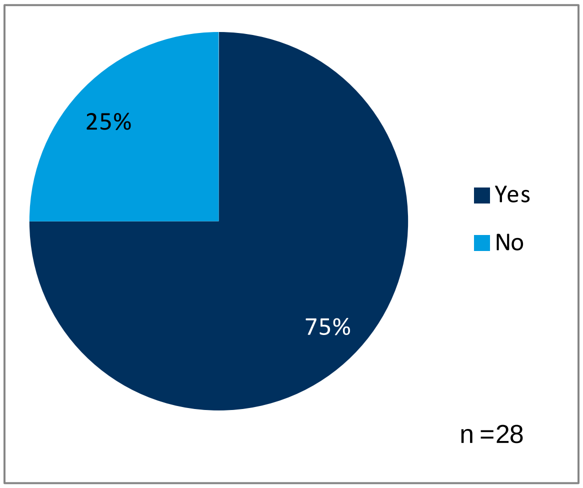
Figure 35 shows distributions of CFLs purchased per RDD respondent household in the last two years. Number varied considerably (ranging from 1 to 50), with an average of 9.1 bulbs per household.

Figure 35. Distribution of CFLs Purchased in Last Two Years



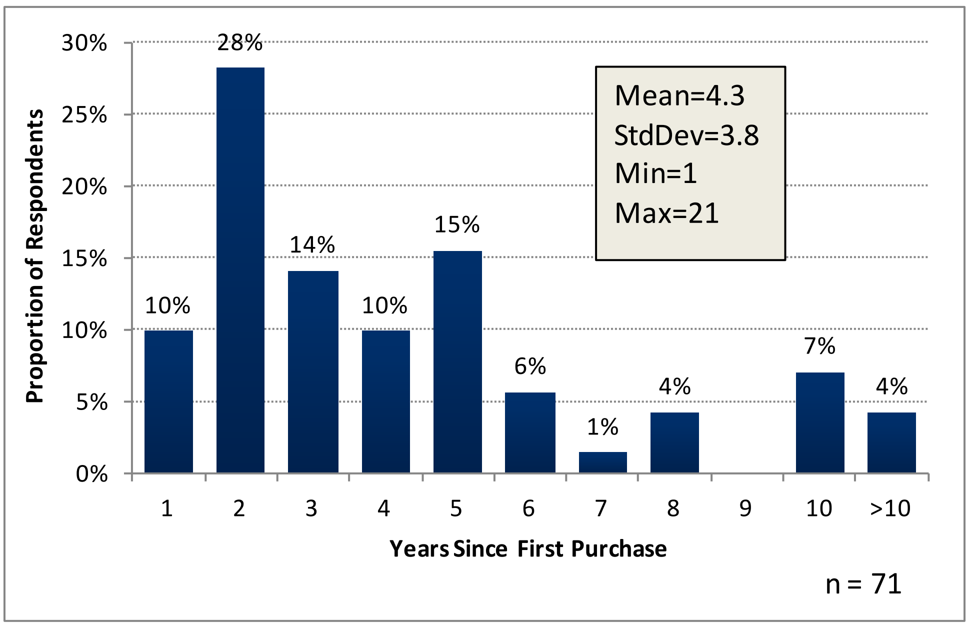
As shown in Figure 36, 75% of giveaway respondents purchased a CFL in the past two years, in addition to receiving a free six-pack of CFLs.

Figure 36. Giveaway Respondents who Purchased CFLs in the Past Two Years



As shown in Figure 37, most RDD survey respondents previously purchasing CFLs bought their first CFL between one and five years ago, with approximately 70% falling within that range; 11% reported purchasing their first CFL 10 or more years ago.

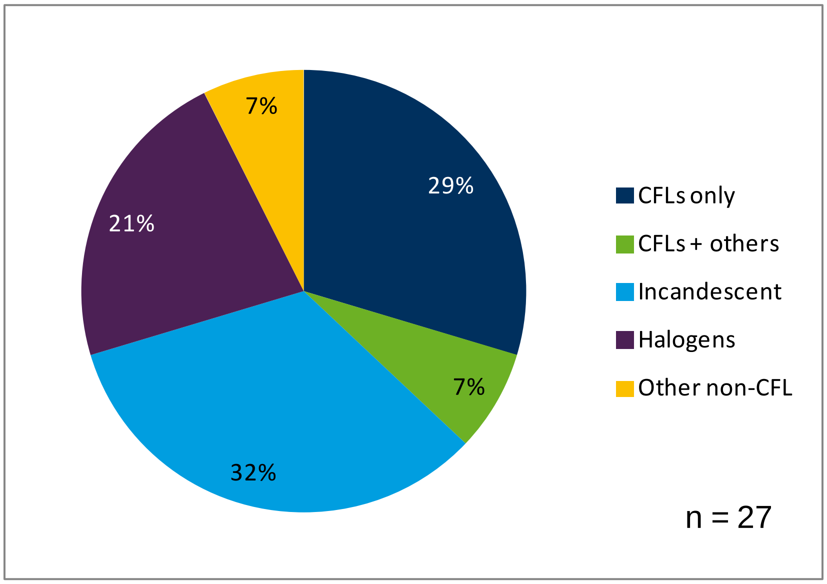
Figure 37. Years Purchasing CFLs



Purchasing Behaviors

The intercept survey recorded information about customers exiting stores with some type of lighting purchase, including CFLs. Figure 38 shows purchases split between CFLs (36%), incandescent lights (32%), and halogen lights (21%). Some light bulb types, such as LEDs fell into the "other" category.

Figure 38. Types of Bulbs Purchased

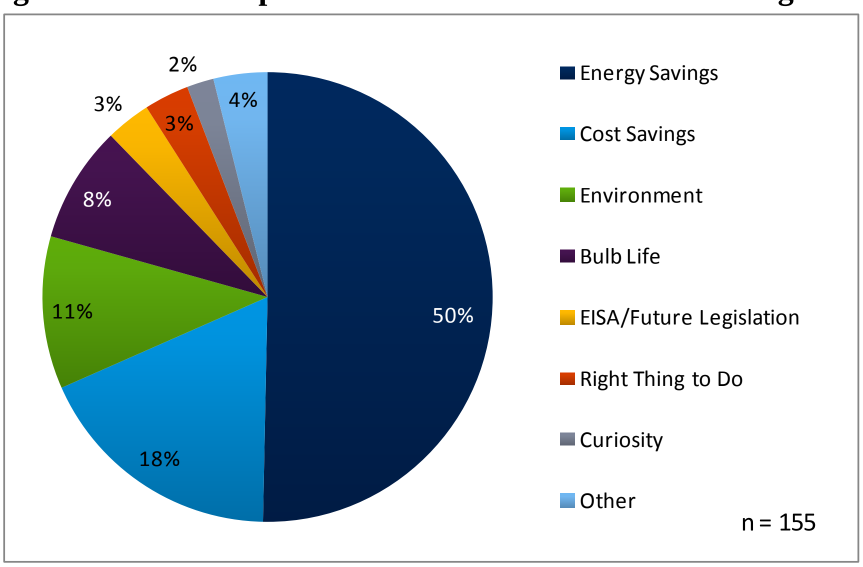


Of 17 intercept respondents purchasing incandescent lights, three could not specify why they chose them over CFLs. Nine others offered reasons: eight said they needed a specialty bulb (a three-way or a dimmable). Five did not like the color of CFLs.

Eleven intercept respondents purchasing incandescent bulbs reported purchasing (or having been given) CFLs in the past.

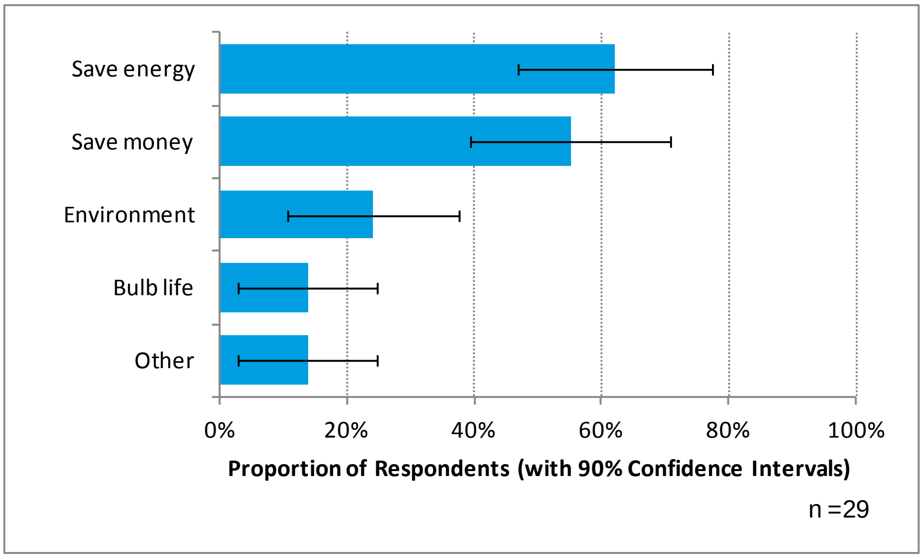
The RDD survey asked respondents why they purchased CFLs. Of RDD respondents purchasing CFLs, 50% said they chose to purchase the models to save energy, while 18% wanted to save money. As shown in Figure 39, other reasons for purchasing CFLs included: a desire to help the environment (11%); and CFLs' longer lifetimes (8%).

Figure 39. RDD Respondents' Main Reason for Purchasing CFLs



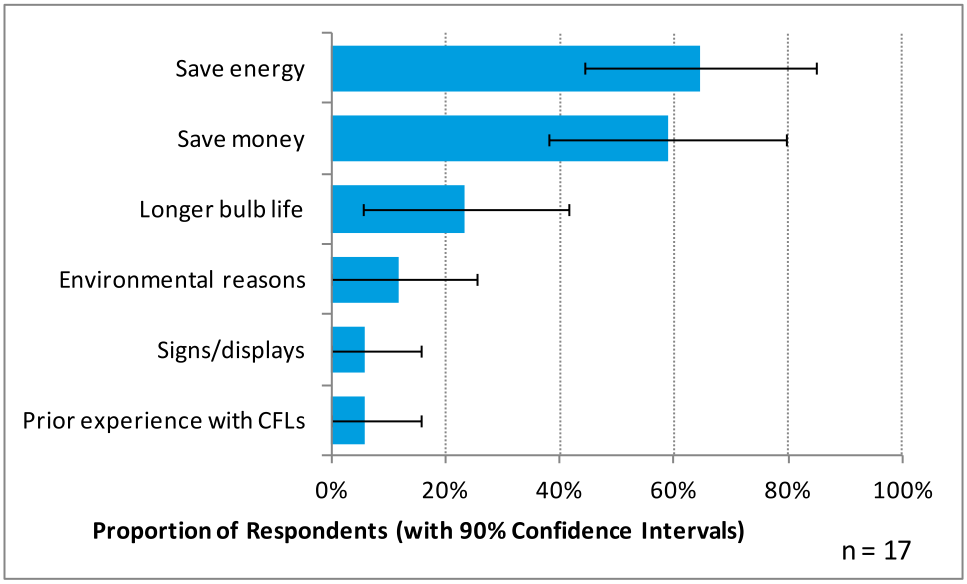
As shown in Figure 40, giveaway respondents offered several reasons for requesting free CFLs, including (in order of importance): saving energy; saving money; environmental benefits; and longer bulb lifetime.

Figure 40. Giveaway Respondents' Reasons for Requesting Free CFLs



As shown in Figure 41, intercept survey respondents bought CFLs for two, top reasons: saving energy and money (10 and 11 respondents, respectively).

Figure 41. Intercept Respondents' Reasons for Purchasing CFLs



Retailers considered CFLs' energy efficiency a huge selling point, and considered RLP incentives, which make CFLs price-competitive with incandescent light bulbs, another reason customers bought more CFLs.

Overall, retailers found the following CFL bulb qualities important and influential for customers (in no particular order):

- Application: how the bulb will be used?
- Dimmable/three-way requirements.
- Energy conservation.
- Bulb brightness.
- Speed at which the light turns on and reaches full light output.
- Physical appearance.
- Bulb life.
- Proper disposal/mercury concerns.

