# EDC PROGRAM YEAR 7

# ANNUAL REPORT

Program Year 7: June 1, 2015 – May 31, 2016

Presented to:

**PENNSYLVANIA PUBLIC UTILITY COMMISSION**

Pennsylvania Act 129 of 2008

Energy Efficiency and Conservation Plan

**Prepared for:**

**PPL Electric Utilities**

**November 15, 2016**

Prepared by:

**The Cadmus Group, Inc.**

CADMUS

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# ACRONYMS

| | |
|---|---|
| AHRI | Air Conditioning, Heating, and Refrigeration Institute |
| C&I | Commercial and Industrial |
| C.L. | Confidence Level |
| CDD | Cooling Degree Days |
| CEE | Consortium for Energy Efficiency |
| CEI | Continuous Energy Improvement |
| CFL | Compact Fluorescent Lamp |
| COP | Coefficient of Performance |
| CSP | Conservation Service Provider or Curtailment Service Provider |
| Cv | Coefficient of Variation |
| DIY | Do-It-Yourself |
| DR | Demand Response |
| ECM | Electronically Commutated Motor |
| EDC | Electric Distribution Company |
| EE&C | Energy Efficiency and Conservation |
| EEMIS | Energy Efficiency Management Information System |
| EER | Energy Efficiency Rating |
| EFLH | Equivalent Full Load Hours |
| EM&V | Evaluation, Measurement, and Verification |
| EPA | U.S. Environmental Protection Agency |
| EPAct | Energy Policy Act |
| ER | Error Ratio |
| EUL | Effective Useful Life |
| GNE | Government, Nonprofit, and Education |
| gpm | Gallons per Minute |
| GSHP | Ground Source Heat Pump |
| HDD | Heating Degree Days |
| HERS | Home Energy Rating System |
| HEW | Home Energy Worksheet |
| hp | Horsepower |
| HSPF | Heating Seasonal Performance Factor |
| HVAC | Heating, Ventilation, and Air Conditioning |
| HVLS | High-Volume Low-Speed |
| ICSP | Implementation Conservation Service Provider |
| IPMVP | International Performance Measurement and Verification Protocol |
| ISR | In-Service Rate |

| | |
|---|---|
| KPI | Key Performance Indicator |
| kW | Kilowatt |
| kWh | Kilowatt-hour |
| LEAP | Low-Income Energy Assistance Program |
| LED | Light Emitting Diode |
| LEED | Leadership in Energy and Environmental Design |
| LEEP | Low-Income Energy Efficiency Program |
| LIHEAP | Low-Income Home Energy Assistance Program |
| LIURP | Low-Income Usage Reduction Program |
| M&V | Measurement and Verification |
| MPI | Market Progress Indicator |
| MW | Megawatt |
| MWh | Megawatt-hour |
| NPV | Net Present Value |
| NTG | Net-to-Gross |
| O&M | Operations and Maintenance |
| Phase II Reported | Reported/ *Ex Ante* Cumulative Program/Portfolio Phase II Inception to Date |
| Phase II Verified / (Phase II-VG) | Verified/ *Ex Post* Cumulative Program/Portfolio Phase II Inception to Date |
| Phase II+CO | Cumulative Program/Portfolio Phase II Inception to Date including Carry Over Savings from Phase I (this is cumulative Phase II verified savings) |
| PUC | Pennsylvania Public Utility Commission |
| PY5 | Program Year 2013, from June 1, 2013 to May 31, 2014 |
| PY6 | Program Year 2014, from June 1, 2014 to May 31, 2015 |
| PY7 | Program Year 2015, from June 1, 2015 to May 31, 2016 |
| PY8 | Program Year 2016, from June 1, 2016 to May 31, 2017 |
| PYTD | Program Year to Date |
| PYX QX | Program Year X, Quarter X |
| QA/QC | Quality Assurance and Quality Control |
| RCT | Randomized Control Trial |
| RPM | Revolutions per Minute |
| SEER | Seasonal Energy Efficiency Rating |
| SEER | Seasonal Energy Efficiency Rating |
| SEG | Strategic Energy Group |
| SEMP | Strategic Energy Management Plan |
| SKU | Stock Keeping Unit |
| SPIF | Sales Performance Incentive Funds |
| SSMVP | Site-Specific Measurement and Verification plan |
| SWE | Statewide Evaluator |

| | |
|---|---|
| T&D | Transmission and Distribution |
| TRC | Total Resource Cost |
| TRM | Technical Reference Manual |
| UMP | Uniform Methods Project |
| USP | Universal Service Program |
| VSD | Variable Speed Drive |
| WRAP | Winter Relief Assistance Program |

# REPORT DEFINITIONS

*Note: Definitions provided in this section are limited to terms that are critical to understanding the values presented in this report. For other definitions, please refer to the Act 129 glossary in Appendix E. Glossary of Terms.*

## REPORTING PERIODS

### Phase I

Refers to the Act 129 programs implemented prior to June 1, 2013. Phase I carryover references verified gross Phase I savings in excess of Act 129 Phase I targets.

### Phase II

Refers to the period of time from the start of Phase II Act 129 programs on June 1, 2013 through May 31, 2016. Phase II savings are calculated by totaling all program year results, including the current program year-to-date results and subtracting any Phase II savings that expired during the current program year. For example, Phase II results for PY7 Q3 is the sum of PY5, PY6, PY7 Q1, PY7 Q2, and PY7 Q3 results, minus any Phase II savings that expired during PY5, PY6 or PY7.

### Program Year-to-Date (PYTD)

Refers to the current reporting program year only. Activities occurring during previous program years are not included. For example, PYTD results for PY7 Q3 will include only results that occurred during PY7 Q1, PY7 Q2, and PY7 Q3; they will not include results from PY5 or PY6.

## SAVINGS TYPES

### Preliminary

Qualifier used in all reports, except the final annual report, to signify that evaluations are still in progress and that results have not been finalized. Most often used with realization rate or verified gross savings.

### Reported Gross

Refers to results of the program or portfolio, determined by the program administrator (e.g., the electric distribution company [EDC] or the program implementer). Also known as ex ante, or “before the fact” savings (using the annual evaluation activities as the reference point for the post period).

### Adjusted Ex Ante Gross

References to Adjusted Ex Ante Gross (or Adjusted Ex Ante) savings in this report refer to reported gross savings from the EDC’s tracking system that have been adjusted, where necessary, to reflect differences between the methods used to record and track savings and the methods in the Technical Reference Manual (TRM). These corrections are made to the population, prior to EM&V activities. The adjusted ex ante gross savings are then verified through EM&V activities.

### Verified Gross

Refers to the verified gross savings results of the program or portfolio determined by the evaluation activities. Also known as ex post, or "after the fact" savings (using the annual evaluation activities as the reference point for the post period).

### Verified Net

The total change in load that is attributable to an energy efficiency program. This change in load may include, implicitly or explicitly, the effects of spillover, free-riders, energy efficiency standards, changes in the level of energy service, and other causes of changes in energy consumption or demand. Net savings are calculated by multiplying verified savings by a net-to-gross (NTG) ratio.

## TOTAL RESOURCE COST COMPONENTS[1]

### Administration, Management, and Technical Assistance Costs

Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.

### EDC Costs

Per the Pennsylvania PUC 2013 Total Resource Cost (TRC) Test Order, the total EDC costs refer to EDC-incurred expenditures only. This includes, but is not limited to, administration, management, technical assistance, design & development of EE&C Plans and programs, marketing, evaluation, and incentives.

### Participant Costs

Participant Costs as defined by the 2013 Total Resource Cost Test Order.

### Total TRC Costs

Total TRC Costs as defined by the 2013 Total Resource Cost Test Order.

### Total TRC Benefits

Benefits as defined by the 2013 Total Resource Cost Test Order.

[1] All Total Resource Cost definitions are subject to the Pennsylvania PUC 2013 Total Resource Cost Test Order.

# 1 OVERVIEW OF PORTFOLIO

Pennsylvania Act 129 of 2008, which was signed on October 15, 2008, mandated energy savings and demand reduction goals for the largest electric distribution companies (EDCs) in Pennsylvania for Phase I (2008 through 2013). In 2009, each EDC submitted energy efficiency and conservation (EE&C) plans pursuant to these goals, which were approved by the Pennsylvania Public Utility Commission (PUC). Each EDC filed new EE&C plans with the PUC in 2012 for Phase II (June 2013 through May 2016) of the Act 129 programs. These plans were approved by the PUC in 2013.

Implementation of Phase II Act 129 programs began June 1, 2013. This report documents the progress and effectiveness of the Phase II EE&C accomplishments for PPL Electric Utilities in Program Year 7 (PY7), defined as June 1, 2015, through May 31, 2016, as well as the cumulative accomplishments of the programs since inception of Phase II. This report additionally documents the energy savings carried over from Phase I. The Phase I carry-over savings count toward EDC savings compliance targets for Phase II.

Cadmus, the evaluation, measurement, and verification conservation service provider (EM&V CSP), evaluated the programs, which included measurement and verification of the savings. PPL Electric Utilities met all of its Phase II energy savings targets (overall portfolio, low-income, and government/nonprofit/education [GNE]), under budget and the portfolio was cost-effective. The programs operated effectively with high customer satisfaction.

In PY7, PPL Electric Utilities' portfolio included 13 active programs:[2]

1. The Prescriptive Equipment Program offers nonresidential customers rebates and incentives from a list of specific energy-efficient lighting and equipment. The program also offers a direct discount component.
2. The Residential Retail Program offers rebates and upstream incentives for energy efficiency products found in retail stores. Exact participation in the upstream lighting component is not known. The EM&V CSP estimates the number of participants in this component of the program by dividing the total number of bulbs discounted or given away by a bulb-per-participant value derived from data collected during the most recent general population surveys with residential and commercial customers. The total participant count for this program comprises equipment-rebate participants, midstream equipment-incentive participants (midstream incentives were discontinued during PY5), and estimated lighting participants.
3. The Custom Incentive Program offers nonresidential customers incentives per annual kilowatt hour (kWh) saved during the first year of participation. Beginning in PY6 Quarter 1 (Q1), the methodology for counting participants for this program changed. The participant count is now the number of projects contributing to reported savings for the specified period (as opposed to the number of projects created in that period).
4. The Residential Energy-Efficiency Behavior & Education Program provides high-usage residential customers with a series of home energy reports showing their energy use, comparing their usage to similar customers, and providing energy savings tips. The participant count for this program includes customers who received at least one home energy report and is not adjusted for opt-outs or those whose accounts became inactive.

2 The list of programs is organized by the largest contributor to Phase II portfolio savings to the smallest. The individual program chapters are presented in this order. Program information in portfolio-level tables are organized in alphabetical order.

5. The Appliance Recycling Program offered customers incentives to recycle their outdated refrigerators, freezers, and air conditioners. This program was not active in PY7 Q4 because in PY7 Q2, the implementation CSP (ICSP), JACO Environmental, ceased operations.
6. The Residential Home Comfort Program offers rebates for energy-saving equipment in retrofitted existing homes and for new construction.
7. The Student & Parent Energy-Efficiency Education Program provides school-based energy-efficiency education through in-classroom workshops for students in various grade levels, training for teachers, and community workshops for parents in low-income neighborhoods. Beginning in PY6 Q3, the methodology for counting participants for this program changed. The participant count is now the number of kits distributed, instead of the previously reported number of classrooms. This change was applied to data for all of Phase II.
8. The Act 129 Winter Relief Assistance Program (WRAP) provides weatherization to income-qualified customers, using Act 129 funding to expand the existing Low-Income Usage Reduction Program. This program includes the De Facto Heating Pilot conducted in PY7.
9. The Low-Income Energy-Efficiency Behavior & Education Program provides qualified low-income customers with a series of home energy reports showing their energy use, comparing their usage to similar customers, and providing energy savings tips. The participant count for this program includes customers who received at least one home energy report and is not adjusted for opt-outs or those whose accounts became inactive.
10. The Master Metered Low-Income Multifamily Housing Program offers energy efficiency improvements in master metered multifamily low-income housing buildings. In PY7, the program expanded to include nursing homes.
11. The E-Power Wise Program provides low-income customers with information about energy use, along with take-home energy efficiency kits. This program includes the Wise Home Pilot conducted in PY7.
12. The Continuous Energy Improvement Program provides technical support for schools to develop and implement a Strategic Energy Management Plan.
13. The School Benchmarking Program works with school administrators to evaluate total building energy use using the Environmental Protection Agency's Portfolio Manager Tool. No energy savings were planned or claimed for this program.

A summary of program metrics can be found in Table 1-1. PPL Electric Utilities met or exceeded all of its Phase II energy savings targets (overall portfolio, low-income, and government/nonprofit/education), under budget and the portfolio was cost-effective with a Phase II portfolio total resource cost (TRC) of 1.59.

**Table 1-1: Phase II Portfolio Summary - Programs**

| Program | Phase II Reported Gross Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Gross Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr)[1] | Phase II NTG Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) | Program Acquisition Cost ($/Annual kWh)[2] | Cost of Conserved Energy (TRC Costs/Lifetime kWh, at Generation)[3] | Phase II Participants |
|---|---|---|---|---|---|---|---|---|---|
| Appliance Recycling | 25,668 | 25,809 | 25,012 | 0.72 | 3.68 | $4,026 | $0.16 | $0.026 | 26,784 |
| Continuous Energy Improvement | 4,808 | 4,783 | 4,697 | 1.00 | 1.25 | $993 | $0.21 | $0.063 | 45 |
| Custom Incentive | 57,610 | 57,610 | 56,852 | 0.54 | 1.32 | $7,373 | $0.13 | $0.057 | 207 |
| E-Power Wise | 7,920 | 8,654 | 5,933 | 1.00 | 3.16 | $1,237 | $0.21 | $0.033 | 11,546 |
| Low-Income Energy-Efficiency Behavior & Education | 10,833 | 10,833 | 10,622 | 1.00 | 0.65 | $1,523 | $0.14 | $0.142 | 87,376 |
| Low-Income WRAP | 12,135 | 12,118 | 11,832 | 1.00 | 0.75 | $16,538 | $1.40 | $0.140 | 10,273 |
| Master Metered Multifamily Housing | 6,012 | 5,948 | 6,488 | 0.78 | 1.52 | $2,172 | $0.33 | $0.056 | 141 |
| Prescriptive Equipment | 317,057 | 316,883 | 303,542 | 0.82 | 1.50 | $54,268 | $0.18 | $0.061 | 7,863 |
| Residential Energy-Efficiency Behavior & Education | 39,786 | 39,786 | 39,078 | 1.00 | 2.50 | $2,463 | $0.06 | $0.035 | 126,290 |
| Residential Home Comfort | 18,354 | 18,427 | 18,649 | 0.61 | 0.66 | $10,330 | $0.55 | $0.176 | 14,770 |
| Residential Retail | 203,802 | 207,565 | 206,018 | 0.69 | 3.75 | $25,960 | $0.13 | $0.033 | 624,277 |
| School Benchmarking[4] | - | - | - | | 0.00 | $370 | N/A | | 89 |
| Student & Parent Education | 16,108 | 17,185 | 13,397 | 1.00 | 2.05 | $5,345 | $0.40 | $0.054 | 67,732 |
| Common Costs | - | - | - | | | $28,709 | N/A | | |
| **Total[5]** | **720,094** | **725,600** | **702,121** | **0.77** | **1.59** | **$161,307[8]** | **$0.23** | **$0.063** | **977,393** |
| Adjustment for Residential Energy-Efficiency Behavior & Education Double-Counted Savings [6] | | | **(2,127)** | | | | | | |
| Adjustment for Low-Income Energy-Efficiency Behavior & Education Double-Counted Savings [6] | | | **(1,258)** | | | | | | |
| **Adjusted Portfolio Savings** | | | **698,736** | | | | | | |
| **Carryover Savings from Phase I** | | | **495,636** | | | | | | |
| **Total Portfolio Savings** | | | **1,194,372** | | | | | | |
| **Portfolio Compliance Target** | | | **>= 821,072** | | **> 1.0** | **< $184,500** [7] | | | |
| **Percentage Over/(Under) Compliance** | | | **45%** | | **62%** | **12.5%** (under budget) | | | |

[1] Excludes expiring one-year measure life savings.
[2] Total EDC Costs divided by first year kWh savings.
[3] Total TRC Costs divided by levelized lifetime kWh savings.
[4] The School Benchmarking Program is not designed to deliver energy savings.
[5] Total will not equal sum of column due to rounding.
[6] See *Appendix G: Energy-Efficiency Behavior & Education Program Savings Counted in Other Energy-Efficiency Programs*, which discusses methods to determine double-counted savings.
[7] Excludes SWE costs that are not subject to the cost cap.
[8] These are actual costs as of Sept. 31, 2016. PPL Electtric Utilities expects approximately $980,000 of additional actual costs (primarily for evaluation) through ~March 2017 when the SWE issues their final Phase II Report.

A summary of sector metrics can be found in Table 1-2.

**Table 1-2: Phase II Portfolio Summary - Sectors**

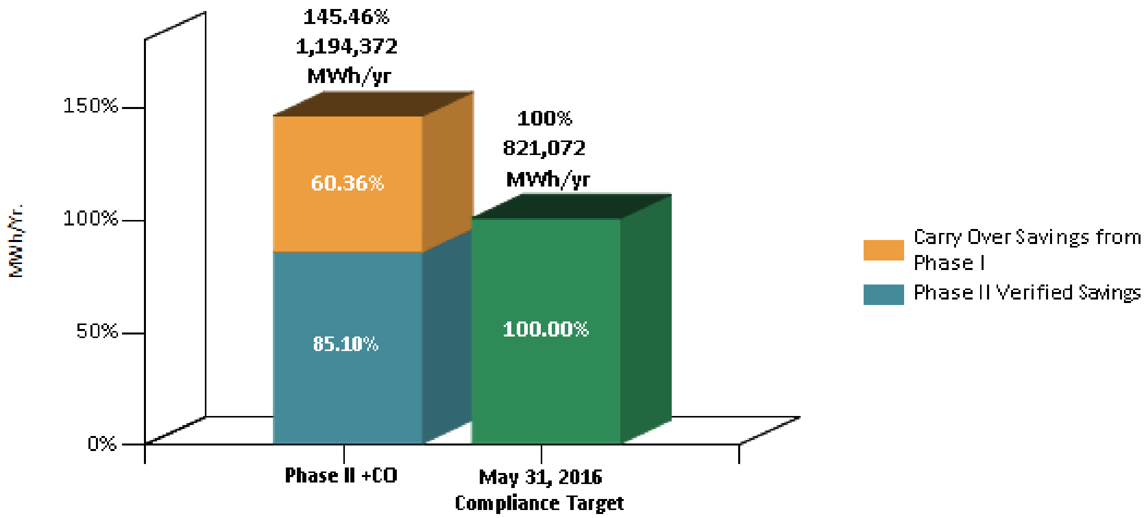
| Sector | Phase II Reported Gross Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Gross Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) [1] | Phase II NTG Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) | Program Acquisition Cost ($/Annual kWh)[2] | Cost of Conserved Energy (TRC Costs/Lifetime kWh, at Generation)[3] | Phase II Participants |
|---|---|---|---|---|---|---|---|---|---|
| Residential | 246,623 | 249,925 | 243,693 | 0.75 | 2.31 | $44,932 | $0.18 | $0.052 | 776,766 |
| Small Commercial & Industrial | 223,771 | 225,566 | 217,743 | 0.78 | 2.10 | $32,680 | $0.15 | $0.049 | 39,216 |
| Large Commercial & Industrial | 120,950 | 120,951 | 117,629 | 0.70 | 1.72 | $13,828 | $0.12 | $0.042 | 427 |
| Government/Nonprofit/Education | 96,395 | 96,130 | 93,248 | 0.80 | 0.94 | $21,017 | $0.23 | $0.094 | 3,789 |
| Low-Income[4] | 32,355 | 33,027 | 29,809 | 0.98 | 0.92 | $20,141 | $0.68 | $0.115 | 157,195 |
| Common Costs | | | | | | $28,709 | | | |
| **Total[5]** | **720,094** | **725,600** | **702,121** | **0.77** | **1.59** | **$161,307** | **$0.23** | **$0.063** | **977,393** |
| Adjustment for Residential Energy-Efficiency Behavior & Education Double-Counted Savings [6] | | | (2,127) | | | | | | |
| Adjusted Residential Savings | | | 241,566 | | | | | | |
| Adjustment for Low-Income Energy-Efficiency Behavior & Education Double-Counted Savings [6] | | | (1,258) | | | | | | |
| Adjusted Low-Income Savings | | | 28,551 | | | | | | |
| **Adjusted Portfolio Savings** | | | **698,736** | | | | | | |

[1] Excludes expiring one-year measure life savings.
[2]Total EDC Costs divided by first year kWh savings.
[3] Total TRC Costs divided by levelized lifetime kWh savings.
[4] Includes savings from designated low-income programs (E-Power Wise, Low-Income Energy-Efficiency Behavior & Education, and Low-Income WRAP) and the Residential Retail Program's LED giveaway component to low-income participants in the Low-Income Energy-Efficiency Behavior & Education Program. Excludes savings attributable to low-income participation in general residential programs. Savings attributed to low-income customers in general residential count toward the low-income sector compliance target. See Table 1-8 and *Appendix C: Low-income Participation in Non-Low-Income Programs.*
[5] Total will not equal sum of column due to rounding.
[6] See *Appendix G: Energy-Efficiency Behavior & Education Program Savings Counted in Other Energy-Efficiency Programs*, discussing methods to determine double-counted savings.

## 1.1 SUMMARY OF PROGRESS TOWARD COMPLIANCE TARGETS

PPL Electric Utilities achieved 145% of the energy savings compliance target, based on cumulative portfolio Phase II inception to date, including carryover savings from Phase I ("Phase II+CO") verified gross energy savings, as shown in Figure 1-1.