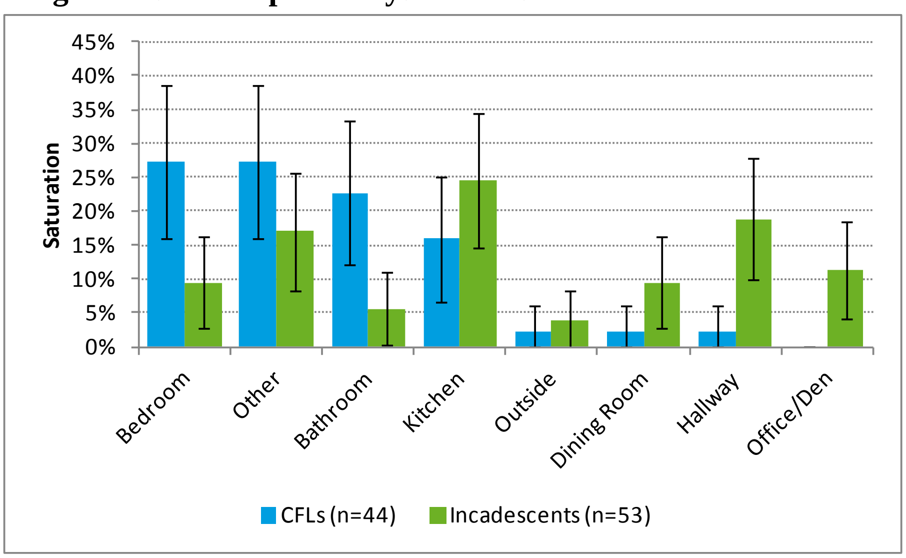
All intercept respondents concurred that they primarily purchased CFLs to save energy and money. Retailers agreed with these two motivations. The longer bulb life and environmental benefits proved to be secondary motivations.

Product Installation Patterns

CFL vs. Incandescent Saturations

On average, intercept survey respondents purchased seven CFLs visits to stores, with approximately one in three purchasing four. All CFL purchasers except one planned on installing CFLs in their homes, with the other planning to install them in a business. Figure 42 shows intercept survey respondents proved much more likely to install incandescent lights in common areas, such as dining rooms and offices, and to use CFLs in low-use rooms, such as bedrooms or bathrooms.

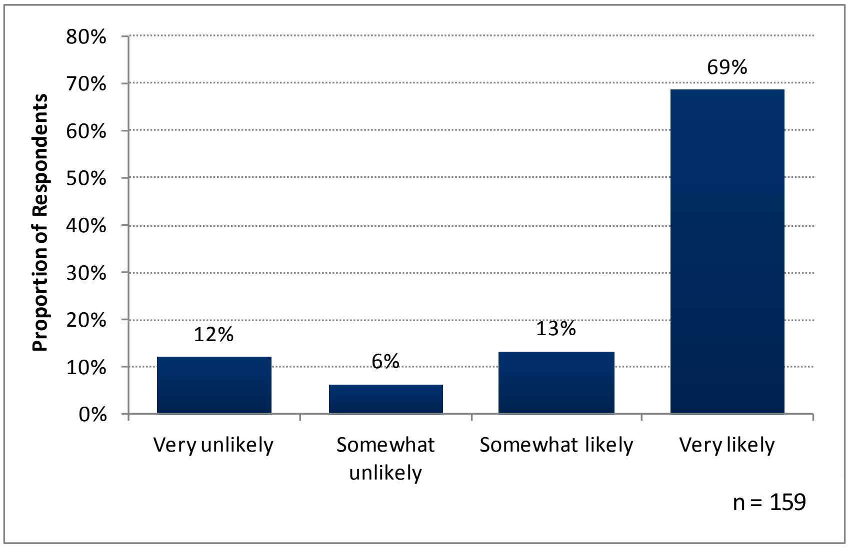
Figure 42. Intercept Survey: CFL vs. Incandescent Saturations



CFL Removal and Replacement

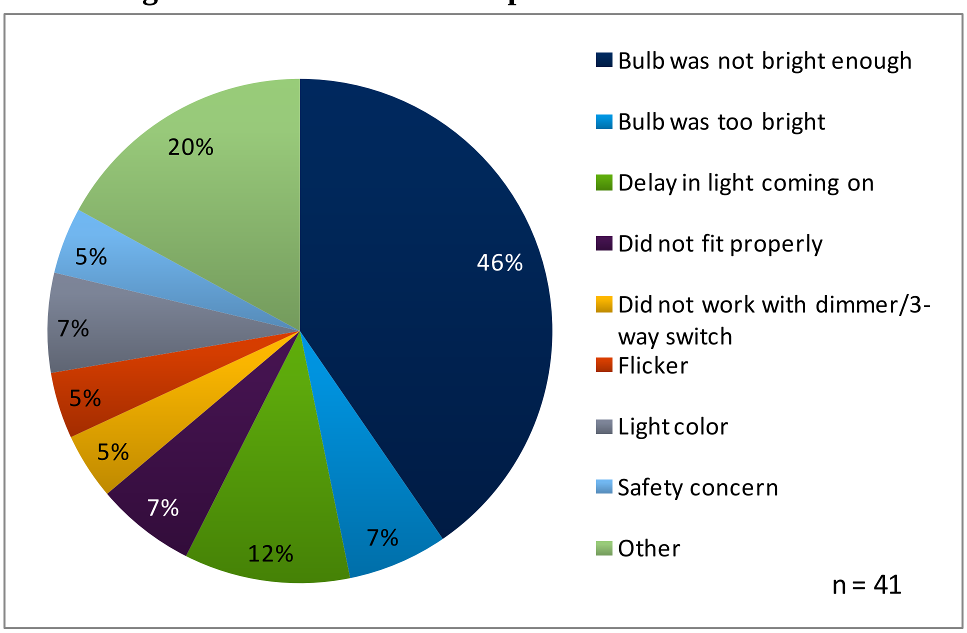
A large majority of respondents (82%) reported being somewhat to very likely to replace a burned-out CFL with a new one, as shown in Figure 43, with 18% unlikely to replace a burned-out CFL bulb with another CFL.

Figure 43. Likelihood of Replacing Burned-Out Bulb with CFL



As shown in Figure 44, 26% of RDD respondents (roughly one in four) removed a working CFL. When asked why they did so, most removed the bulb due to insufficient brightness. Other reasons included: delays in light coming on (12%); excess brightness (7%); poor fit (7%); and dislike of the light color (7%).

Figure 44. Reasons RDD Respondents Removed CFLs



"Other" responses included:

- *"They were made in China."*

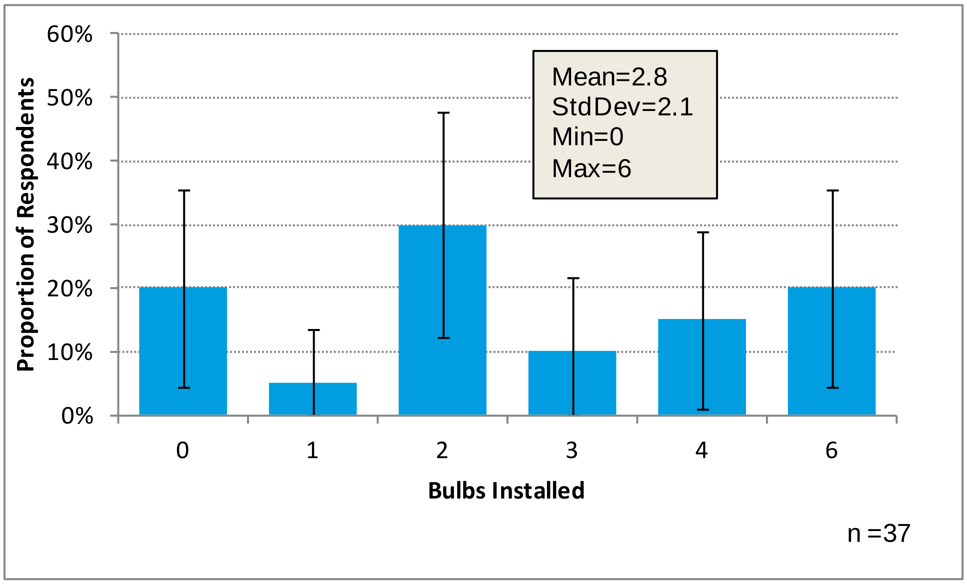
- *"Temperature was too cold for the CFL to work properly."*
- *"Buzzed when they were getting low."*

Storage Rates

RDD survey respondents reported approximately 28% of their CFLs (or 2.6 of 9.1 bulbs, on average) remained in storage, with the other 72% installed at some time.[25] These self-reported numbers consistently reflected Cadmus' site visit findings that 73% of CFLs purchased remained in service (installed).[26]

Figure 45 shows bulbs installed by customers receiving free CFL six-packs through the Appliance Rebate Program: 20% respondents did not install any bulbs, while another 20% installed all six. Thirty percent of respondents installed two CFLs.

Figure 45. Giveaway Respondents: Number of Bulbs Installed



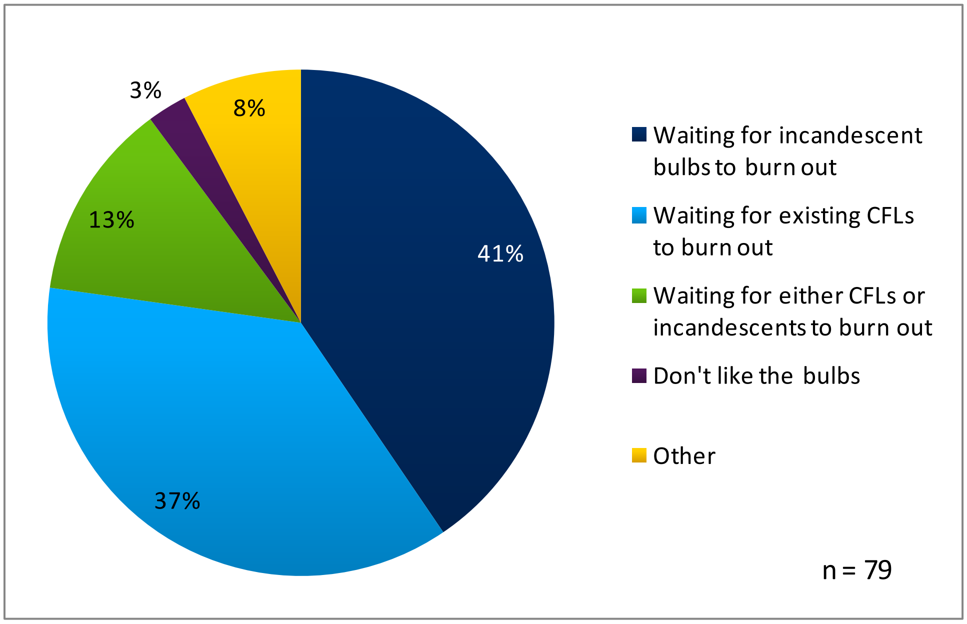
Intercept survey respondents reported they would install, on average: 5.5 of CFLs they purchased within the next 30 days, with an average of 1.5 CFLs going into storage, for an installation rate of 79%.

25 These may have been removed later due to product failure.

26 Findings cannot be said to differ with 90% confidence.

Surveys asked RDD respondents why they would store CFLs. As shown in Figure 46, most respondents claimed they placed CFL bulbs in storage while waiting for burn outs of their incandescent bulbs (41%), CFLs (37%), or both (13%) before replacing them with newly purchased CFLs.

Figure 46. Reason for Storing Bulbs



CFL Sales and Stocking Patterns

CFL Sales

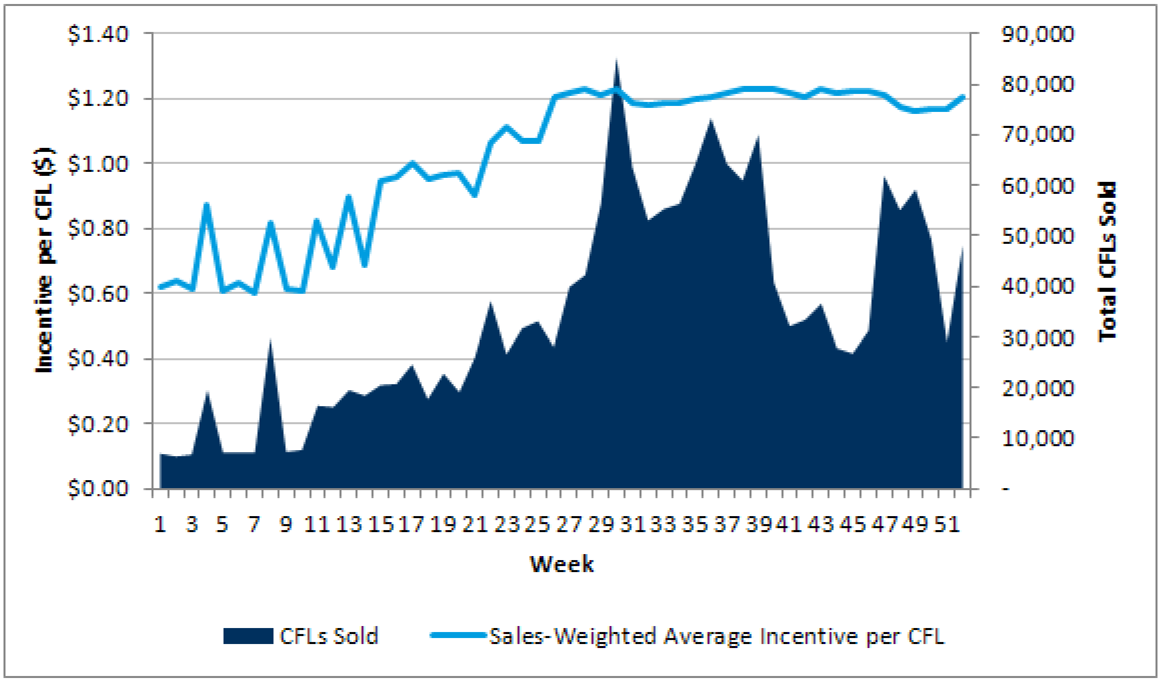
All interviewed retailers joined the program as they thought it a useful way to increase CFL sales. When the program started, retailers wanted to keep pace with consumer demand, given the heightened interest in CFLs. The Environmental Protection Agency (EPA) and manufacturers also promoted CFLs to retailers around 2007 and 2008, helping raise retailer interest and encourage participation.