**Figure 1-1: Cumulative Portfolio Phase II Inception to Date Verified Gross Energy Impacts**




According to the Phase II Implementation Order, PPL Electric Utilities is allowed by the PUC to "carry over" into Phase II the Phase I verified energy savings that exceeded the Phase I compliance target. Table 1-3 shows the incremental annual MWh savings from Phase I that PPL Electric Utilities is carrying over into Phase II. Table 1-4 shows the lifetime MWh savings from Phase I that PPL Electric Utilities is carrying over into Phase II.

**Table 1-3: Phase II Verified Gross Savings and Verified Gross Savings from Phase I Carried Into Phase II [1]**

| Sector | PYTD Verified Gross Savings (MWh/yr) | Phase II Verified Gross Savings (Cumulative Phase II MWh/yr)[2] | Verified Gross Savings Carried Over from Phase I (Cumulative Annual MWh/yr) | Phase II+CO Verified Gross Savings (Cumulative MWh/yr) |
|---|---|---|---|---|
| Residential | 108,760 | 243,693 | - | 243,693 |
| Low-Income[3] | 19,658 | 29,809 | - | 29,809 |
| **Total Residential (Non-Low-Income Plus Low-Income) [4]** | **128,417** | **273,502** | **-** | **273,502** |
| Small Commercial & Industrial | 86,208 | 217,743 | - | 217,743 |
| Large Commercial & Industrial | 55,692 | 117,629 | - | 117,629 |
| **Commercial & Industrial [4]** | **141,900** | **335,372** | | **335,372** |
| Government/Nonprofit/Education | 47,044 | 93,248 | 92,143 | 185,391 |
| **Total[4]** | **317,361** | **702,121** | **495,636** | **1,197,757** |
| Adjustment for Residential Energy-Efficiency Behavior & Education Double-Counted Savings[5] | (2,127) | (2,127) | | (2,127) |
| Adjusted Residential Savings | 106,633 | 241,566 | | |
| Adjustment for Low-Income Energy-Efficiency Behavior & Education Double-Counted Savings[4] | (1,258) | (1,258) | | (1,258) |
| Adjusted Low-Income Savings | 18,400 | 28,551 | | |
| **Adjusted Portfolio Savings** | **313,976** | **698,736** | | **1,194,372** |

[1] Values in this table refer to savings at the point of consumption. (Savings targets for MWh refer to values at the point of consumption.) Due to line losses, savings at the point of generation are systematically larger.
[2] Excludes expiring one-year measure life savings.
[3] Includes savings from designated low-income programs (E-Power Wise, Low-Income Energy-Efficiency Behavior & Education, and Low-Income WRAP) and the Residential Retail Program's LED giveaway component to low-income participants in the Low-Income Energy-Efficiency Behavior & Education Program. Excludes savings attributable to low-income participation in general residential programs. Savings attributed to low-income customers in general residential programs count toward the low-income sector compliance target. See Table 1-8 and *Appendix C: Low-income Participation in Non-Low-Income Programs*.
[4] Sum of group totals may not equal cumulative total due to rounding.
[5] See *Appendix G: Energy-Efficiency Behavior & Education Program Savings Counted in Other Energy-Efficiency Programs* discussing methods to determine double-counted savings, which discusses methods to determine double-counted savings.

**Table 1-4: Phase II Verified Gross Lifetime Savings and Verified Gross Lifetime Savings from Phase I Carried Into Phase II [1]**

| Sector | PYTD Verified Gross Savings (Lifetime MWh) | Phase II Verified Gross Savings (Lifetime MWh) | Verified Gross Savings Carried Over from Phase I (Lifetime MWh) [2] | Phase II+CO Verified Gross Savings (Lifetime MWh) |
|---|---|---|---|---|
| Residential | 794,357 | 1,987,279 | - | 1,987,279 |
| Low-Income | 110,905 | 246,389 | - | 246,389 |
| **Total Residential (Non-Low-Income Plus Low-Income)** | **905,262** | **2,233,668** | **-** | **2,233,668** |
| Small Commercial & Industrial | 1,106,789 | 2,683,517 | - | 2,683,517 |
| Large Commercial & Industrial | 788,445 | 1,698,829 | - | 1,698,829 |
| **Total Commercial & Industrial [3]** | **1,895,234** | **4,382,347** | **-** | **4,382,347** |
| Government/Nonprofit/Education | 606,169 | 1,253,114 | 1,349,379 | 2,602,494 |
| **Total[3]** | **3,406,665** | **7,869,129** | **5,235,829** | **13,104,958** |

[1] Values in this table refer to savings at the point of consumption. (Savings targets for MWh refer to values at the point of consumption.) Due to line losses, savings at the point of generation are systematically larger.
[2] The statewide evaluator (SWE) requested reporting lifetime carryover in this table to demonstrate lifetime savings from Phase I and Phase II. Because there was no compliance target for lifetime savings in Phase I, lifetime carryover is estimated by multiplying the proportion of lifetime to annual savings from Phase I by the Phase I annual carryover.
[3] Total will not equal sum of columns due to rounding.

**Table 1-5: Phase I and Phase II Cumulative Annual Savings**

| Sector | Phase I Cumulative Annual Savings (MWh) | Phase II Cumulative Annual Savings (MWh) | Act 129 Cumulative Annual Savings (MWh) Through Phase II |
|---|---|---|---|
| Residential (non-low-income) | 597,896 | 241,566 | 839,462 |
| Residential (low-income) [1] | 23,180 | 28,551 | 51,731 |
| **Total Residential (Non-low-Income Plus Low-Income** | **621,076** | **270,117** | **891,193** |
| Commercial & Industrial | 814,204 | 335,372 | 1,149,576 |
| Government/Nonprofit/Education | 206,786 | 93,248 | 300,034 |
| **Total[2]** | **1,642,067** | **698,736** | **2,340,803** |

[1] Includes savings from designated low-income programs (E-Power Wise, Low-Income Energy-Efficiency Behavior & Education, and Low-Income WRAP) and the Residential Retail Program's LED giveaway component to low-income participants in the Low-Income Energy-Efficiency Behavior & Education Program.. Excludes savings attributable to low-income participation in general residential programs. Savings attributed to low-income customers in general residential count toward the low-income sector compliance target. See Table 1-8 and *Appendix C: Low-income Participation in Non-Low-Income Programs*.
[2] Total will not equal sum of columns due to rounding.

**Table 1-6: Phase II Verified Net First-Year and Lifetime Savings [1]**

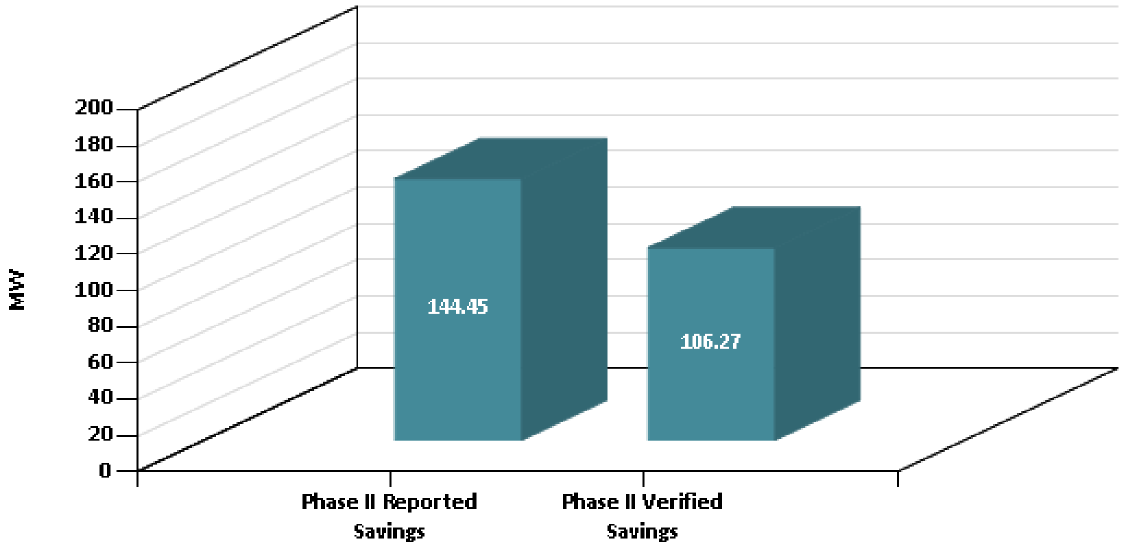
| Sector | PYTD Verified Net Savings (MWh/yr) | Phase II Verified Net Savings (Cumulative Phase II MWh/yr) | PYTD Verified Net Savings (Lifetime MWh)[2] | Phase II Verified Net Savings (Lifetime MWh) [2] |
|---|---|---|---|---|
| Government/Nonprofit/Education | 36,207 | 75,008 | 466,529 | 1,008,001 |
| Large C&I | 39,636 | 82,795 | 561,140 | 1,195,755 |
| Low-Income | 19,103 | 29,254 | 107,777 | 241,806 |
| Residential | 83,355 | 183,970 | 608,809 | 1,500,247 |
| Small C&I | 63,096 | 170,785 | 810,061 | 2,104,804 |
| **Total[3]** | **241,397** | **541,813** | **2,591,240** | **6,072,455** |
| Adjustment for Residential Energy-Efficiency Behavior & Education Double-Counted Savings | (2,127) | (2,127) | | |
| Adjusted Residential Savings | 81,228 | 181,843 | | |
| Adjustment for Low-Income Energy-Efficiency Behavior & Education Double-Counted Savings | (1,258) | (1,258) | | |
| Adjusted Low-Income Savings | 17,845 | 27,996 | | |
| **Adjusted Portfolio Savings** | **238,012** | **538,428** | | |

[1] Values in this table refer to savings at the point of consumption. (Savings targets for MWh refer to values at the point of consumption.) Due to line losses, savings at the point of generation are systematically larger.
[2] Phase II Verified Net Lifetime Savings are estimated by multiplying Verified Gross Lifetime Savings by the ratio of net-to-gross savings at the sector level. Using this same method at the portfolio level will not produce the same estimate.
[3] Total will not equal sum of columns due to rounding and due to the method described in table note [2].

In addition, PPL Electric Utilities achieved 106 MW of gross verified demand reduction during Phase II.[3] See Figure 1-2. Additional detail on achieved demand reduction by program can be found in Table 1-13 and Table 1-14 of this section.

[3] Unlike Phase I, there is no compliance target for demand reduction in Phase II. The Commission, however, requires that demand reduction savings in Phase II be reported including line losses, as was done in Phase I.

Figure 1-2: Phase II Portfolio Reported and Verified Demand Reduction




There are 36 measures available at no cost to low-income customers. These measures comprise 46% of the total measures offered. As required by the Phase II goal, this exceeds the fraction of the electric consumption of the utility's low-income households divided by the total electricity consumption in the PPL Electric Utilities territory by 36%.[4] These values are shown in Table 1-7 and Table 1-8.

Table 1-7: Phase II Low-Income Sector Compliance (Number of Measures)

| | Low-Income Sector | All Sectors | Percentage of Low-Income | Goal |
|---|---|---|---|---|
| **Number of Measures Offered** | 62 | 134 | 46% | 9.95% |

4 Act 129 includes a provision requiring electric distribution companies to offer a number of energy efficiency measures to low-income households that are "proportionate to those households' share of the total energy usage in the service territory." 66 Pa.C.S. §2806.1(b)(i)(G).

**Table 1-8: Phase II Low-Income Sector Compliance (Percentage of Savings)**

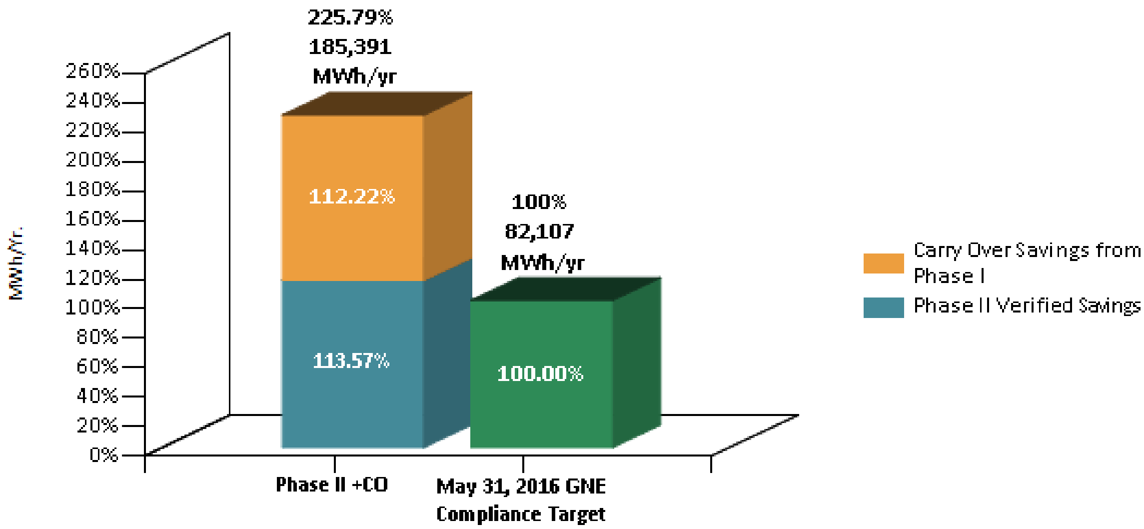
| Sector | Phase II Verified Gross Energy Savings (MWh/yr) | Proportion of Pre-Adjusted Total |
|---|---|---|
| Low-Income Verified Gross Savings from Low-Income Programs (Cumulative Annual MWh/yr) [1] | 28,387 | 47.3% (28,387 / 59,961) |
| Low-Income Verified Gross Savings from Other Residential Programs (Incremental Annual MWh/yr) [2] | 31,574 | 52.7% (31,574 / 59,961) |
| **All Low-Income Verified Gross Savings** (Sum of First Two Rows) | **59,961** | **100%** |
| Adjustment for Low-Income Energy-Efficiency Behavior & Education Double-Counted Savings[3] | (1,258) | N/A |
| Adjusted Low-Income Savings | **58,703** | |
| **Progress Toward Low-Income Goal** (Previous Row Divided by Phase II MWh Target) | 158.88% | |
| **Target** (MWh/yr) | **36,948** | |
| Savings in Excess of Target (MWh/yr) (58,703 – 36,948) | 21,755 | |
| **Savings Carried into Phase III** (Excess Savings (21,755) x Proportion from Low-Income Programs (47.3%)) [4] | **10,299** | |

[1] Savings from low-income specific programs: E-Power Wise, Low-Income Energy-Efficiency Behavior & Education, and Low-Income WRAP. Does not include bulbs given away to low-income customers reported under the Residential Retail Program.
[2] Includes savings attributed to low-income participation in general residential programs and bulbs given away to low-income customers reported under the Residential Retail Program. (See *Appendix C: Low-income Participation in Non-Low-Income Programs*.)
[3] See *Appendix G. Energy-Efficiency Behavior & Education Program Savings Counted in Other Energy-Efficiency Programs,* discussing methods to determine double-counted savings.
[4] The Phase III Implementation Order allows low-income verified savings in excess of the compliance target to be carried into Phase III based on the proportion of low-income specific program savings to the total low-income verified savings. Because the adjustment to double-counting savings is based on cross-participation between the Low-Income Energy-Efficiency Behavior & Education Program and other programs (both low-income specific and general residential programs), the proportion was calculated prior to application of this adjustment. The proportion is then applied to the total adjusted savings.

The Phase II verified gross energy savings achieved through programs specifically designed for income-eligible customers are 28,387 MWh/yr and an additional 31,574 MWh/yr through other programs; after adjusting for double-counting (see *Appendix G. Energy-Efficiency Behavior & Education Program Savings Counted in Other Energy-Efficiency Programs*), this is 159% against the 4.5% Phase II total portfolio verified gross energy savings target for the low-income sector.

PPL Electric Utilities achieved 226% of the May 31, 2016, energy reduction compliance target for the government, nonprofit, and education sector based on cumulative program/portfolio savings from Phase II+CO verified gross energy savings achieved from the inception of Phase II through PY7 and including carry-over savings from Phase I as shown in Figure 1-3.

**Figure 1-3: Government, Nonprofit, and Education Sector Phase II Verified Gross Energy Impacts**




A summary of the number of participants, Phase II verified gross energy savings (MWh/yr), Phase II demand reduction (MW), and incentives paid ($1,000) are shown in Table 1-9.

**Table 1-9: Summary of Phase II Performance by Sector**

| Sector | Participants | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Verified Gross Demand Reduction (MW) [1] | Incentives ($1,000) |
|---|---|---|---|---|
| Residential | 776,766 | 243,693 | 31.81 | $21,972 |
| Small C&I | 39,216 | 217,743 | 40.90 | $21,449 |
| Large C&I | 427 | 117,629 | 14.73 | $10,167 |
| Government/Nonprofit/Education | 3,789 | 93,248 | 14.41 | $14,072 |
| Low-Income [2] | 157,195 | 29,809 | 4.41 | $0 |
| **Phase II Total[3]** | **977,393** | **702,121** | **106.27** | **$67,661** |
| Adjustment for Residential Energy-Efficiency Behavior & Education Double-Counted Savings[4] | | (2,127) | | |
| Adjusted Residential Savings | | 241,566 | | |
| Adjustment for Low-Income Energy-Efficiency Behavior & Education Double-Counted Savings[4] | | (1,258) | | |
| Adjusted Low-Income Savings | | 28,551 | | |
| **Adjusted Portfolio Savings** | | **698,736** | | |

[1]Verified gross demand reductions include T&D losses.
[2] Includes savings from low-income specific programs (E-Power Wise, Low-Income Energy-Efficiency Behavior & Education and Low-Income WRAP) and the LED giveaway component of Residential Retail. Excludes savings attributable to low-income participation in general residential programs. Savings attributed to low-income customers in general residential count toward the low-income compliance target. See Table 1-8 and *Appendix C: Low-income Participation in Non-Low-Income Programs*.
[3]Total will not equal sum of columns due to rounding.
[4] See *Appendix G. Energy-Efficiency Behavior & Education Program Savings Counted in Other Energy-Efficiency Programs*, discussing methods to determine double-counted savings.

A summary of the energy savings from Phase I programs that remain in Phase II is shown in Table 1-10 for both the beginning and the end of Phase II.

**Table 1-10: Summary of Phase I Verified Gross Savings Remaining Through Phase II**

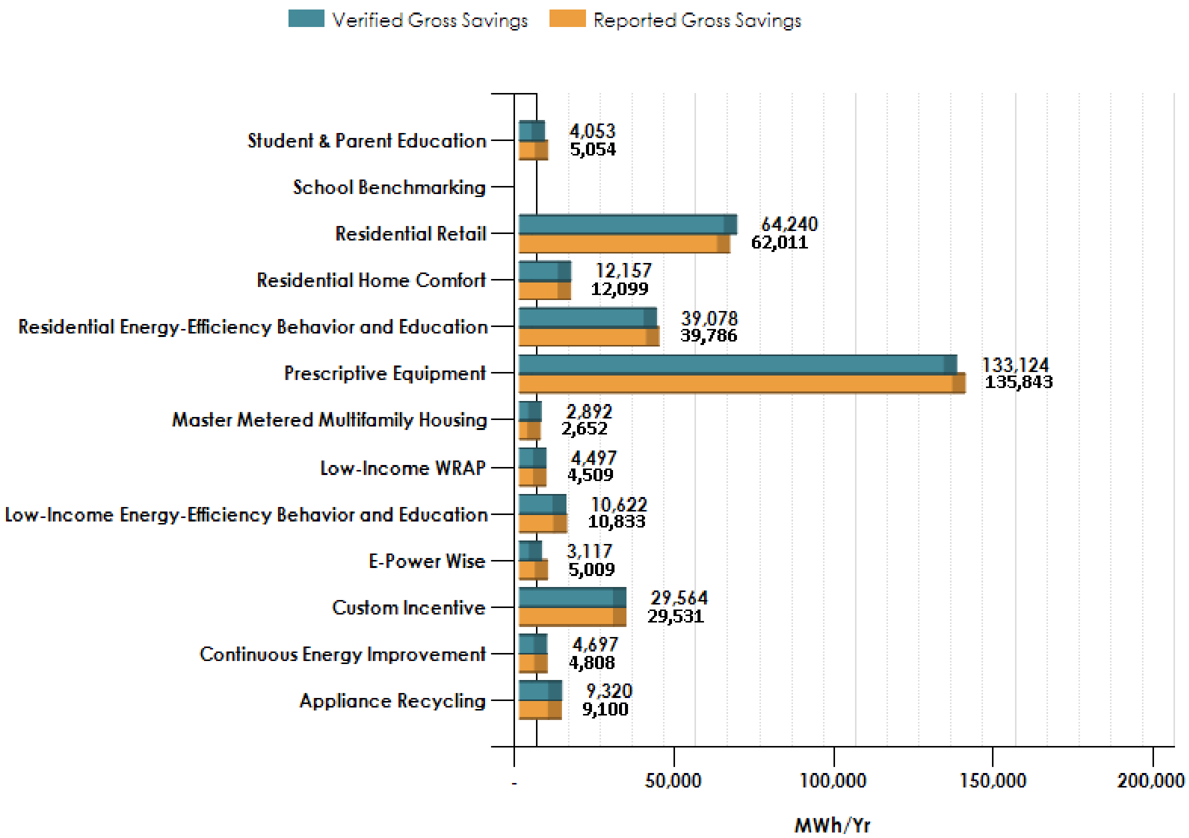
| Sector | Phase I Carryover MWh/yr | Phase II Verified Gross Savings (Cumulative Phase II MWh/yr)[1] | Phase I Carryover Savings + Phase II Cumulative Annual Savings MWh/yr | Adjusted Low – Income Savings (MWh/yr) [2] | Phase II Targets (MWh/yr) | Phase II Carryover Savings into Phase III (MWh/yr) |
|---|---|---|---|---|---|---|
| Residential | - | 243,693 | 243,693 | | - | - |
| Low-Income | - | 29,809 | 29,809 | 58,703 | 36,948 | 10,299[2] |
| Small C&I | - | 217,743 | 217,743 | | - | - |
| Large C&I | - | 117,629 | 117,629 | | - | - |
| Government/Nonprofit/Education | 92,143 | 93,248 | 185,391 | | 82,107 | 11,141 |
| **Total[4]** | **495,636** | **702,121** | **1,197,757** | | **821,072** | **-** |
| Adjustment for Residential Energy-Efficiency Behavior & Education Double-Counted Savings[5] | | (2,127) | | | | |
| Adjusted Residential Savings | | 241,566 | | | | |
| Adjustment for Low-Income Energy-Efficiency Behavior & Education Double-Counted Savings[5] | | (1,258) | | | | |
| Adjusted Low-Income Savings | | 28,551 | | | | |
| **Adjusted Portfolio Savings** | | **698,736** | | | | **0** |

[1] Excludes expiring one-year measure life savings.
[2] See Table 1-8 for breakdown of low-income savings counted toward compliance.
[4] Sum of group totals may not equal cumulative total due to rounding. Portfolio total including carryover includes portfolio-level carryover, not GNE carryover (i.e., does not double-count GNE carryover).
[5] See *Appendix G. Energy-Efficiency Behavior & Education Program Savings Counted in Other Energy-Efficiency Programs*, discussing methods to determine double-counted savings.