Retailers unanimously indicated the RLP helped them sell more CFL bulbs. Several reasons, however, make quantitatively confirming those sentiments somewhat difficult:

- First, many retailers did not have robust tracking systems in place prior to participating in the Efficiency Maine RLP; so they could not track sales changes attributable to the program.
- Second, as the RLP began around the time CFLs were introduced in many retail outlets, retailers could not independently assess any jumps in sales attributable to the program. However, both coupon retailers and markdown retailers indicated seeing CFL sales increase due to the program.

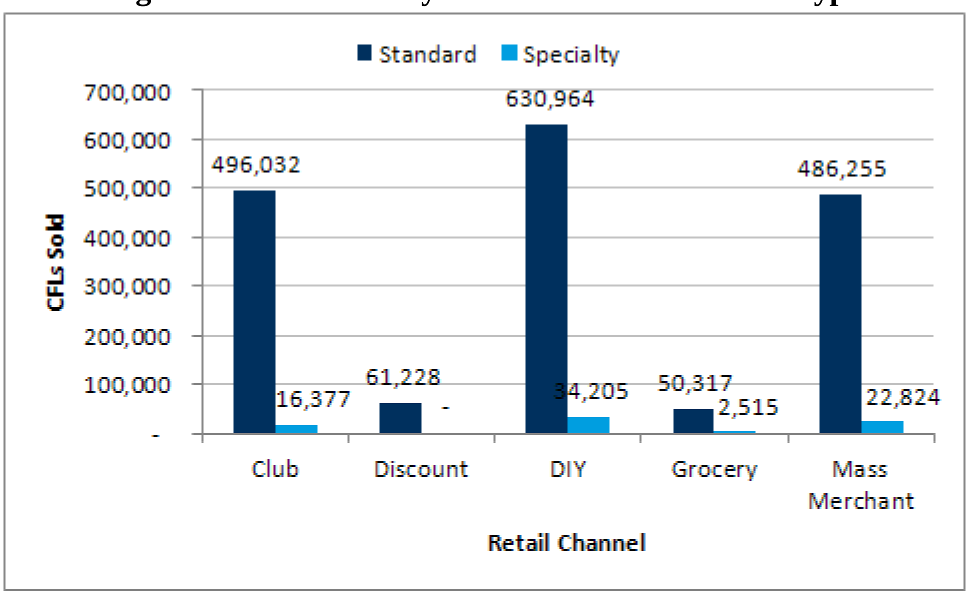
Figure 47 shows relationships between sales and incentive levels, and serves as the driver behind the freeridership analysis, discussed in the impact evaluation.

Figure 47. Sales and Incentive over Time



Sales volumes differed between those participating in the markdown program and those remaining on the coupon program. As shown in Figure 48, overall markdown program sales at big box stores (such as DIY, club, and mass merchant retailers) had the greatest sales volumes.

Figure 48. CFL Sales by Retail Channel and Bulb Type



CFL Stock

Several retailers indicated they increased their CFL stocks after joining the program. One retailer said his company probably tripled its CFL stock since joining the program, and another retailer indicated shelf space devoted to CFLs doubled, from 4 feet to 8 feet, and numbers of SKUs increased from approximately 24 to approximately 75.

All retailers interviewed indicated they would not have changed their store stocking practices without the RLP. Retailers reported they consistently sold their CFL stocks.

In June 2011, one large retailer conducted a massive lighting reset, independent of the RLP. This included: committing to more energy-efficient lighting; placing a great deal of educational material before customers in October 2011; and familiarizing them with the energy benefits for each product.

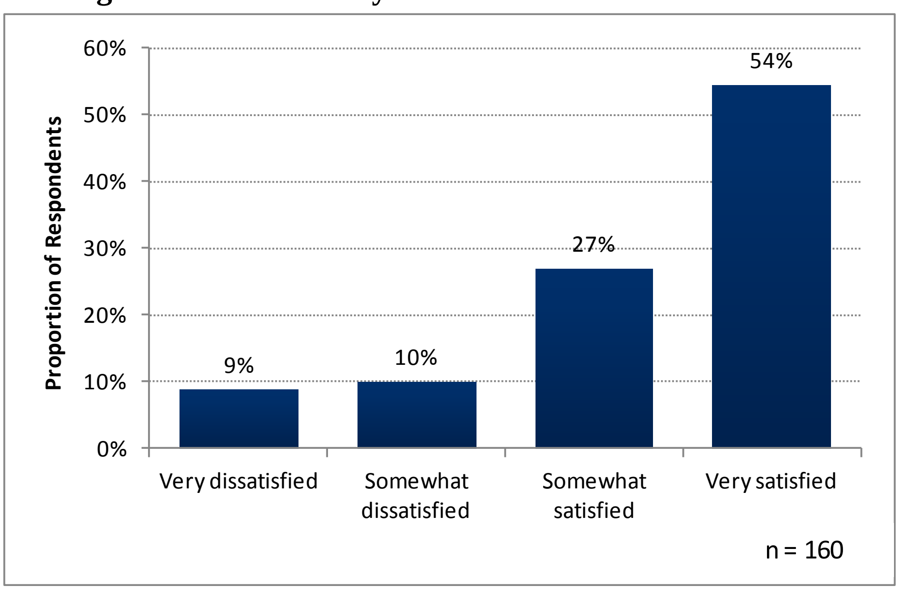
The larger retailer interviewed, which had to remain competitive and move larger volumes of lights, reported its organization focused on selling more-efficient products and leading the market through sales of efficient technologies. The retailer indicated, even without the RLP, it would continue to stock and promote CFLs and efficient lighting technologies at the same rate.

Smaller retailers reported, without the program, they probably would not stock the same type and quantity of CFLs, and would sell fewer.

CFL Satisfaction

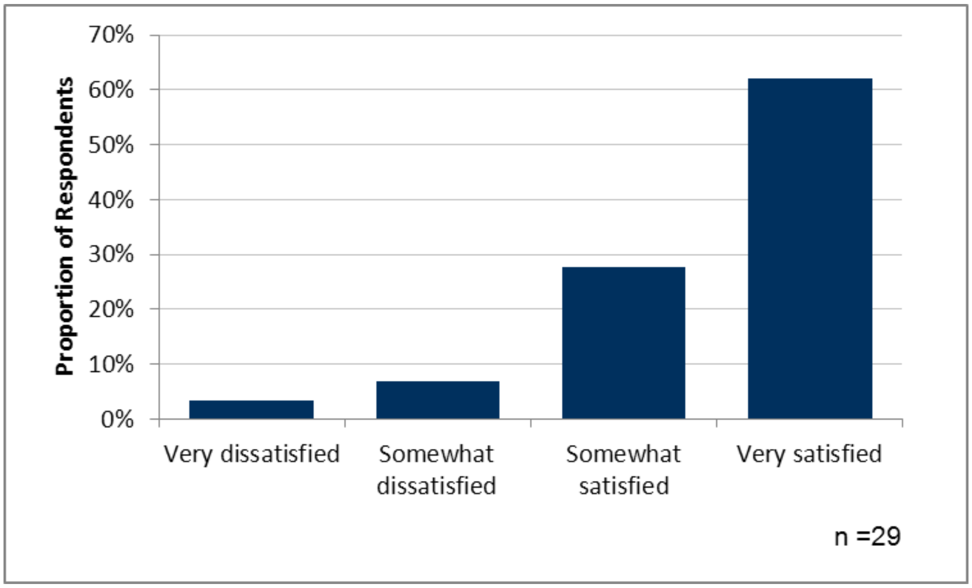
The majority of RDD survey respondents purchasing CFLs expressive high satisfaction levels with their bulbs (54%), with 27% were somewhat satisfied. However, nearly one in 10 reported being highly dissatisfied, as shown in Figure 49.

Figure 49. RDD Survey: Overall Satisfaction with CFLs



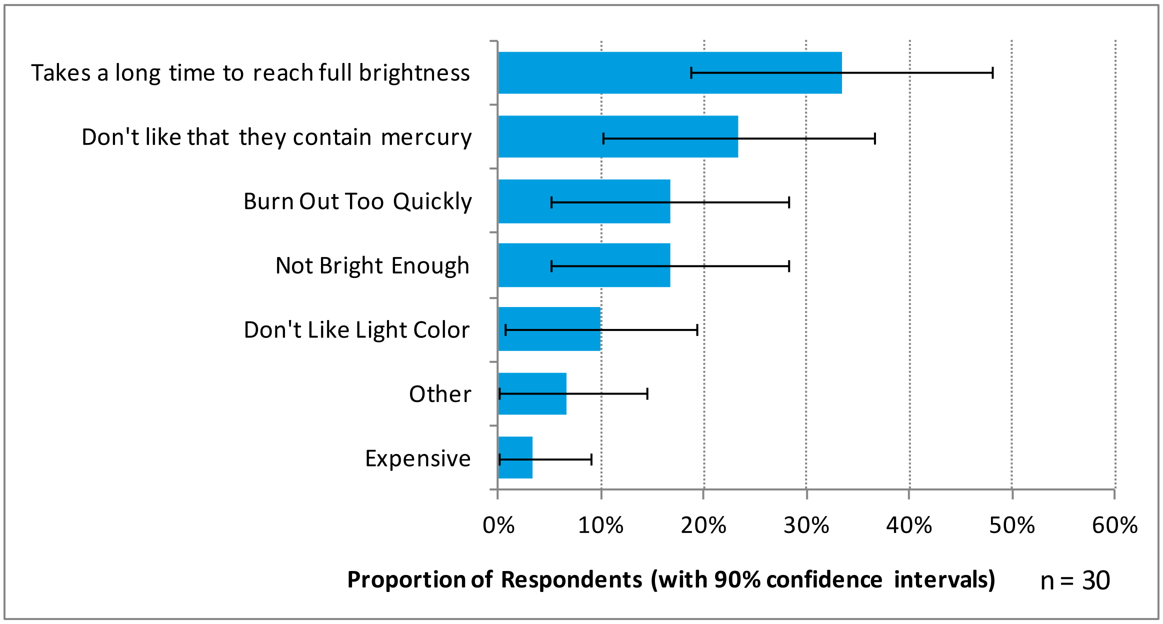
Giveaway respondents reported somewhat higher satisfaction with CFLs, as shown in Figure 50, with 62% of customers very satisfied with their CFLs, and 28% somewhat satisfied.

Figure 50. Giveaway Respondents: Satisfaction with CFLs



Of the 19% of RDD respondents not satisfied with their CFL purchases, the time required for bulbs to reach full brightness proved to be the primary issue causing dissatisfaction (33%). Other dissatisfaction sources included: concern over mercury content (23%); and bulb life (17%).

Figure 51. RDD Survey: Reason for Dissatisfaction with CFLs



Retailers indicate customers expressed the greatest concerns about:

- CFL mercury content
- Delayed turn-on times;
- Color; and
- Bulb brightness.

Program staff also heard customer objections to: price, color, light quality, and CFL mercury content.

Cadmus asked retailers which CFLs sold the best, with retailers reporting their best-selling bulbs as the 60/65-watt equivalents with a medium base. Retailers did not provide a consistent answer to a question regarding whether packaged bulbs sold better than individual bulbs. Some retailers said one- and two-pack bulbs sold most quickly; others reported no differences between packaged bulb sales and individual bulb sales. A third vendor said higher-wattage, four-and five-packs sold most rapidly.

The Mercury Issue

Retailers and program staff reported customers' concerns regarding mercury in CFLs. Participating retailers believed mercury concerns could be alleviated by providing customers with educational materials about mercury content and proper CFL disposal. All participating retailers offered free CFL recycling, and indicated reminding customers about recycling options helped alleviate these concerns. Retailers reported offering CFL recycling as essential to successfully selling CFLs.

The Trust neither operated a recycling program nor provided an informational leaflet on mercury issues. However, Efficiency Maine's Website provided information on both. Field representatives retained copies of Website information, and could direct customers to visit the Website. Program staff believed lower CFL prices overrode customer concerns about mercury; so field staff focused more on CFL benefits than on trying to allay such concerns.

Increasing Customer Participation

When asked how the RLP could be improved to increase customer participation, retailers offered the following suggestions:

- Maintain the markdown program, and gradually eliminate the coupon program.
- Enhance POP: retailers reported customers responded better to seeing prices advertised as a "sale" or "discount."
- Enhance customer education materials; retailers indicated customers responded well to in-store displays.
- Continue to place discounted CFLs on end caps.
- Consider offering bulbs at a higher incentive level for short-term promotions.
- Ask retailers to advertise in their own circulars or flyers.