## 1.2 SUMMARY OF ENERGY IMPACTS

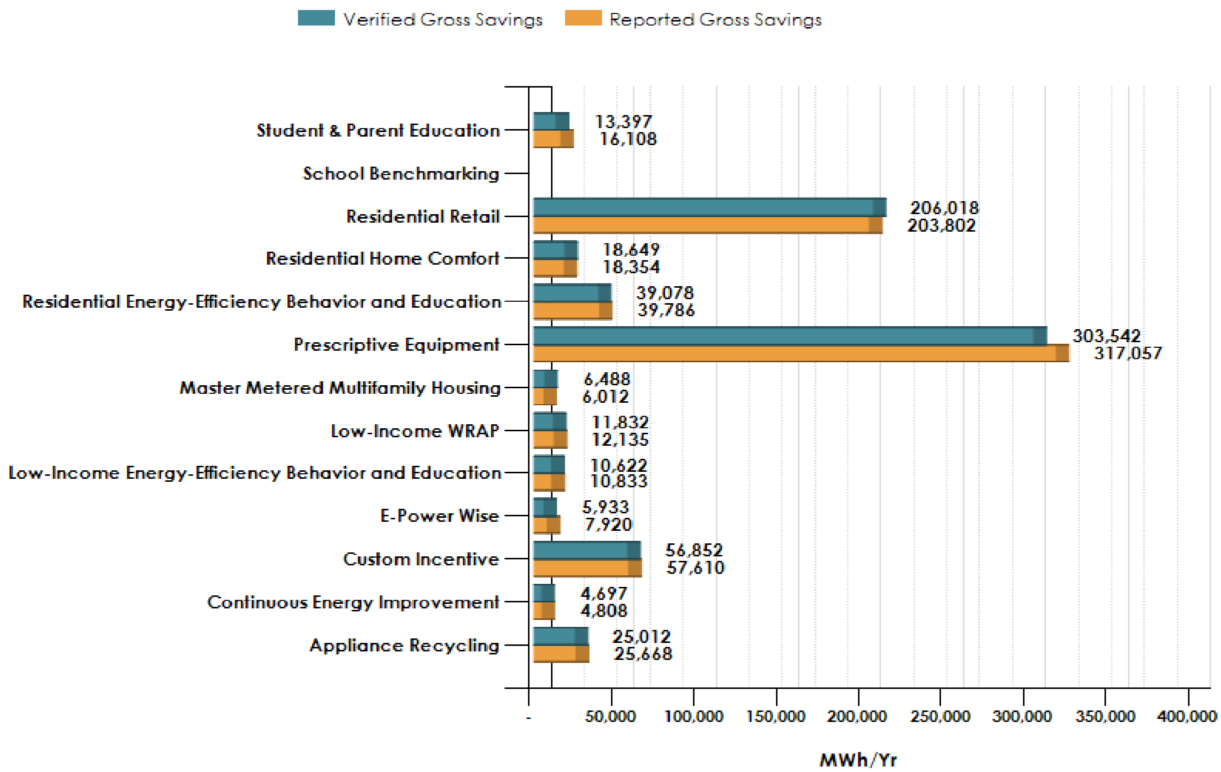
A summary of the reported and verified energy savings by program for PY7 is presented in Figure 1-4.

**Figure 1-4: PYTD Reported and Verified Gross Energy Savings by Program (MWh/yr)**




A summary of the Phase II reported and verified energy savings by program is presented in Figure 1-5.

**Figure 1-5: Phase II Reported and Verified Gross Energy Savings by Program (MWh/yr)**




Summaries of energy impacts by program through PY7 are presented in Table 1-11 and Table 1-12.

**Table 1-11: Reported Participation and Gross Energy Savings by Program**

| Program | Participants[1] | | Reported Gross Impact (MWh/yr) | |
|---|---|---|---|---|
| | PYTD | Phase II | PYTD | Phase II[2] |
| Appliance Recycling | 7,200 | 26,784 | 9,100 | 25,668 |
| Continuous Energy Improvement | 45 | 45 | 4,808 | 4,808 |
| Custom Incentive[3] | 82 | 207 | 29,531 | 57,610 |
| E-Power Wise | 5,229 | 11,546 | 5,009 | 7,920 |
| Low-Income Energy-Efficiency Behavior & Education[3] | 87,376 | 87,376 | 10,833 | 10,833 |
| Low-Income WRAP | 3,434 | 10,273 | 4,509 | 12,135 |
| Master Metered Multifamily Housing | 55 | 141 | 2,652 | 6,012 |
| Prescriptive Equipment | 1,821 | 7,863 | 135,843 | 317,057 |
| Residential Energy-Efficiency Behavior & Education[3] | 126,290 | 126,290 | 39,786 | 39,786 |
| Residential Home Comfort | 7,947 | 14,770 | 12,099 | 18,354 |
| Residential Retail[3] | 225,783 | 624,277 | 62,011 | 203,802 |
| School Benchmarking[3] | 52 | 89 | - | - |
| Student & Parent Education[3] | 25,085 | 67,732 | 5,054 | 16,108 |
| **Total Portfolio [4]** | **490,399** | **977,393** | **321,234** | **720,094** |

[1] Participation counts are the number of jobs, except where noted otherwise. See *Appendix A. EM&V Information* for participant definitions.
[2] Excludes expiring one-year measure life savings.
[3] See Residential Retail program chapter for details regarding the methodology for counting participants.
[4] Total will not equal sum of column due to rounding.

**Table 1-12: Verified Gross Energy Savings by Program**

| Program | PYTD Reported Gross Energy Savings (MWh/yr) | PYTD Adjusted *Ex Ante* Gross Energy Savings (MWh/yr) [5] | PYTD Energy Realization Rate | PYTD Verified Gross Savings (MWh/yr) | PYTD Achieved Precision[1] | Phase II Verified Gross Savings (Cumulative Phase II MWh/yr) | Phase II Achieved Precision[2] |
|---|---|---|---|---|---|---|---|
| Appliance Recycling | 9,100 | 9,320 | 100.00% | 9,320 | N/A | 25,012 | 1.23% |
| Continuous Energy Improvement | 4,808 | 4,783 | 98.21% | 4,697 | 3.83% | 4,697 | 3.83% |
| Custom Incentive | 29,531 | 29,531 | 100.11% | 29,564 | 4.26% | 56,852 | 3.38% |
| E-Power Wise | 5,009 | 4,994 | 62.41% | 3,117 | 3.34% | 5,933 | 2.52% |
| Low-Income Energy-Efficiency Behavior & Education | 10,833 | 10,833 | 98.05% | 10,622 | 20.82% | 10,622 | 20.82% |
| Low-Income WRAP | 4,509 | 4,492 | 100.11% | 4,497 | 2.27% | 11,832 | 2.60% |
| Master Metered Multifamily Housing | 2,652 | 2,651 | 109.09% | 2,892 | 9.85% | 6,488 | 4.71% |
| Prescriptive Equipment | 135,843 | 135,667 | 98.13% | 133,124 | 1.77% | 303,542 | 1.45% |
| Residential Energy-Efficiency Behavior & Education | 39,786 | 39,786 | 98.22% | 39,078 | 10.69% | 39,078 | 10.69% |
| Residential Home Comfort | 12,099 | 12,220 | 99.48% | 12,157 | 2.45% | 18,649 | 1.61% |
| Residential Retail | 62,011 | 64,243 | 100.00% | 64,240 | 11.47% | 206,018 | 4.99% |
| School Benchmarking | - | - | - | - | - | - | 0.00% |
| Student & Parent Education | 5,054 | 5,113 | 79.26% | 4,053 | 0.93% | 13,397 | 0.55% |
| **Total Portfolio[3]** | **321,234** | **323,634** | **98.06%** | **317,361** | **N/A** | **702,121** | 1.80% |
| Adjustment for Residential Energy-Efficiency Behavior & Education Double-Counted Savings [4] | | | | (2,127) | | | |
| Adjustment for Low-Income Energy-Efficiency Behavior & Education Double-Counted Savings[4] | | | | (1,258) | | | |
| **Adjusted Portfolio Savings** | | | | **313,976** | | | |
| Phase I Carryover | N/A | N/A | N/A | N/A | N/A | 495,636 | N/A |
| **Total Ph II+CO** | **N/A** | **N/A** | **N/A** | **N/A** | **N/A** | **1,195,630** | **N/A** |

[1] At the 85% confidence level
[2] At the 90% confidence level
[3] Total will not equal sum of column due to rounding.
[4] See *Appendix G. Energy-Efficiency Behavior & Education Program Savings Counted in Other Energy-Efficiency Programs*, which discusses methods to determine double-counted savings.
[5] See Report Definitions in this report (page xxiii), and program chapters for discussions about program-specific *ex ante* adjustments. Adjusted *ex ante* savings are used in the denominator to determine the realization rate.

## 1.3 SUMMARY OF FUEL-SWITCHING IMPACTS

Although the fuel-switching pilot program is a small part of the PPL Electric Utilities portfolio, the PUC is interested in the pilot's results. This section offers a summary. Additional detail is provided in *Appendix L: Fuel-Switching Pilot Analysis: Electricity to Fossil Fuels*.

In PY7, PPL Electric Utilities continued the fuel-switching pilot program, which was offered for the first time in PY5. This program offered rebates to customers who used electric space or water heat and installed new efficient non-electric space or water heating equipment. Three programs in PPL Electric Utilities' Phase II portfolio include equipment that could involve fuel-switching—Residential Home Comfort, Residential Retail, and Prescriptive Equipment. Only customers in the Residential Retail and Residential Home Comfort Programs participated in PY7. A total of 90 fossil fuel measures were rebated through this pilot program.