Energy Independence and Security Act

In addition to the issues discussed above, Cadmus examined lighting trends impacting future program designs, including: EISA's implementation; emergence of LED products; and roles of various specialty bulbs in homes and in future programs.

Consumer Concerns

Program staff reported customers expressed concerns about how EISA's implementation would affect their bulb selection. Consequently, staff believed some customers may stock up on incandescent bulbs. However, retailers noted incandescent sales have declined over the past few years. They considered the EISA-mandated elimination of the 100-watt bulbs as a non-event for most consumers. Older customers generally preferred continuing to use the light bulbs they knew (e.g., incandescent lights), and have purchased large quantities of incandescent bulbs. Most retailers and program staff, however, believed consumers attached to incandescent technologies will eventually shift to 75-watt incandescent products.

Consumer Awareness

All manufacturers interviewed considered consumers largely unaware of pending EISA changes, and consumers aware of EISA misinformed about its scope and impact. Manufacturers did not think consumers understood the legislation's motivation to reduce energy consumption, with all manufacturers interviewed citing the importance of consumer education as the transition from 100-watt incandescent bulbs takes place nationwide, particularly during the phase-out of the 75-watt incandescent bulb.

One manufacturer stated: "We just spent two months conducting a consumer study. People are confused; they have never had to make decisions on lighting like this. People want to buy the right thing but don't know how when they are looking at 40-feet of lighting products on a shelf. They then purchase something and get home and hate the light."

Most manufacturers considered a focus necessary regarding creation of educational materials addressing light quality.

Retailer Response

In spite of industry concerns that retailers might stock incandescent light bulbs to ensure availability to their customer base for as long as possible, all retailers interviewed had not made substantial stocking changes in their stores since the beginning of 2012.

Manufacturer Response

During Fall 2011, Cadmus interviewed 11 lighting manufacturers regarding their plans under the new EISA legislation. Manufacturers ranged from small companies to large companies, operating nationally and internationally. All 11 manufacturers operated within the United States.

Purchasing and Manufacturing Trends in California

On January 1, 2011, California implemented EISA one year prior to national implementation. Cadmus asked manufacturers their expectations for products California consumers would choose, once 100-watt incandescent bulbs no longer became available, along with their observations regarding consumer purchasing habits after implementation.

Some manufacturers prepared retailers for California's early EISA implementation, and said a fairly smooth transition occurred. While legislation stipulated manufacturers could not make 100-watt incandescent bulbs after the January 1 date, retailers could sell bulbs until their stock expired (which happened, according to larger manufacturers).

Cadmus asked manufacturers which bulb types California customers chose rather than 100-watt incandescent bulbs. Most reported customers purchasing lower-wattage incandescent bulbs. Retailers also noticed small increases in CFL sales. However, as halogens did not become readily available in California until Summer 2011, California may not provide an accurate model for national EISA implementation. Generally, manufacturers expected consumers to buy bulbs most similar to incandescent bulbs, as this would cause the least change for them. So far, California's results bear out this prediction.

Changed Production in Preparation for EISA Implementation Nationwide

Cadmus asked manufacturers whether they changed their lighting production in preparation for nationwide EISA implementation. Two of five respondents manufacturing incandescent bulbs did not change their inventory planning, producing the same quantity of 100-watt incandescent bulbs until banned from doing so.

One said: "We are not building our inventory or adjusting, we are just producing 100-watt incandescents until we cannot produce them anymore. If people start stockpiling in the beginning, the national inventory will not last long."

The other three respondents manufacturing incandescent bulbs said they planned to take advantage of customers hoarding bulbs by increasing incandescent production slightly prior to January 1, 2012. At the same time, one of these manufacturers said they would develop new technologies (such as halogens, saving 28% to 30% energy, with the same shape and dimming capability as incandescent bulbs).

Lighting Products to Replace Phased-Out Bulbs

Cadmus asked manufacturers their expectations of light bulbs market distributions following EISA's national implementation. Several new and competing lighting technologies have entered the market, such as EISA-compliant halogens and more efficient CFLs. Manufacturers expected the market would continue to change rapidly, and prices, marketing, and consumer preferences would decide which technologies dominate the market. In the near-term, most manufacturers predicted halogens, CFLs, and lower-wattage incandescent bulbs would be most popular among consumers. In the longer-term, they expected LEDs, halogens, and CFLs to maintain a strong market presence.

Manufacturers told Cadmus they would prefer utilities offer direct installation and giveaway programs, specifically for LEDs, to help that technology become more competitive. One large manufacturer has worked to engage many utilities across the country to develop LED-rebate programs, starting in 2012, and have convinced five utilities to offer $10 point-of-sale rebates for A-19 LEDs, reducing the cost to $14.97 per bulb.

Influence of Market Factors on Production

Cadmus asked manufacturers how market factors influenced their production and pricing. One manufacturer reporting being pleasantly surprised at rates of increased demand for one of its canned LED-light technologies; the manufacturer partnered with a major big-box store to reduce the retail price by 64%, and saw demand rise. Even with this market interest, however, the manufacturer believed the: "economics of LEDs are out of reach for most consumers, unless they are extremely green, wealthy, or want the first of everything."

One manufacturer reported, as it remained at the mercy of its supplier for material costs, it no longer offered set pricing agreements to retailers, and had to pass along increased costs. Another manufacturer could decrease its own prices through volumes and production efficiencies. Most manufacturers expressed concerns that utility funding, enabling them to offer lower CFL prices on CFLs, may not continue once EISA takes effect.

Rare Earth Mineral Price Increase for CFLs

Cadmus asked manufacturers how they responded to increases in CFL material costs. All manufacturers cited costs of rare earth materials increasing significantly over the last several months. Manufacturers purchasing phosphors from China have faced increases between 500% and 2,000% over the last year. The rare earth material price increase has seen the first real price spike in the CFL market to date, and manufacturers eventually will have to increase bulb prices to accommodate the changes. Most manufacturers reported delaying price increases for consumers as long as possible, usually four to six months from the time material costs increase.

Specialty CFL Bulbs

Cadmus asked manufacturers to identify types of specialty CFL bulbs they expected to produce in the future. Eight manufacturers described improvements to existing CFLs or named specialty CFL bulbs they believed would become available in the market. Three expected future CFLs to look and function more like incandescent bulbs, coming on instantly (with no lag time) and having better dimming capabilities and performance. Three expected the CFL market to increase for outdoor applications, offering floodlights, spotlights, globes, A-shaped bulbs, recessed cans, retrofit lamps, and, eventually, decorative lamps.

LED and Halogen Technologies

As EISA begins to take effect, specialty CFLs, LEDs, and halogen bulbs may increase their share of the lighting market.

Manufacturer and Retailer Response

Most manufacturers expressed concerns that consumers remained uneducated about the economics of energy efficiency. Manufacturers provided input about how to overcome higher upfront costs of efficient lighting when marketing such products to consumers. Ten manufacturers used marketing strategies such as e-mail campaigns, in-store signs, and promotional displays to assist consumers with lighting purchase decisions. One manufacturer worked with kitchen and bath showrooms, demonstrating multiple efficient lighting options for consumers purchasing cabinets or kitchen countertops.

Another manufacturer redesigned its bulb packaging for color-coding by lumen category; the packaging will also include details about costs to operate the bulb for a full year. In spite of their varied efforts, all manufacturers expected distribution companies, contractors, lighting training institutions and organizations, the EPA, and the media to take responsibility for marketing.

None of the retailers surveyed sold many LEDs, given high LED prices. However, retailers reported LED sales seem to increase as prices came down. Some retailers believed 100-watt halogen lights will take the demand for 100-watt incandescents. While halogens cost more than incandescents or CFLs, their prices have started to fall; so retailers expected sales increase. RLP retailers said they looked to LEDs as the next efficient products they hope the program will support.

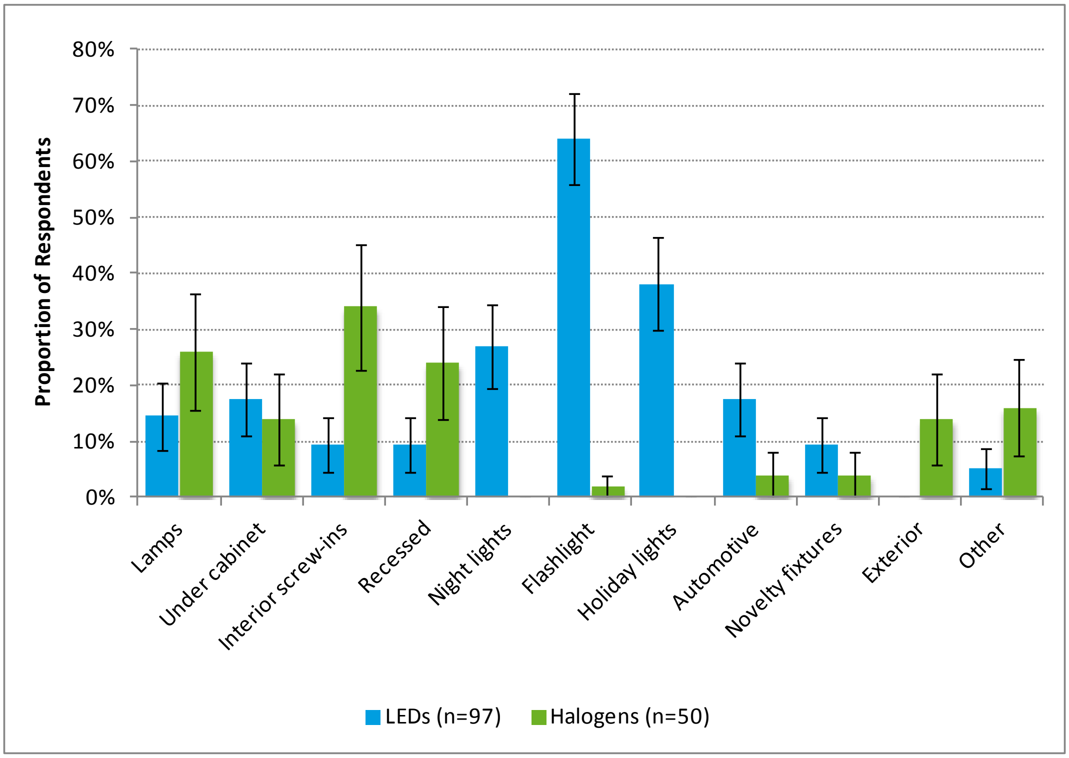
Consumer Response

Approximately 68% of the RDD customers knew of LEDs, and slightly fewer than 80% knew of halogen bulbs. Of those familiar with LEDs, 21% reported using them; 39% of respondents familiar with halogen bulbs used them.

Retailers believed bulb brightness, prices, and applications would be important to customers looking to purchase halogen and LED bulbs.

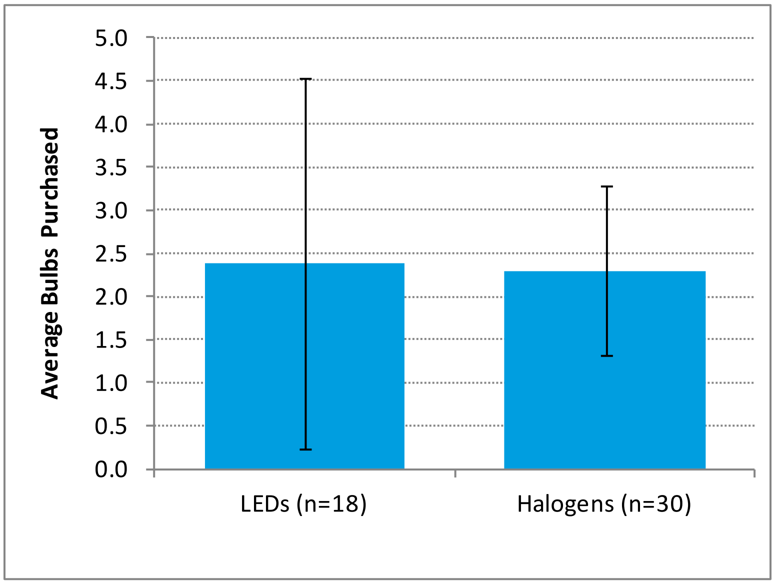
Figure 52 shows LED and halogen bulbs, reported installed by RDD respondents, by location.

Figure 52. RDD Survey: Halogen and LED Saturations by Location



Among RDD survey respondents owning both LED and halogen bulbs, a sizable portion had not purchased any new light bulbs of these types in the past year (61% and 37%, respectively). Those purchasing such bulbs in the past year reported purchasing an average of two bulbs, as shown in Figure 53.

Figure 53. Average Number of LEDs and Halogens Purchased in Past 12 Months



Programs and Product Sponsors

Manufacturers interpreted utility programs as providing a seal of approval for their lighting technologies. Utility programs helped manufacturers reduce new technologies' costs, which helped place them in consumers' homes. Utility programs also helped retailers sell new products.