For fuel-switching pilot measures, eligibility for electricity savings is based on conversion from a standard electric water heater. Per-unit energy and demand savings are deemed in the Pennsylvania Technical Reference Manual (TRM). Cadmus applied the deemed values from either the 2013, 2014, or the 2015 Pennsylvania TRM, depending on the year within which the measure was installed. Fuel-switching measures account for 331 MWh/yr and 0.02 MW of PPL Electric Utilities' total PY7 verified gross savings and $23,550 of incentives paid.

Cadmus conducted a phone survey of the pilot program's participants to determine the reasons participants switched fuels and the influence of the incentives offered.

## 1.4 SUMMARY OF DEMAND IMPACTS

A summary of the reported and verified demand reduction by program for PY7 is presented in Figure 1-6. A summary of the cumulative reported and verified demand reduction by program is presented in Figure 1-7. The verified impacts in Figure 1-6 and Figure 1-7 reflect the line loss factors shown in Table 1-18.

**Figure 1-6: PYTD Reported and Verified Gross Demand Reduction by Program**

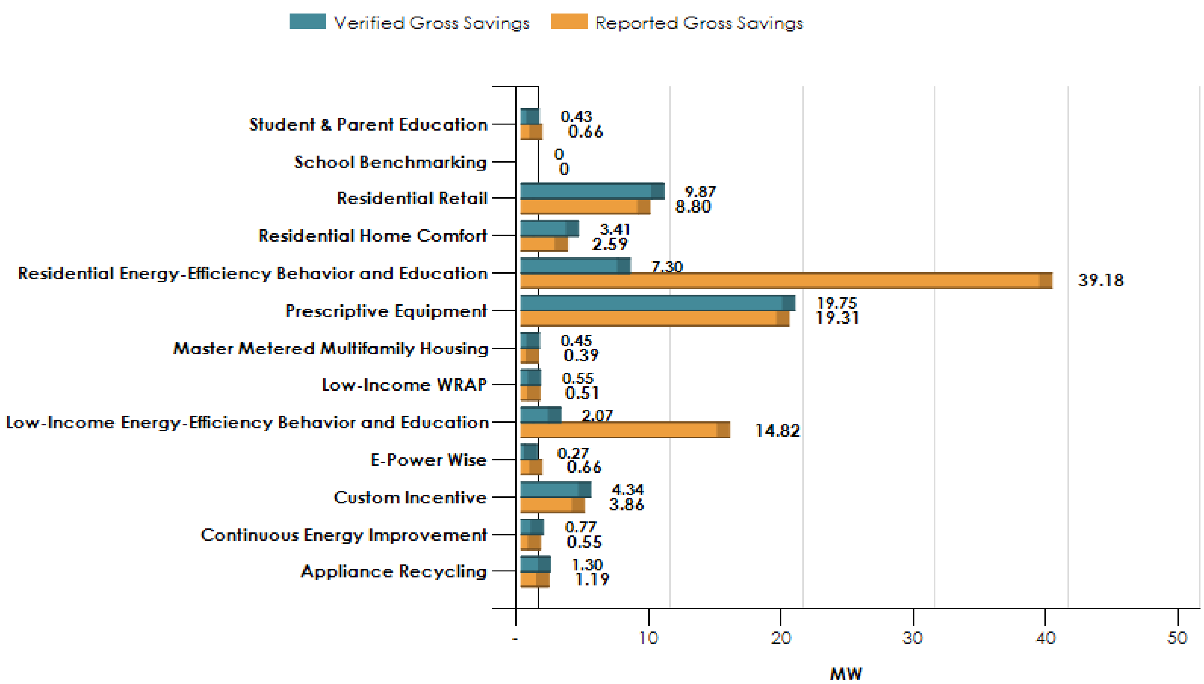
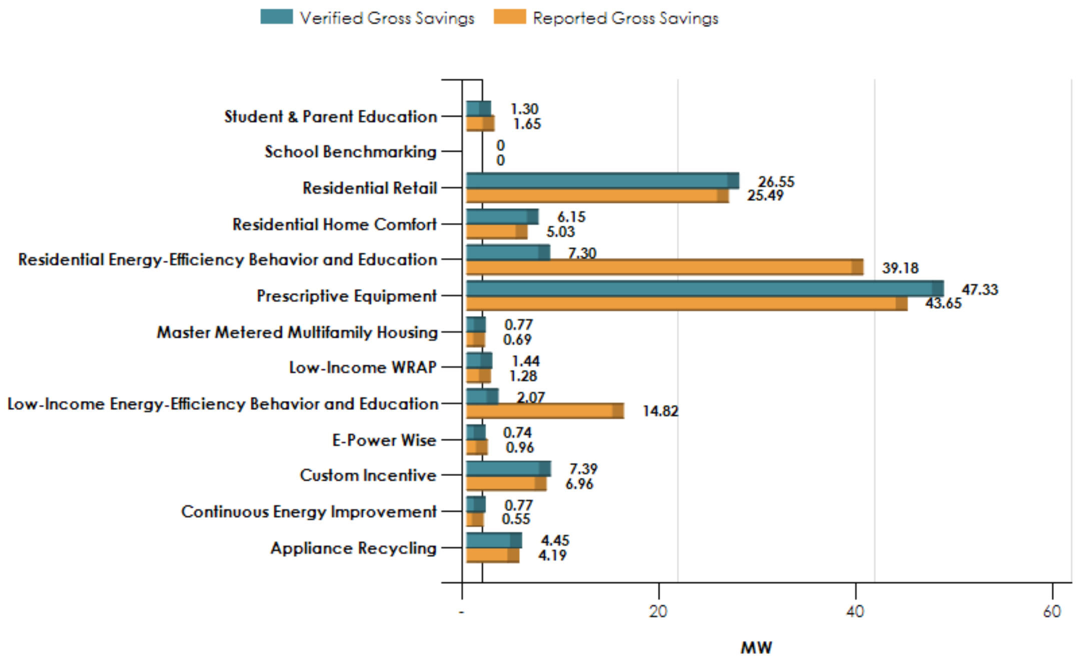


**Figure 1-7: Phase II Reported and Verified Gross Demand Reduction by Program**




A summary of demand reduction impacts by program through PY7 is shown in Table 1-13 and Table 1-14.

**Table 1-13: Reported Participation and Gross Demand Reduction by Program**

| Program | Participants[1] | | Reported Gross Impact (MW) | |
|---|---|---|---|---|
| | PYTD | Phase II | PYTD | Phase II[2] |
| Appliance Recycling | 7,200 | 26,784 | 1.19 | 4.19 |
| Continuous Energy Improvement | 45 | 45 | 0.55 | 0.55 |
| Custom Incentive[3] | 82 | 207 | 3.86 | 6.96 |
| E-Power Wise | 5,229 | 11,546 | 0.66 | 0.96 |
| Low-Income Energy-Efficiency Behavior & Education[3] | 87,376 | 87,376 | 14.82 | 14.82 |
| Low-Income WRAP | 3,434 | 10,273 | 0.51 | 1.28 |
| Master Metered Multifamily Housing | 55 | 141 | 0.39 | 0.69 |
| Prescriptive Equipment | 1,821 | 7,863 | 19.31 | 43.65 |
| Residential Energy-Efficiency Behavior & Education[3] | 126,290 | 126,290 | 39.18 | 39.18 |
| Residential Home Comfort | 7,947 | 14,770 | 2.59 | 5.03 |
| Residential Retail [3] | 225,783 | 624,277 | 8.80 | 25.49 |
| School Benchmarking [3] | 52 | 89 | - | - |
| Student & Parent Education [3] | 25,085 | 67,732 | 0.66 | 1.65 |
| **Total Portfolio [4]** | **490,399** | **977,393** | **92.51** | **144.45** |

[1] Participation counts are the number of jobs, except where noted otherwise. See *Appendix A. EM&V Information* for participant definitions.
[2] Excludes expiring one-year measure life savings.
[3] See Residential Retail program chapter for details regarding the methodology for counting participants.
[4] Total will not equal sum of column due to rounding.

**Table 1-14: Verified Gross Demand Reduction by Program**

| Program | PYTD Reported Gross Demand Savings (MW) | PYTD Adjusted *Ex Ante* Gross Demand Savings (MW) [1] [5] | PYTD Demand Realization Rate | PYTD Verified Gross Demand (MW) [1] | PYTD Achieved Precision [2] | Phase II Verified Gross Demand Savings (Cumulative Phase II MW) | Phase II Achieved Precision [3] |
|---|---|---|---|---|---|---|---|
| Appliance Recycling | 1.19 | 1.30 | 100.00% | 1.30 | | 4.45 | 1.33% |
| Continuous Energy Improvement | 0.55 | 0.58 | 131.44% | 0.77 | 46.57% | 0.77 | 43.84% |
| Custom Incentive | 3.86 | 4.06 | 107.01% | 4.34 | | 7.39 | 5.19% |
| E-Power Wise | 0.66 | 0.68 | 39.79% | 0.27 | 4.14% | 0.74 | 3.34% |
| Low-Income Energy-Efficiency Behavior & Education | 14.82 | 16.06 | 12.86% | 2.07 | 46.20% | 2.07 | 0.00% |
| Low-Income WRAP | 0.51 | 0.54 | 101.68% | 0.55 | | 1.44 | 2.90% |
| Master Metered Multifamily Housing | 0.39 | 0.41 | 109.96% | 0.45 | 7.62% | 0.77 | 5.21% |
| Prescriptive Equipment | 19.31 | 20.62 | 95.78% | 19.75 | 2.80% | 47.33 | 2.35% |
| Residential Energy-Efficiency Behavior & Education | 39.18 | 42.44 | 17.21% | 7.30 | 29.05% | 7.30 | 0.00% |
| Residential Home Comfort | 2.59 | 3.54 | 96.10% | 3.41 | 1.64% | 6.15 | 1.16% |
| Residential Retail | 8.80 | 9.87 | 100.00% | 9.87 | 11.70% | 26.55 | 5.56% |
| School Benchmarking | - | - | - | - | | - | 0.00% |
| Student & Parent Education | 0.66 | 0.72 | 59.25% | 0.43 | 0.96% | 1.30 | 0.51% |
| **Total Portfolio [4]** | **92.51** | **100.83** | **50.10%** | **50.51** | | **106.27** | 2.01% |
| Phase I Carryover | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **Total Ph II+CO** | **N/A** | **N/A** | **N/A** | **N/A** | **N/A** | **N/A** | **N/A** |

[1] *Ex ante* and verified gross demand reductions include T&D losses.
[2] At the 85% confidence level
[3] At the 90% confidence level
[4] Total will not equal sum of column due to rounding.
[5] See Report Definitions in this report (page xxiii), and program chapters for discussions about program-specific *ex ante* adjustments. Adjusted *ex ante* savings are used in the denominator to determine the realization rate.