Manufacturers believed utility CFL programs would not see a decrease in savings, at least until one year after EISA goes into effect. Once EISA has been fully implemented, one manufacturer hypothesized utilities could realize fewer savings from CFLs than at present, but CFLs will remain a viable energy-savings technology.

Six manufacturers Cadmus interviewed suggested utilities consider increasing direct-install and giveaway programs to generate savings and demonstrate to consumers how far CFL technology has advanced. They suggested such programs might induce customers who tried (and been unsatisfied with) CFLs in the past give them another chance.

Reaching Maine's Demographics of Survey Respondents

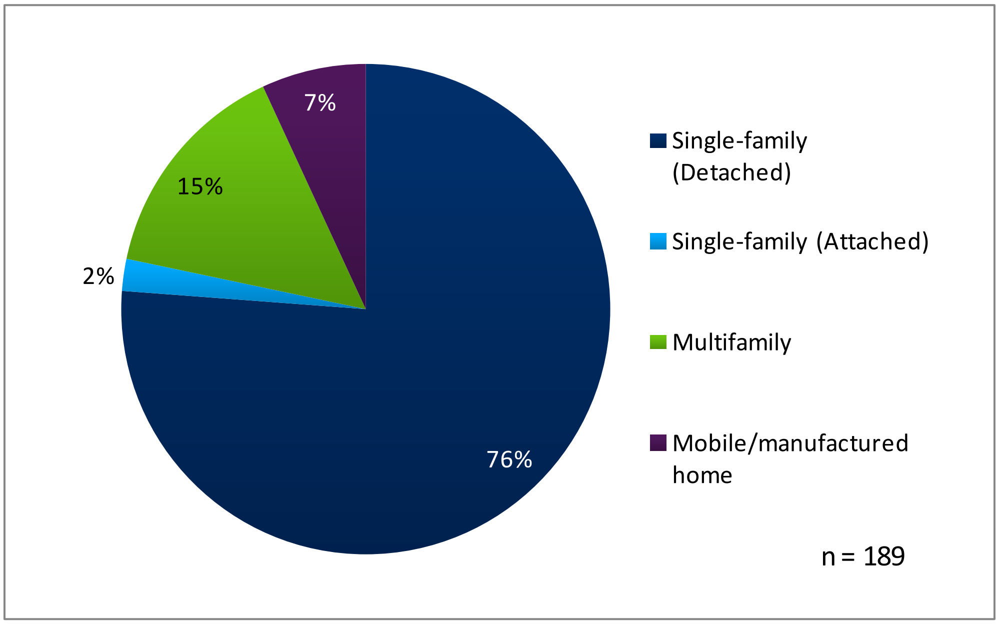
RDD Respondents

Cadmus examined key demographic characteristics of survey respondents, and made comparisons to statewide Census data, where possible.

Seventy-eight percent of RDD respondents lived in detached or attached single-family dwellings, and approximately 15% of respondents lived in apartment or condominium complexes, as shown in Figure 54. Homeownership ranked somewhat higher in the survey sample than in Census data for the state: 86% of respondents owned their homes, compared with a 71% statewide value.[27]

[27] 2010 United States Census.

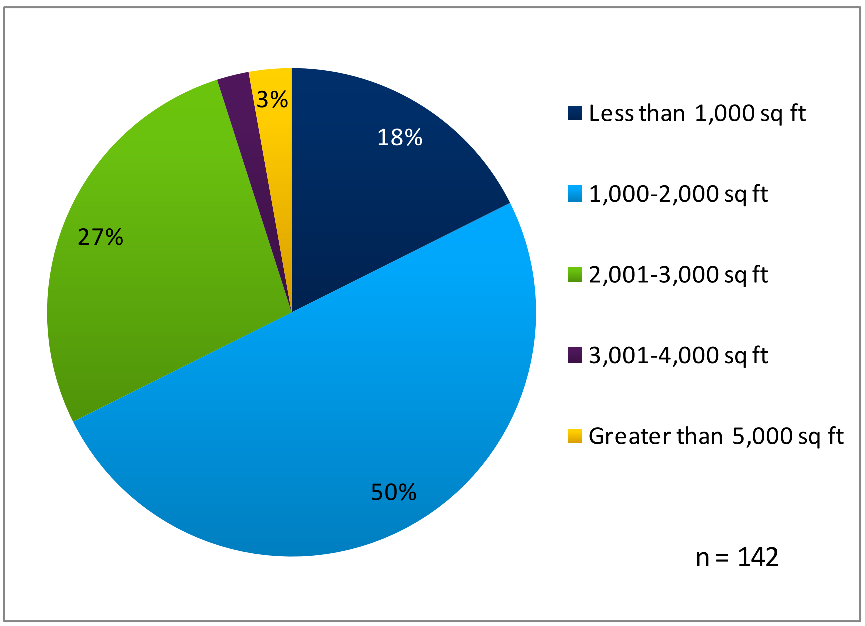
Figure 54. Home Type Distributions



Most RDD respondents lived in homes built between 1960 and 2000. Roughly one-third of respondents' homes were built before 1960. Only 14% of homes were built after 2000.

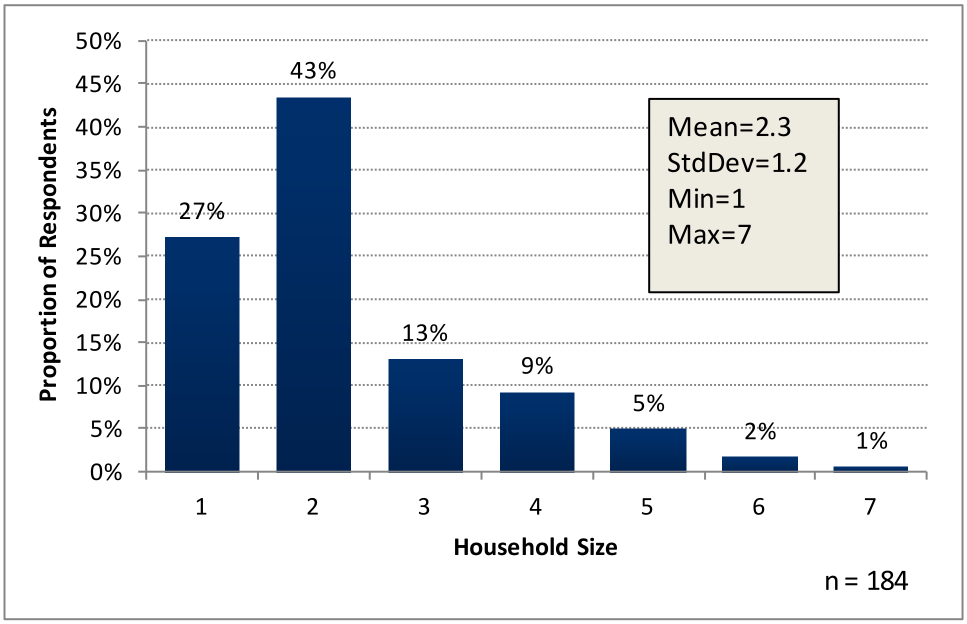
Figure 55 shows home size distributions, reported by customers who could provide square footage. About 28% of respondents could not provide approximate square footage for their homes.

Figure 55. Home Size Distributions



Average RDD respondent households had two to three people living in the house year-round, matches the state average of 2.32 people per household.[28]

Figure 56. Distributions of Household Size



Reaching Hard-to-Reach Customers

Cadmus used the RDD survey results to determine CFL distributions across three segments: residential non-low income; residential low income; and commercial.

This analysis defined low income on the basis of LIHEAP eligibility, which is based on a resident's household size and income level. Cadmus asked respondents a series of questions regarding their household occupancy and income levels to evaluate their qualification under LIHEAP.

Once respondents provided their household's size, Cadmus determined the "threshold income": the LIHEAP qualifying cut-off level for Maine. For example, the threshold income for a home with one person would be $16,335 a year; the dollar amount increases as the number of household members increase. After determining the corresponding threshold income level, Cadmus asked the respondent whether his or her household income exceeded the cut-off level. If a household's income fell below the respective threshold income level, Cadmus noted it qualified for LIHEAP.[29]

Of 200 residents surveyed, 154 respondents answered both household size and income threshold questions. About 78% of total respondents reported a household income greater than the LIHEAP threshold income level, and about 22% of total respondents reported an income level below their corresponding threshold income level.

---

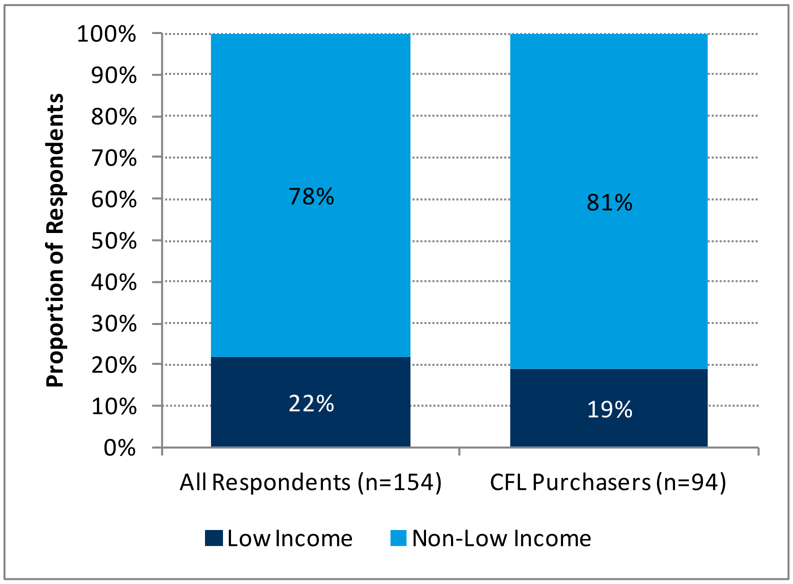
[28] 2010 United States Census.

[29] The report refers to qualifying residents as low-income households, and residents with threshold incomes above the LIHEAP cutoff as non-low-income households.

Of 154 respondents, 94 respondents answered both household size and income threshold questions, and identified themselves as CFL purchasers or program participants (CFL purchasers). Nineteen percent of CFL purchasers reported household income levels lower than the LIHEAP threshold income level qualifying them for LIHEAP.

Figure 57 displays question results and subsequent analysis.

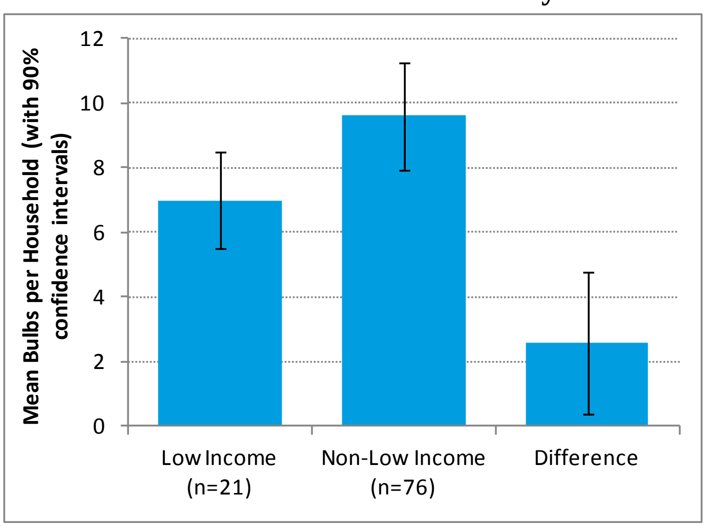
Figure 57. LIHEAP Qualification



Bulbs Purchased

Per survey results, 19.15% of RDD respondents who purchased CFLs qualified for LIHEAP. On average, participating low income households purchased seven CFLs, while non-low income households purchased 9.6 bulbs. As shown in Figure 58, the difference between low income and non-low income households was statistically significant at a 90% confidence level.

Figure 58. CFLs Purchased in the Last Two Years by LIHEAP Qualification



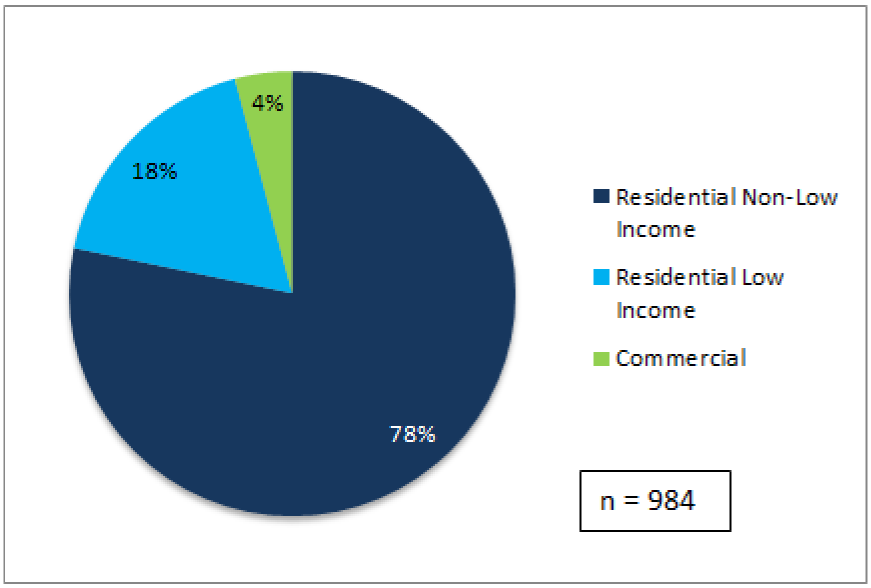
Commercial

Cadmus asked residents a series of questions about their CFL purchases for business or commercial use. Approximately 6% of respondents purchasing CFLs in the past two years had already installed them, or planned to install them, in a commercial or business building rather than a home. These respondents installed, on average, 6.2 bulbs in their commercial facilities, accounting for 48% of their total CFL purchases.

Summary

Cadmus estimated distributions of program CFLs across residential non-low income, residential low income, and commercial segments using the RDD survey data collected on income designation and commercial usage. To properly segment program sales, Cadmus subset survey data to respondents purchasing CFLs in the last two years, and not responding with a "don't know" or refuse to answer questions on commercial bulb usage and income levels. This reduced the sample to 105 respondents. Cadmus aggregated commercial sales because the commercial sector does not segment by income, and, subsequently, summarized CFLs for the three possible combinations of sector and income level, as shown in Figure 59.

Figure 59. Segmentation of Program CFL Sales



While the RLP program is targeted at residential consumers, respondents installed a small number of CFLs in commercial buildings.

Low-Income Opportunities

In mid-December 2011 (midway through the FY 2012 program), Efficiency Maine began working with local food banks (e.g., Good Shepherd) to distribute CFLs to low-income residents. This initiative shipped CFLs directly from manufacturers to a central food bank for distribution to local food pantries that, in turn, distributed bulbs to consumers. Food pantry clients received the CFL for free, along with information about CFL technology.

APT negotiated pricing and orchestrated CFL purchases for the food bank initiative, arranging distributions of three-packs in Maine, and shipped more than 170,000 CFLs (two shipments of

88,000) into Maine through food banks by the end of January 2012. APT confirmed the program has had an acceptable cost-effectiveness level.

To date, the food bank initiative has been termed "eye-popping." While retail channels can be effective, the food bank offered Efficiency Maine access to an entirely different demographic, which it might not otherwise reach.

The food bank initiative did does take funding from other CFL delivery channels, given the RLP has a fixed budget. Program implementers expressed a desire for retaining enough funding to continue retail channel activities, while still reaching out to the low-income community.

4. CONCLUSIONS AND RECOMMENDATIONS

Impact Evaluation

Lighting Use

Site visits provided a picture of Maine CFL use. Table 33 shows various bulb penetrations, defined as the proportion of homes with at least one given bulb type and saturation (the proportion of total bulbs) attributable to each bulb type.

Table 33. Bulb Penetration and Saturation (n=2,415)

Bulb Type	Penetration	Saturation (Percent of Bulbs)
CFL	97.6%	25.8%
Fluorescent	82.9%	10.4%
Incandescent	100.0%	58.1%
Halogen	48.8%	5.7%
LED	2.4%	0.0%

Though incandescent bulbs continue to comprise the majority of Maine's lighting load, CFLs have gained ground, averaging one-in-four bulbs in use. A typical household would have 15 CFLs installed, with 76% of 2,447 sockets identified as medium screw base or standard sockets.

Overall, customers installed incandescent bulbs most frequently, as a percentage of total bulbs for each room type. Incandescents represented at least 50% of installed bulbs in all rooms, except offices, kitchens, closets, and basements. Fluorescents and CFLs were found to be installed in each room type.

Installations by bulb type varied considerably, when analyzed by socket type. Nearly all small-screw base sockets contained an incandescent bulb. Analysis did not find CFLs in the following socket types: small-screw base; large screw base; or pin-based fixtures. About one-third of all medium-screw base sockets contained CFLs, while the remainder contained incandescents.

Gross and Net Savings

For FY 2011, the RLP achieved net first-year savings of 34,628 MWh, accounting for the 73% installation rate. In subsequent years, once all bulbs have been installed, the program will save an expected 47,432 MWh annually. Total annual net savings estimates fell within ±10.6% relative precision with 80% confidence.

In the first year, the program achieved net demand reductions of 3.1 MW for the summer on-peak period and 8.6 MW for the winter on-peak period in the first year, and will maintain expected net reductions of 4.3 MW and 11.7 MW in summer and winter on-peak periods, respectively, in subsequent years. Cadmus estimated total annual net demand savings within ±11.0% relative precision for the summer peak period and within ±9.4% relative precision for the winter peak period with 80% confidence.

Table 34 shows program estimated lifetime gross and net savings (and associated realization rates), calculated using the EULs estimated above and annual savings values, which assume all CFLs in storage will eventually be installed.

Table 34. Lifetime Gross and Net Savings*

Type	EUL (years)	Lifetime Gross Savings (MWh)	Lifetime Net Savings (MWh)	Reported Lifetime Gross Savings (MWh)	Gross Realization Rate	Net Realization Rate
Standard	12.5	618,344	421,623			
Specialty	11.0	29,974	2,539			
Giveaway	13.4	10,770	10,770			
Program Overall	12.5	659,088	434,932	614,388	107%	71%

*As lifetime savings have been adjusted for EISA implementation, they may not directly equal the product of annual savings and EUL.

Cost-Effectiveness

Table 35 shows cost-effectiveness analysis results. As noted, MWh savings are calculated at the system level (at generation), taking into account line losses (energy lost through transmission and distribution), and lifetime savings are adjusted to account for increased efficiency of standard residential lighting due to EISA. The final TRC ratio, which was calculated using net savings and participant net costs, passed the TRC test readily, with a ratio of 9.62.

Table 35. Cost-Effectiveness Results*

Category	Reported Savings Scenario
Annual Gross MWh Savings (at generation)	76,433
Annual Net MWh Savings (at generation)	50,816
Lifetime Net MWh Savings (at generation)	463,203
Net TRC Benefits	$29,019,675
Participant Net Incremental Costs	$1,715,503
Technical Support Costs	$1,012,534
Marketing Costs	$34,432
Administrative Costs	$254,883
Net TRC Costs	$3,017,352
TRC Ratio	9.62

*As lifetime savings have been adjusted for EISA implementation, they may not directly equal the product of annual savings and the EUL.

Recommendations

Based on impact evaluation findings, Cadmus recommends Efficiency Maine takes the following actions:

- Update savings parameters in the Maine Residential Technical Reference Manual (TRM) to incorporate findings from this evaluation.
- Incorporate savings parameter estimates from this evaluation, as appropriate, in demand resource performance reporting calculations for ISO-New England.

Process Evaluation

Program incentives. Efficiency Maine's decision to eliminate television advertising in favor of higher incentive levels expanded its RLP. Once Efficiency Maine's efforts and program allowed retailers to sell CFLs at a lower price, CFL purchases increased. Due to this effort's success, Cadmus recommends:

- Efficiency Maine continues with similar incentive levels to maintain the lower price level for Maine residents.

Markdown vs. coupon program: After Efficiency Maine transitioned larger stores to the markdown program, CFL sales increased, and the program operated more smoothly once MOUs had been implemented. Retailers consistently praised the markdown program, with those participating very satisfied and planning to continue participation. Markdown participants moved to the coupon program wanted to participate in the markdown program again. Several retailers participating in the markdown program through the MOU wanted to resume participation. Cadmus recommends Efficiency Maine take the following actions:

- **Work to increase the markdown program's scope.** Chain stores have historically been markdown program participants. Retailers such as True Value and Ace Hardware may be attractive candidates.
- **Work to incorporate retailers operating as part of a buying group or a larger corporation into the markdown program.**

Program implementation. APT has implemented the program well, with knowledgeable field representatives that ensure participating retailers comply with the program. Coupon and markdown retailers appear to rely on field representatives for program management or implementation questions. Efficiency Maine and APT appeared to have a strong working relationship, built on mutual goals and respect, which promoted the RLP's success.

In-store education and training: APT field staff conducts in-store events on a monthly basis, educating retail sales associates and customers. These educational efforts have provided Efficiency Maine with a presence in stores, and have provided customers and staff with monthly educational opportunities. However, coupon and markdown programs retailers did not rely on APT to educate their sales associates or customers about efficient lighting. Retailers and customers indicated sales associates proved influential when determining which light bulbs to purchase; so they want APT to make sales associate training a higher priority. As retail sales associates turn over relatively quickly, retailers experience high training needs. Efficiency Maine should work with APT to increase sales associate education through the following actions:

- **Implement more comprehensive, repetitive sales associate training.** If APT staff cannot spend more time in stores to train sales associates, the company may want to implement a store manager "train the trainers" program, allowing store managers or their designees to supplement APT's training for new staff.
- **Increase retailer outreach materials.** APT should create more leave-behind materials for retailers' sales associate education, including a pamphlet summarizing frequently asked questions. APT also could send a monthly blast fax, communicating program updates.

In-store promotion. Cadmus also recommends Efficiency Maine increase its focus on in-store promotion as the next best way to reach customers. The Trust should take the following actions:

- **Work with retailers to continue to place CFLs on end caps**. CFL placement within stores has helped drive sales. The Trust and APT should work with retailers to continue to maintain strong CFL placements on aisle end caps.
- **Increase signage detail**. Improving information contained in the POP materials will help customers understand Efficiency Maine operates the RLP program, and bulbs are "on sale," both of which can help attract consumers. Efficiency Maine could modify POP materials to include more information about the program and CFL benefits.
- **Increase other types of educational material**. Provide retailers with small, in-store displays that take little shelf space, but can educate consumers about light output levels and CFL energy consumption. Efficiency Maine also could work with retailers to have them advertise CFL bulbs in their circulars or flyers.

Reaching Hard to Reach Customers. Efficiency Maine has launched a cooperative relationship with Maine food banks and manufacturers to provide CFL bulbs to the low-income market, a relationship reported to be very successful, increasing numbers of CFLs in low-income homes.

- **Efficiency Maine may consider pursuing additional arrangements with faith-based groups, after-school programs, or other not-for-profit organizations, reaching out to the low-income community.**

Consumer education around EISA: Due to EISA's pending implementation and removal of 100-watt incandescent bulbs, consumers seek information about EISA and lighting. Many misunderstand the legislation's rationale, but know they will have to change. EISA information has not been made readily available, offering Efficiency Maine with an opportunity to educate consumers about EISA implementation and CFL technology benefits.

Energy Advisor for Lighting: Cadmus recommends Efficiency Maine position itself as the state's trusted energy advisor on all lighting matters by taking the following actions:

- **Add EISA information to the Trust's Website**, explaining how it will affect Maine residents, and providing customers with information about energy-saving CFL alternatives.
- **Consider opportunities to educate Maine consumers about benefits from installing CFLs in high-use areas**, such as: bedrooms, bathrooms, living areas, and kitchens. CFLs currently comprise 27% of sockets found in high-use rooms. Placing CFLs in locations where they would be used more frequently and for greater lengths of time would allow consumers to reduce their lighting end-use energy consumption.
- ***Expand the RLP's presence on the Trust's Website***. For example, the Trust could place a POP photo with the caption: "Look for this sticker at participating retailers to find a discounted bulb that will help you to save energy, money, and the environment."

LED Technology. When Cadmus completed intercept surveys with customers, many asked about LED technology and when "[Efficiency Maine]" would shift its focus to LEDs. Many customers appeared eager to experience the technology and purchase the most efficient light bulbs. Customers and retailers indicated LED prices remained too high, and, if they could be lowered, customers would more readily purchase the bulbs. Consequently:

- **Efficiency Maine could consider proposing an augmented incentive level to manufacturers to determine whether they show interest in initiating an LED markdown program.** While a program focusing on LED technology may not be cost-effective yet, LED bulbs offer next primary energy saving technology, and programs focusing LEDs can lead to significant market transformation. Several utilities in the United States have started implementing successful upstream LED programs.

Mercury and CFL Recycling: Retailers have worked with consumers who, before purchasing CFL bulbs, want to know the bulbs can be safely and responsibly disposed of. While all major retailers recycle CFLs, some smaller sales outlets do not, and some consumers may be deterred from purchasing CFLs if they do not know how to recycle them. While Efficiency Maine provides information about how and where to properly dispose of CFLs, the RLP currently relies on retailers and manufacturers to properly dispose of bulbs, as it does not operate its own CFL recycling program.[30] Cadmus recommends:

- **Efficiency Maine or APT should offer a CFL recycling program** to supplement those already in operation. If launched, such a program could be further promoted on the Website and through educational materials; so consumers would know the RLP program supports proper CFL disposal.

[30] All retailers interviewed currently offer CFL recycling programs.

APPENDIX A: ISO-NE M-MVDR COMPLIANCE AND SAMPLING

The ISO-NE Manual for Measurement and Verification of Demand Reduction Values from Demand Resources (M-MVDR) provides guidelines to ensure that energy and demand savings impacts are properly evaluated and verified. For this evaluation, ISO-NE requirements apply to the sampling and data collection process done as part of our metering effort.