## 1.5 SUMMARY OF PY7 NET-TO-GROSS RATIOS

Per the 2013 TRC Order, EDCs are required to conduct net-to-gross (NTG) research. NTG ratios are not used for compliance purposes but are used for cost-effectiveness reporting and future program planning purposes and are applied to gross savings to calculate net verified energy and demand savings. Table 1-15 presents a summary of NTG ratios by program and by the categories included in the analysis. Additional discussion about the net savings methodology and findings can be found in each program-specific chapter.

No freeridership or spillover analyses were conducted for income-qualified programs and those noted in Table 1-15, as discussed in the evaluation plans approved by the statewide evaluator (SWE). Accordingly, no budget was allocated for activities associated with the net savings analyses for these particular programs. Cadmus and PPL Electric Utilities believe that income-qualified participants who receive free products and services in Act 129 programs lack the financial means to purchase energy-efficient products, equipment and services in the absence of the program.

**Table 1-15: PY7 NTG Ratios by Program**

| Program Name | Free-ridership (%) | Spillover (%) | NTG Ratio PY7 | PY7 Verified Net | | NTG Categories Included |
|---|---|---|---|---|---|---|
| | | | | Energy Savings (MWh/yr) | Demand Savings (MW/yr) | |
| Appliance Recycling[2] | 40% | 0% | 0.60 | 5,592 | 0.78 | Self-report participant freeridership, secondary market impact, induced replacement, participant spillover. |
| Continuous Energy Improvement | 0% | 0% | 1.0 | 4,697 | 0.77 | Self-report survey, participant freeridership. |
| Custom Incentive | 39% | 0% | 0.61 | 18,034 | 2.65 | Self-report survey, participant freeridership, spillover. |
| E-Power Wise | N/A | N/A | N/A | 3,117 | 0.27 | Low-income program offers energy conservation kit at no cost to income-qualified customers. No freeridership. |
| Low-Income Energy-Efficiency Behavior & Education | N/A | N/A | N/A | 10,622 | 2.07 | Low-income program offers home energy report at no cost to customers. This is not an opt-in program for rebated products. Savings are determined using a billing analysis with a treatment and control group. This results in net savings. |
| Low-Income WRAP | N/A | N/A | N/A | 4,497 | 0.55 | Low-income program offered weatherization and heat pump water heaters at no cost to income-qualified customers. No freeridership. |
| Master Metered Multifamily Housing | N/A | N/A | N/A | 2,170 | 0.34 | No interviews conducted with decision-makers in PY7; Savings weighted average of PY5 NTGR and PY6 NTGR was applied to PY7 rebated lighting projects.[3] |
| Prescriptive Equipment | 23% | 0% | 0.77 | 102,795 | 15.25 | Self-report survey, participant freeridership, spillover. |
| Residential Energy-Efficiency Behavior & Education | N/A | N/A | N/A | 39,078 | 7.30 | This is not an opt-in program for rebated products. Program offers home energy report at no cost to customers. Savings are determined using a billing analysis with a treatment and control group. This results in net savings. |
| Residential Home Comfort | 42% | 4% | 0.61 | 7,464 | 2.21 | Self-report survey, participant freeridership, spillover. |
| Residential Retail | 39% | 0% | 0.61 | 39,278 | 6.03 | Self-report participant freeridership, spillover for rebated equipment (refrigerators and heat pump water heaters).<br>Demand elasticity modeling for upstream lighting freeridership; not adjusted for nonparticipant spillover, other market effects, or market progress indicators. |
| School Benchmarking | N/A | N/A | N/A | 0 | 0.00 | Not applicable; no savings claimed. |
| Student & Parent Education | N/A | N/A | N/A | 4,053 | 0.43 | Classroom education and energy conservation kits offered in school curricula at no cost to the school, teachers, or the students who receive the kit. No freeridership. |
| **Portfolio[1]** | **24%** | **0%** | **0.76** | **241,397** | **38.65** | |

[1] Weighting determined by the sum of PY7 program verified net energy savings divided by PY7 program verified gross energy savings.
[2] Cadmus did not estimate an NTG ratio but instead estimated the net per-unit savings and program-level net savings. This is because replacements were accounted for in the gross savings. The replacement status of the appliance determines the appropriate gross savings value to be applied; therefore, Cadmus calculated the net savings not from the gross savings but rather from the unit energy consumption (UEC) multiplied by part use (represented as UEC*part use). This avoids double-counting the penalty to the program for replacements.
[3] Cadmus did not conduct interviews with program decision-makers in PY7. Cadmus calculated a weighted average of PY5 and PY6 NTG ratios using PY5 and PY6 rebated lighting *ex post* gross population savings and applied the weighted NTG ratio to PY7 rebated lighting projects.

Table 1-16 presents the NTG ratios from PY5 compared to PY6 and PY7.

**Table 1-16: PY5, PY6 and PY7 NTG Ratios by Program**

| Program Name | NTG Ratio PY5 | NTG Ratio PY6 | NTG Ratio PY7 |
|---|---|---|---|
| Appliance Recycling | 0.74 | 0.87 | 0.60 |
| Continuous Energy Improvement | 1.0 | 1.0 | 1.0 |
| Custom Incentive | 0.55 | 0.45 | 0.61 |
| E-Power Wise (Low-Income) | N/A | N/A | N/A |
| Low-Income Energy-Efficiency Behavior & Education[1] | -- | - | N/A |
| Low-Income WRAP | N/A | N/A | N/A |
| Master Metered Multifamily Housing | 0.77 | 0.86 | -- |
| Prescriptive Equipment | 0.75 | .074 | 0.77 |
| Residential Energy-Efficiency Behavior & Education | - | N/A | N/A |
| Residential Home Comfort | 0.58 | 0.60 | 0.61 |
| Residential Retail | 0.83 | 0.52 | 0.61 |
| School Benchmarking[2] | - | - | - |
| Student & Parent Education | N/A | N/A | N/A |
| **(Weighted by Program Savings for Programs Reporting NTG Ratios)[3]** | **79%** | **71%** | **76%** |

[1] Program launched late in PY6.
[2] No savings are claimed for School Benchmarking.
[3] Weighting determined by the sum of program verified net energy savings divided by program verified gross energy savings for a given program year.

## 1.6 SUMMARY OF PORTFOLIO FINANCES AND COST-EFFECTIVENESS

A breakdown of the portfolio finances is presented in Table 1-17.

**Table 1-17: Summary of Portfolio Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs [6] ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs | $139,877 | $224,586 |
| 2 | EDC Incentives to Participants | $32,219 | $61,140 |
| 3 | EDC Incentives to Trade Allies | - | - |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $108,028 | $164,452 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6, 7, 8, 9, 10 ) | $32,497 | $86,370 |
| 6 | Design & Development | $46 | $1,484 |
| 7 | Administration, Management, and Technical Assistance[1] | $27,872 | $67,064 |
| 8 | Marketing[2] | $1,076 | $7,865 |
| 9 | EDC Evaluation Costs | $3,279 | $8,160 |
| 10 | SWE Audit Costs | $225 | $1,798 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | $333 | $2,222 |
| | | | |
| 12 | Total TRC Costs [3] (Sum of rows 1, 5 and 11) | $173,078 | $314,182 |
| 13 | Total NPV Lifetime Energy Benefits | $207,715 | $432,829 |
| 14 | Total NPV Lifetime Capacity Benefits | $17,625 | $34,834 |
| 15 | Total NPV O&M Saving Benefits | $12,945 | $31,576 |
| 16 | Total NPV TRC Benefits[4] | $238,285 | $499,240 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | 1.38 | 1.59 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.
[2] Includes the marketing CSP and marketing costs by program CSPs.
[3] Total TRC Costs includes Total EDC Costs and Participant Costs. Row 1 does not include Appliance Recycling Program incentives ($370), which are included in TRC costs.
[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.
[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[6] Phase II Costs in this table are discounted back to PY5, thus will not match cumulative costs reported in the PY6 Q4 quarterly report.

## 1.7 SUMMARY OF COST-EFFECTIVENESS BY PROGRAM IN PY7

TRC benefit-cost ratios are calculated by comparing the total net present value (NPV) TRC benefits and the total NPV TRC costs. Table 1-18 shows the TRC ratios by program and other key factors used in the TRC ratio calculation for Phase II programs.

**Table 1-18: PYTD TRC Ratios by Program**

| Program Name | PY7 TRC NPV Benefits ($1,000) | PY7 TRC NPV Costs ($1,000) | PY7 TRC Benefit-Cost Ratio | Discount Rate | Energy Line Loss Factor | Demand Line Loss Factor |
|---|---|---|---|---|---|---|
| Appliance Recycling | $5,782 | $1,240 | 4.66 | 8.14% | Multiple [1],[2],[3],[4] | Multiple [1],[2],[3],[4] |
| Continuous Energy Improvement | $1,035 | $361 | 2.87 | 8.14% | Multiple [1],[2],[3],[4] | Multiple [1],[2],[3],[4] |
| Custom Incentive | $20,302 | $16,178 | 1.25 | 8.14% | Multiple [1],[2],[3],[4] | Multiple [1],[2],[3],[4] |
| E-Power Wise | $1,729 | $601 | 2.88 [5] | 8.14% | 8.33% | 8.33% |
| Low-Income Energy-Efficiency Behavior & Education | $1,062 | $385 | 2.76 | 8.14% | 8.33% | 8.33% |
| Low-Income WRAP | $4,883 | $6,671 | 0.73 [6] | 8.14% | 8.33% | 8.33% |
| Master Metered Multifamily Housing | $1,581 | $951 | 1.66 | 8.14% | 6.23% | 6.23% |
| Prescriptive Equipment | $120,755 | $101,548 | 1.19 | 8.14% | Multiple [1],[2],[3],[4] | Multiple [1],[2],[3],[4] |
| Residential Energy-Efficiency Behavior & Education | $3,894 | $504 | 7.73 | 8.14% | Multiple [1],[2],[3],[4] | Multiple [1],[2],[3],[4] |
| Residential Home Comfort | $12,473 | $18,977 | 0.66 | 8.14% | Multiple [1],[2],[3],[4] | Multiple [1],[2],[3],[4] |
| Residential Retail | $61,325 | $16,347 | 3.75 | 8.14% | Multiple [1],[2],[3],[4] | Multiple [1],[2],[3],[4] |
| School Benchmarking | $0 | $92 | 0.00 | 8.14% | 6.23% | 6.23% |
| Student & Parent Education | $3,465 | $2,216 | 1.56 | 8.14% | 6.23% | 6.23% |
| Common Costs | | $7,006 | N/A | 8.14% | N/A | N/A |
| **Total [7]** | **$238,285** | **$173,078** | **1.38** | **8.14%** | **Multiple [1],[2],[3],[4]** | **Multiple [1],[2],[3],[4]** |

[1] Residential line loss factor of 8.33%
[2] Small C&I line loss factor of 8.33%
[3] Large C&I line loss factor of 4.12%
[4] GNE line loss factor of 6.23%. The GNE line loss factor is the average of Small/Large C&I and is consistent with the line loss used in PPL Electric Utilities' EE&C plan. Going forward, the actual participant rate class will be used to determine the blended GNE line loss factor.
[5] This represents the TRC including the Wise Home Pilot. The TRC for the Wise Home Pilot separately is 1.17, and the TRC for E-Power Wise separately is 3.21.
[6] This represents the TRC including the De Facto Heating Pilot. The TRC for the De Facto Heating Pilot separately is 0.21, and the TRC for LI WRAP separately is 0.75.
[7] Total will not equal sum of column due to rounding.