Site Sampling

Sample Size and Precision

Sampling was used to select sites for on-site metering of CFL usage in Maine households. For the metering study, the target population was residential households in Maine. Given the size of this population, no finite population correction was necessary. Per ISO-NE guidelines, Cadmus assumed a CV of 0.5 for all estimates (residential households are considered a homogenous population). The sample size was, therefore, calculated as simply:

$$n = \left(\frac{z * CV}{e}\right)^2 = \left(\frac{1.282 * 0.5}{0.1}\right)^2 \approx 41$$

This sample size target for the final sample was 41. More sites would have been recruited if any attrition had occurred during the evaluation period.

The sampling plan was effective, as estimates of gross peak demand and energy reductions were precise within 10% relative precision at 80% confidence. Table 36 shows the achieved precision for demand and energy savings

Table 36. Precision for Annual and Total Program Savings (80% Confidence)

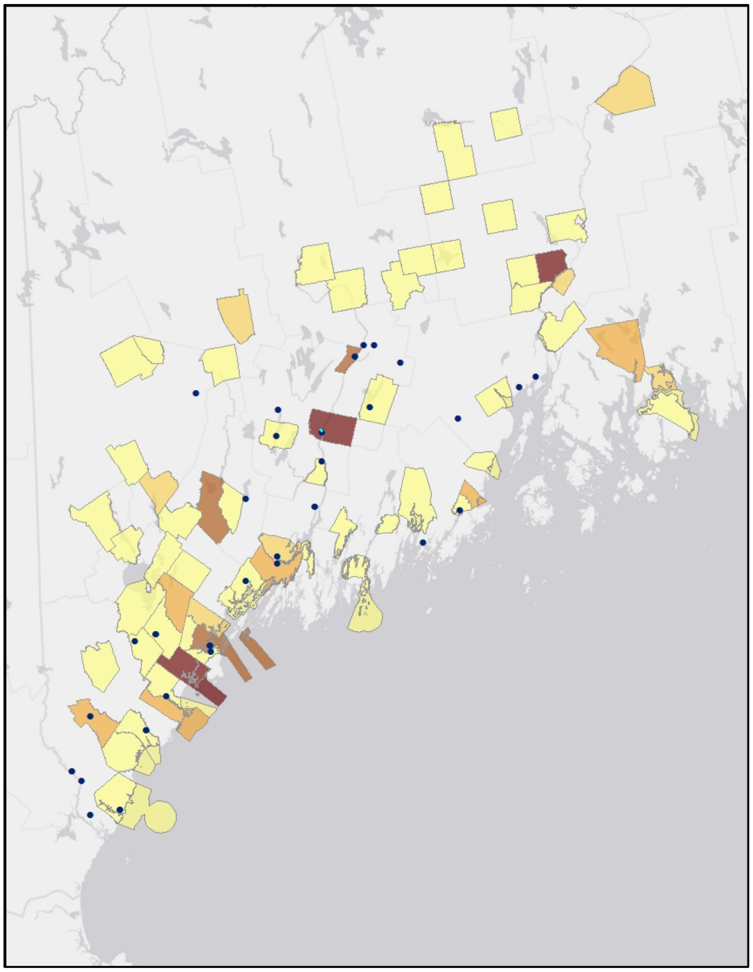
Type	Energy	Summer Peak Demand	Winter Peak Demand
Gross	±9.7%	±10.1%	±8.1%
Net	±10.6%	±11.0%	±9.4%

Sample Selection

Forty-one sites were selected for on-site metering. Sampling of sites for the metering study was completed using the RDD telephone survey that was conducted to gather data for the process evaluation. The telephone survey was a customer survey of 200 Maine residents located south and west of Orono, Maine. At the end of each survey, the respondent was asked whether they would be willing to participate in the on-site metering study; an incentive of up to $125 was offered for their participation. Survey respondents who indicated interest and reported having at least one CFL installed were then re-contacted by Cadmus for the on-site study (on a first-come, first-served basis) until 41 had enrolled. At the time of the site visits, all but one of the 41 sites selected for the metering study had at least one CFL installed.

To aid in confirming the representativeness of the sample, Cadmus compared the geographic distribution of metered sites to the geographic distribution of program bulb sales. Figure 60 shows the location of metering sites overlaid on a map of towns (shaded) in Maine that included retailers selling program CFLs. The degree of color-shading indicates the proportion of total program sales, with darker tints indicating more sales. This map shows that metered sites mapped well to program bulb sales.

Figure 60. Map of 41 Site Visit Locations against Program Sales



APPENDIX B: ON-SITE METERING AND DATA COLLECTION

ISO-NE requires that one of four monitoring and verification options (IPMVP Options A, B, C, D) be used for metering. In order to estimate RLP program savings, Cadmus selected Option A (partially measured retrofit isolation/stipulated measurement). In this evaluation, the isolated measurement was the time and duration of residential lighting usage. The M-MVDR stipulates that measurement should be made over the peak period and cover at least three to four weeks. Each site in our sample was metered over both peak periods (summer and winter) and consisted of a full eight months of data (with approximately 7 weeks during the winter peak period and 8 weeks during the summer peak period). Annualization is discussed in detail in Appendix D.

In early December, Cadmus installed loggers on 324 unique circuits (defined as a set of bulbs on a given switch/control) in 41 Maine households. Cadmus installed an average of eight loggers per site, in various space types and uses (including outdoor lighting), yielding approximately 324 loggers, each on a unique circuit. As some CFL fixtures contained more than one bulb (e.g., a three-lamp ceiling light) and others were switched together (e.g., a three-lamp bathroom vanity), the 324 loggers covered 351 CFLs.

If participants had more than seven CFL fixtures, Cadmus used an online random number generator to select which fixtures to meter within homes. If technically feasible, each house also had its front porch light metered, whether or not the porch light had a CFL. If a home had fewer than seven CFL fixtures, incandescent bulbs were chosen for remaining meters in room types not covered by CFLs. Cadmus investigated data consistency not only by room type, but by factors such as bulb types and saturation levels. To account for differences in average CFL installation rates in the metered sample, Cadmus weighted collected data back to the metered sample (addressing unmetered CFLs in some homes).

Table 37 shows the distribution of loggers installed by room type, which is a function of the random fixture selection. Inherently, rooms with a greater number of CFL fixtures were more likely to be randomly chosen for metering.

At the end of an eight month period (in August 2012), Cadmus retrieved all installed loggers to collect and analyze the data gathered. Ultimately, data from loggers installed on 305 unique circuits were retrievable. Table 37 also shows the numbers circuits with metered data both at the onset of the study and in available for use in the final analysis.

Table 37. Loggers Installed and Analyzed[31]

Room	Circuits with Loggers Installed	Final Circuits in Analysis	Percent of Original Circuits
Basement	18	17	94%
Bedroom	51	47	92%
Dining Room	9	9	100%
Exterior/Outdoor	41	34	83%
Garage	6	7	117%
Hallway/Stairway/Foyer	37	37	100%
Kitchen	31	29	94%
Living	68	65	96%
Office	9	9	100%
Other	10	11	110%
Toilet/Bathroom	44	40	91%
Total Loggers	324	305	94%

As shown in the table above, 94% of the original circuits were used in the final analysis. To ensure a low rate of logger attrition, Cadmus engineers visited the metered sites in the shoulder season (during February or May) and replaced any ineffective or malfunctioning meters.

As seen in Table 38, technicians installed:

- Sixty-six percent (66%) of light loggers on fixtures with only CFL bulbs installed;
- Twenty-seven percent (27%) on non-CFL fixtures; and
- The remainder (about 8%) on fixtures with a mixture of CFLs and non-CFLs.

Table 38. Loggers Installed by Bulb Type (n = 305)

Metered Bulb Types	Loggers	Percent of Loggers
CFLs Only	81	26.6%
Non-CFLs Only	24	7.9%
CFLs and Non-CFLs	200	65.6%
Total Loggers Installed	305	100%

The HOU analysis included usage data from CFL-only fixtures as well as fixtures containing both CFLs and non-CFLs. Fixtures with CFLs and non-CFLs were treated as CFL fixtures, given that fixture operation resulted in CFL usage.

Data Cleaning and Preparation

After retrieving the loggers from the sites, Cadmus downloaded logger data, importing them into Statistical Analysis Software (SAS) for review, cleaning, and HOU estimation. Cadmus also reviewed logger notes documented by the logger removal team, which helped identify loggers

[31] During the study period, some meters were moved either by Cadmus engineers or participants. As a result, some rooms had more metered circuits in place at the end of the study than at the beginning (this only occurred in garages and low-use, "other", rooms).

that might not have accurately collected lighting data, and, ultimately, helped determine whether to include or exclude a logger from HOU analysis.

In some cases, logger exclusion from HOU analysis could be determined easily, such as when participants prematurely removed loggers from metered fixtures. In other cases, final decisions to include or exclude logger data depended on further review of raw data in SAS and Excel.

The data quality control (QC) process included the following:

- Cadmus reviewed all raw logger data using Excel, reviewing counts of all events per logger. Loggers with very low or very high counts were reviewed further, as the former could indicate an improperly launched logger, and the latter could indicate flickering problems. For incorrectly set logger sensitivity, particularly on outdoor fixtures, on and off events typically occurred two to five seconds apart, indicating the logger captured ambient light. In such cases, logger data were carefully reviewed, and most were removed from analysis.
- Field technicians performed a "state test" on each logger prior to removing it from the fixture. During this test, field technicians turned the light on and off to ensure the logger properly recorded each event. Loggers not passing this state were assumed to contain inaccurate data, and, following a review of their data, were removed from analysis. Field technicians also documented whether loggers had been prematurely uninstalled or moved by the participant while *in situ*. Loggers were carefully reviewed to ensure data represented *in situ* observations.
- Some loggers were immediately coded as "toss" due to premature removal by the participant, or if loggers fell off the fixture during the metering period.
- Logger data, audit data, and removal data were imported into SAS for further review and cleaning prior to HOU estimation.
- To provide a general QC check, Cadmus wrote the SAS program to "trim" data points occurring before the install date/time or after the removal date/time. This check prevented analysis from including events occurring prior to installation, in case a technician did not reset the logger at the time of installation. The check also prevented the analysis from including events occurring after the removal date, if logger data were downloaded on a day other than the removal date.

Table 39 shows examples of light logger data.

Table 39. Light Logger Meter Data Example

Description	Serial Number	Date	Time	Status	Status Code
DENT SMART LOGGER	LC09040380	7/21/2012	12:11:11 AM	Turned OFF	0
		7/21/2012	12:13:13 AM	Turned ON	1
		7/21/2012	12:16:22 AM	Turned OFF	0
		7/21/2012	2:50:45 PM	Turned ON	1
		7/21/2012	2:50:46 PM	Turned OFF	0
		7/21/2012	5:58:09 PM	Turned ON	1
		7/21/2012	5:58:10 PM	Turned OFF	0
		7/21/2012	10:07:42 PM	Turned ON	1
		7/21/2012	10:39:44 PM	Turned OFF	0
		7/21/2012	10:52:13 PM	Turned ON	1
		7/21/2012	10:55:14 PM	Turned OFF	0
		7/21/2012	11:00:40 PM	Turned ON	1
		7/21/2012	11:04:16 PM	Turned OFF	0
		7/22/2012	8:44:46 AM	Turned ON	1
		7/22/2012	8:45:22 AM	Turned OFF	0
		7/22/2012	8:38:36 PM	Turned ON	1
		7/22/2012	9:24:51 PM	Turned OFF	0
		7/22/2012	11:02:07 PM	Turned ON	1
		7/22/2012	11:09:29 PM	Turned OFF	0

APPENDIX C: NET-TO-GROSS MODEL DETAILS

Cadmus modeled program data as a panel, with a cross-section of program package quantities modeled over time as a function of fixed and varied effects. As the dependent variable, package[32] sales per week serves as a count variable, and cannot be normally distributed, Cadmus chose to use a "negative binomial" approach to construct the models.

Cadmus tested a variety of specifications to ascertain price impacts (the primary instrument used by the program) on CFL demand.[33] Cadmus controlled for observed and unobserved factors using an intricate dummy variable structure, controlling for: each model number observed; time effects; bulb characteristics; and differences in price response seen at different retailers. The final model follows below.

This model has been based on assumptions three broad factors affect bulb sales: bulb characteristics, seasonal trends, and prices. In the model, Cadmus expressed bulb characteristics as a series of fixed effects, related to model-specific characteristics, retail channels, and general bulb characteristics (e.g., wattage, package size, and specialty/standard designation). Seasonal trends were expressed using a set of monthly dummy variables. Price effects were expressed using the following logarithmic impacts, both in isolation and in interaction with a variety of fixed and time effects:

$$
\begin{aligned}
\ln\left(sales_{t,i}\right) = {} & \beta_0 + \beta_1 \ln(retail)_{\mathrm{t,i}} + \beta_2 \ln(retail)_{\mathrm{t-1,i}} + \beta_3 \mathrm{watts_i} + \beta_4 \mathrm{pack\ size_i} \\
& + \beta_5(\mathrm{spec\ dum_i} * \ln(retail)_{\mathrm{t,i}}) + \sum_{\gamma} (\beta_\gamma \mathrm{retailer\ dum_i} * \mathrm{event\ dum_{t,i}}) \\
& + \sum_{\gamma} (\beta_\gamma \mathrm{pack\ dum_i} * \ln(retail)_{\mathrm{t,i}}) + \sum_{\tau} (\beta_\tau \mathrm{retailer\ dum_i} * \ln(retail)_{\mathrm{t,i}}) \\
& + \sum_{\delta} (\beta_\delta \mathrm{month\ dum_t}) + \sum_{\pi} (\beta_\pi \mathrm{model\ dum_i})
\end{aligned}
$$

Where:

$sales_{t,i}$	=	the number CFL packages (whether the y individual or multipack) of bulb type, i, sold in week, t;
$retail_{t,i}$	=	the retail price of bulb type, i, in week, t;
$watts_i$	=	the rated wattage of bulb type, i;
$pack\ size_i$	=	the number of bulbs of type, i, in a package;
$spec\ dum_i$	=	a dummy variable equaling 1 if bulb type, i, is a specialty bulb and 0 if otherwise;

[32] Packages can be individually wrapped CFLs or multipacks.

[33] These diagnostics' focus sought to ensure no omitted variables correlated with price and demand, as this could lead to biasing of the coefficient estimated for price and, hence, bias the freeridership estimate.

$event\ dum_{t,i}$	=	a dummy variable equaling 1 if a promotional event for the retailer of bulb type, i, took place in week, t, and 0 if otherwise;
$pack\ dum_i$	=	a dummy variable equaling 1 if bulb type, i, is of a given pack size and 0 if otherwise;
$retailer\ dum_i$	=	a dummy variable equaling 1 if bulb type, i, is sold at a given retailer and 0 if otherwise;
$month\ dum_t$	=	a dummy variable equaling 1 in a given month and 0 if otherwise; and
$model\ dum_i$	=	a dummy variable equaling 1 if bulb type, i, is of a model number and 0 if otherwise.

Model selection sought to balance the efficiency and bias of estimates. Though Cadmus began with a fixed effects regression model in mind, many decisions had to be made regarding the model's functional form and variables to be included.

Cadmus chose to use a maximum-likelihood, negative-binomial regression for this analysis, as opposed to a log-log OLS model. Reasons for this choice included:

- The model preserved the discrete nature of count data, such as CFL sales data;
- Unlike the log-log model, zero values could be included in the analysis;
- The standard errors would be robust; and
- The logarithmic functional form still preserved easy interpretation of price coefficients as price elasticities.[34]

Once a functional form had been selected, Cadmus began selecting variables, primarily seeking to mitigate bias in estimates, regarding program effects. As freeridership was determined by predicting impacts of program effects (changes in price and occurrence of promotional events), biasing related to these variables would have the greatest impact on the final freeridership estimates. Therefore, the model included any known variables that might correlate with sales and program effects.

Preserving model parsimony also proved critically important. Once all absolutely critical variables had been included, different specifications were compared using AICs and BICs to balance the need for well-fitting and parsimonious models. The final model had a McFadden's pseudo-R^2 of 0.28.

Final model estimates remained well behaved (coefficients had values consistent with expectations), and fit the data (a good proportion of variability explained by the model). Because the model predicted sales for every bulb type in the program, one could not only estimate program-wide freeridership, but could compare these values across different subgroups.

[34] Or, in the case of interaction terms, changes in prices elasticities.

Once the final model specification had been chosen, the entire NTG calculation (described in this report's net savings section) was "bootstrapped" to determine the estimates' sensitivity. The bootstrap involved drawing 100 new samples (with replacements) from the original data, estimating coefficients with each sample, and calculating a new NTG. Using this method, the 5th and 95th percentiles in these data represented the lower and upper bounds of the 90th confidence interval. As shown in Table 40, estimates were relatively efficient, with a confidence interval of 0.60 to 0.67.[35]

Table 40. NTG Bootstrap Distribution (100 Samples)

Min	5th Percentile	95th Percentile	Max
0.59	0.60	0.67	0.68

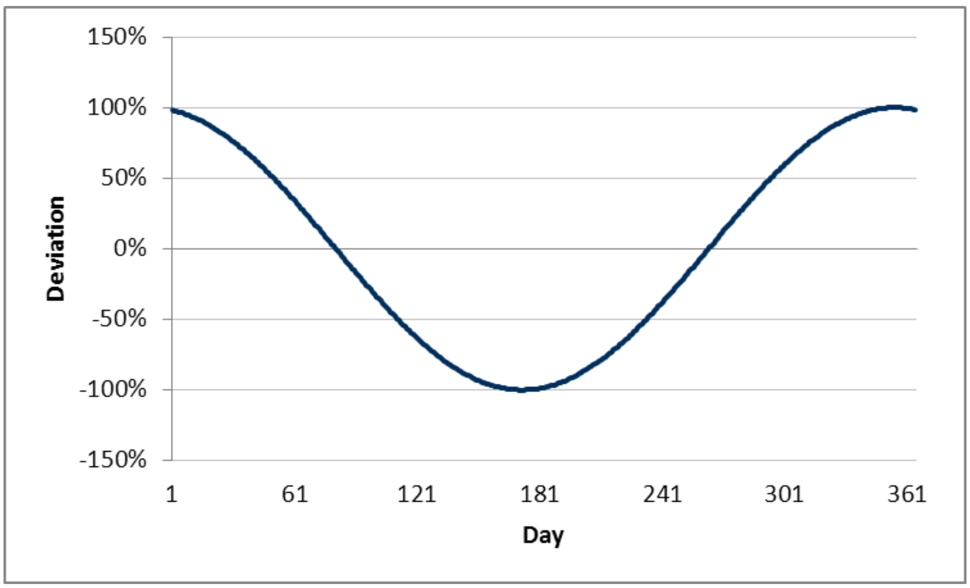
35 As the model was logarithmic, distribution was left-skewed and not symmetric, as with normally distributed data.

APPENDIX D: HOU ANNUALIZATION

The basis for Efficiency Maine logger HOU annualization was the Cadmus/KEMA CPUC 2006–2008 Light Evaluation study, which took place in California.[36] The Maine study installed, two different waves of light loggers, resulting in data for each peak period. To annualize these data, a daylight adjustment factor was calculated as the maximum deviation in daily HOU, relative to the annual average.

Average HOU for all CFL lamps during the summer solstice was expected lowest of the year, while HOU usage during winter solstice was expected highest of the year. Average daily use was assumed coincident with the spring and fall equinox, occurring on March 20 and September 22, respectively. Relative deviation from the average annual daylight hours across one year was represented as a sinusoid curve. In Figure 61, the peak and trough (at 1 and -1, respectively) represent winter and summer solstices, and 0 represents the percent deviation from the annual average daylight hours.

Figure 61. Deviation from Average Annual Daylight Hours



To account for this variation in daylight hours, Cadmus used generalized least-squares: fixed-effects models to fit the observed HOU from the meter data to this sinusoid curve by room type (the other major determinant of HOU). Random effects models were used for each room type, each taking the form:

$$H_{d,i} = \alpha_i + \beta sin(\theta_d) + \varepsilon_d + \gamma_i$$

[36] http://www.energydataweb.com/cpucFiles/18/FinalUpstreamLightingEvaluationReport_2.pdf

Where:

$H_{d,i}$ = HOU on day, d, for logger, i.

$sin(\theta_d)$ = angle for day d, where $sin(\theta_d)$ is 0 at the spring and fall equinox, 1 for December 21, and -1 for June 21. This angle, θ, is represented by the following equation: (-2π)(284+d)/365), where d represents the Julian date of the year.

α = the intercept specific to logger, i, representing the annual average HOU estimate (which coincides with the spring and fall equinox).

β = the difference between the HOU on the solstice and the average HOU (maximum amplitude of the curve).

ε_d, γ_i = the residual errors due across days and loggers, respectively.

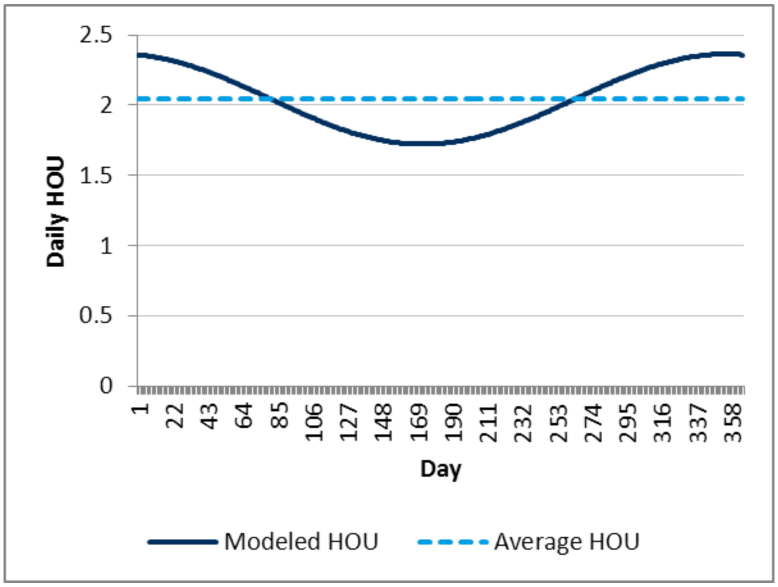
The elegance of this equation was, given the sinusoidal curve was symmetric about the mean; the average of the fixed-effects terms represented the mean annual HOU. The coefficient on the curve was then the average maximum deviation at the solstices. These models were fit for each room type, as this afforded the biggest determinant of usage and its response to daylight. Once estimated, a weighted average of HOU estimates was calculated to arrive at the population estimate of HOU. Table 41 presents these estimates.

Table 41. HOU Regression Estimate by Room Type

Room	Annual HOU (α)		Max Deviation (β)		Audit %
	Mean	SE	Mean	SE	
Basement	1.29	0.15	0.04	0.05	11%
Bedroom	1.35	0.18	-0.21	0.04	18%
Dining Room	2.72	0.15	1.37	0.09	3%
Exterior/Outdoor	2.76	0.25	0.83	0.07	6%
Garage	0.96	0.32	-0.53	0.09	4%
Hallway/Stairway/Foyer	2.14	0.24	0.29	0.06	10%
Kitchen	3.96	0.27	1.29	0.07	11%
Living	2.65	0.19	0.54	0.03	18%
Office	1.66	0.15	0.57	0.07	3%
Other	0.37	0.17	-0.05	0.06	2%
Toilet/Bathroom	1.42	0.08	0.04	0.02	13%
Room Weighted	2.04	0.15	0.32	0.04	

Figure 62 shows the final weighted estimate for HOU and its curve across the year.

Figure 62. HOU Curve



APPENDIX E: SWITCHING FACTOR

The lamp industry uses a three-hour-on/20-minute-off switching cycle to determine rated lamp life. In residential applications, however, lamps are switched on and off at different rates, and CFL life depends on how frequently lamps are switched. Experiments have investigated effects of different operating cycles on the life of CFL products.[37]

Cadmus considered incorporating a “switching factor” into the analysis to account for variations in runtimes within residential homes, and the effect that variation would have on the effective useful life of a CFL.

A study published in 1998,[38] examining CFL performance for five different operating cycles, found that when the length of time lamps remained on fell from three hours to one hour, lamps lasted for 80% of their rated life. When reduced to 15 minutes and five minutes, lamps lasted for 30% and 15%, respectively, of their rated life.[39]

Given the evaluation found an HOU of 2.04, the “three-hour-on” cycle assumed in the manufacturers’ rated life did not match actual light switching cycle in Maine homes.

Ultimately, however, Cadmus chose not to use a switching factor because the relationships found between run times and life in the few available studies were inconsistent, or deemed inconclusive. Cadmus expects future research will provide more precise switching factors, and recommends Efficiency Maine consider including switching factors in its future EUL calculations.

37 http://www.lrc.rpi.edu/resources/pdf/19-2000.pdf

38 Yunfen Ji, Robert Davis, Weihong Chen. 1999. “An investigation of the effect of operating cycles on the life of compact fluorescent lamps”. Journal of the Illuminating Engineering Society. Volume: 28, Issue: 2. Publisher: Illuminating Engineering Society of North America, 57.

39 http://unina.stidue.net/Politecnico%20di%20Milano/Elettronica%20ed%20Informazione/Paco.Melia/Tesi/lampade/C08-02_CFL_LCA.pdf

APPENDIX F. LIGHT LOGGERS

For the metering portion of the evaluation, Cadmus used two different types of light loggers (described below) to monitor light bulb use.

Make: DENT Instruments
Model: SMARTlogger TOU Lighting Logger
Description: Time of use light logger

Make: Onset Computer Corporation
Model: Hobo U9-002
Description: Light on/off data logger