## 1.8 COMPARISON OF PY7 PERFORMANCE TO APPROVED EE&C PLAN

Table 1-19 shows PY7 expenditures compared to the estimates set forth in the EE&C plan.

**Table 1-19: Comparison of PY7 Program Expenditures to PY7 EE&C Plan**

| Program | PY7 Estimate from EE&C Plan ($1,000) | PY7 Actual Expenditures ($1,000) | % Difference from PY7 EE&C Plan [(Actual-Planned)/Planned] |
|---|---|---|---|
| Appliance Recycling | $1,897 | $1,240 | -35% |
| Continuous Energy Improvement | $302 | $361 | 20% |
| Custom Incentive | $3,700 | $3,626 | -2% |
| E-Power Wise | $688 | $601 | -13% |
| Low-Income Energy-Efficiency Behavior & Education | $701 | $385 | -45% |
| Low-Income WRAP | $6,400 | $6,667 | 4% |
| Master Metered Multifamily Housing | $1,361 | $771 | -43% |
| Prescriptive Equipment | $25,491 | $21,713 | -15% |
| Residential Energy-Efficiency Behavior & Education | $1,161 | $504 | -57% |
| Residential Home Comfort | $4,865 | $6,881 | 41% |
| Residential Retail | $14,870 | $12,652 | -15% |
| School Benchmarking | $125 | $92 | -26% |
| Student & Parent Education | $2,244 | $2,216 | -1% |
| **Total Direct Costs [2]** | **$63,804** | **$57,710** | **-10%** |
| Common Costs [1] | $12,021 | $7,006 | -42% |
| **Total [2]** | **$75,824** | **$64,716** | **-15%** |

[1] Planned common costs were estimated for Phase II, not by program year. For this table, program-year common costs are assumed to be one-third in each program year.
[2] Total will not equal sum of column due to rounding.

Table 1-20 shows PY7 program savings compared to the energy and demand savings estimates in the EE&C plan.

**Table 1-20: Comparison of PY7 Reported Program Savings to EE&C Plan Estimates**

| Program | PY7 Savings Estimates in EE&C Plan (MWh/yr) | PYTD Reported Gross Energy Savings (MWh/yr) | Energy % Difference [(PY7 Actual-Planned)/ PY7 Planned] | PY7 MW Savings Estimates in EE&C Plan[1] | PYTD Reported Gross Demand Savings (MW)[1] | Demand % Difference [(PY7 Actual-Planned)/ PY7 Planned] |
|---|---|---|---|---|---|---|
| Appliance Recycling | 7,729 | 9,100 | 18% | 1.04 | 1.19 | 14% |
| Continuous Energy Improvement | 2,567 | 4,808 | 87% | 0.42 | 0.55 | 30% |
| Custom Incentive | 23,682 | 29,531 | 25% | 3.89 | 3.86 | -1% |
| E-Power Wise | 2,261 | 5,009 | 122% | 0.29 | 0.66 | 126% |
| Low-Income Energy-Efficiency Behavior & Education | 8,280 | 10,833 | 31% | 1.07 | 14.82 | 1282% |
| Low-Income WRAP | 3,598 | 4,509 | 25% | 0.45 | 0.51 | 12% |
| Master Metered Multifamily Housing | 2,429 | 2,652 | 9% | 0.40 | 0.39 | -4% |
| Prescriptive Equipment | 85,053 | 135,843 | 60% | 16.10 | 19.31 | 20% |
| Residential Energy-Efficiency Behavior & Education | 30,749 | 39,786 | 29% | 3.98 | 39.18 | 884% |
| Residential Home Comfort | 9,302 | 12,099 | 30% | 1.49 | 2.59 | 73% |
| Residential Retail | 50,044 | 62,011 | 24% | 9.25 | 8.80 | -5% |
| School Benchmarking | - | - | 0% | - | 0.00 | 0% |
| Student & Parent Education | 4,746 | 5,054 | 6% | 0.61 | 0.66 | 8% |
| **Program Total [2]** | **230,441** | **321,234** | **39%** | **39.01** | **92.51** | **137%** |

[1] Planned MW reductions include T&D losses; Reported gross MW reductions do not include T&D losses.
[2] Total will not equal sum of column due to rounding.

Table 1-21 shows PY7 actual verified program savings compared to the energy and demand savings estimates filed in PPL Electric Utilities' EE&C Plan. The percentage difference column shows the percentage by which the verified gross savings differed from planned savings.

In PY7, all but one programs' verified energy savings exceeded projected savings described in PPL Electric Utilities' EE&C Plan, as shown in Table 1-21. The process evaluation sections in the program-specific chapters provide additional information about PY7 achievements against planned savings. The impact and process evaluations also discuss program updates and changes that may have affected energy savings.

The single program that did not achieve the PY7 energy savings projections was the Student & Parent Energy-Efficiency Education Program. Several products included in the energy efficiency kit distributed to students (at no cost) had low-installation rates, which reduced projected energy savings. Additionally, two products that had fixed-installation rates in the PY5 and PY6 TRM required the collection of survey data to determine the installation rates in PY7, resulting from a change in the PY7 TRM algorithms.

The EE&C Plan estimates the TRC ratio for each program for the entire Phase II and, therefore, does not provide an annual estimated TRC ratio for each program that could be used to compare to the actual PY7 TRC. The TRC comparisons for Phase II are discussed in Section 1.10 of this chapter.

The Phase III PY8 Final Annual Report will discuss any changes to Phase III programs that were implemented based on the PY7 results.

**Table 1-21: Comparison of PY7 Verified Program Savings to EE&C Plan Estimates**

| Program | PY7 Savings Estimated in EE&C Plan (MWh/yr) | PYTD Verified Gross Energy Savings (MWh/yr) | Energy % Difference [( PY7 Actual-Planned)/ PY Planned] | PY7 MW Savings Estimated in EE&C Plan[1] | PYTD Verified Gross Demand Savings (MW) [1] | Demand % Difference [(PY7 Actual-Planned)/ PY Planned] |
|---|---|---|---|---|---|---|
| Appliance Recycling | 7,729 | 9,320 | 21% | 1.04 | 1.30 | 25% |
| Continuous Energy Improvement | 2,567 | 4,697 | 83% | 0.42 | 0.77 | 81% |
| Custom Incentive | 23,682 | 29,564 | 25% | 3.89 | 4.34 | 12% |
| E-Power Wise | 2,261 | 3,117 | 38% | 0.29 | 0.27 | -8% |
| Low-Income Energy-Efficiency Behavior & Education | 8,280 | 10,622 | 28% | 1.07 | 2.07 | 93% |
| Low-Income WRAP | 3,598 | 4,497 | 25% | 0.45 | 0.55 | 22% |
| Master Metered Multifamily Housing | 2,429 | 2,892 | 19% | 0.40 | 0.45 | 13% |
| Prescriptive Equipment | 85,053 | 133,124 | 57% | 16.10 | 19.75 | 23% |
| Residential Energy-Efficiency Behavior & Education | 30,749 | 39,078 | 27% | 3.98 | 7.30 | 83% |
| Residential Home Comfort | 9,302 | 12,157 | 31% | 1.49 | 3.41 | 128% |
| Residential Retail | 50,044 | 64,240 | 28% | 9.25 | 9.87 | 7% |
| School Benchmarking | - | - | 0% | - | 0.00 | 0% |
| Student & Parent Education | 4,746 | 4,053 | -15% | 0.61 | 0.43 | -30% |
| Adjustment for Residential Energy-Efficiency Behavior & Education Double-Counted Savings | | (2,127) | | | | |
| Adjustment for Low-Income Energy-Efficiency Behavior & Education Double-Counted Savings | | (1,258) | | | | |
| **Program Total** | **230,441** | **313,976** | **36%** | **39.01** | **50.51** | **29%** |

[1] Planned and actual MW reductions include T&D losses.

## 1.9 SUMMARY OF COST-EFFECTIVENESS BY PROGRAM FOR PHASE II

TRC benefit-cost ratios are calculated by comparing the total NPV TRC benefits and the total NPV TRC costs. Table 1-22 shows the TRC ratios by program and other key factors used in the TRC ratio calculation for Phase II programs.

**Table 1-22: Phase II TRC Ratios by Program**

| Program Name | Phase II TRC NPV Benefits ($1,000) | Phase II TRC NPV Costs ($1,000) | Phase II TRC Benefit-Cost Ratio | Discount Rate | Energy Line Loss Factor | Demand Line Loss Factor |
|---|---|---|---|---|---|---|
| Appliance Recycling | $13,857 | $3,763 | 3.68 | 8.14% | Multiple [1],[2],[3],[4] | Multiple [1],[2],[3],[4] |
| Continuous Energy Improvement | $1,176 | $939 | 1.25 | 8.14% | Multiple [1],[2],[3],[4] | Multiple [1],[2],[3],[4] |
| Custom Incentive | $35,390 | $26,827 | 1.32 | 8.14% | Multiple [1],[2],[3],[4] | Multiple [1],[2],[3],[4] |
| E-Power Wise | $3,538 | $1,121 | 3.16 | 8.14% | 8.33% | 8.33% |
| Low-Income Energy-Efficiency Behavior & Education | $908 | $1,402 | 0.65 | 8.14% | 8.33% | 8.33% |
| Low-Income WRAP | $11,388 | $15,087 | 0.75 | 8.14% | 8.33% | 8.33% |
| Master Metered Multifamily Housing | $3,664 | $2,410 | 1.52 | 8.14% | 6.23% | 6.23% |
| Prescriptive Equipment | $242,098 | $161,119 | 1.50 | 8.14% | Multiple [1],[2],[3],[4] | Multiple [1],[2],[3],[4] |
| Residential Energy-Efficiency Behavior & Education | $5,745 | $2,296 | 2.50 | 8.14% | Multiple [1],[2],[3],[4] | Multiple [1],[2],[3],[4] |
| Residential Home Comfort | $17,162 | $25,890 | 0.66 | 8.14% | Multiple [1],[2],[3],[4] | Multiple [1],[2],[3],[4] |
| Residential Retail | $154,325 | $41,183 | 3.75 | 8.14% | Multiple [1],[2],[3],[4] | Multiple [1],[2],[3],[4] |
| School Benchmarking | $0 | $347 | 0.00 | 8.14% | 6.23% | 6.23% |
| Student & Parent Education | $9,988 | $4,875 | 2.05 | 8.14% | 6.23% | 6.23% |
| Common Costs | | $26,923 | N/A | 8.14 | N/A | N/A |
| **Total [5]** | **$499,240** | **$287,260** | **1.59** | **8.14%** | **Multiple [1],[2],[3],[4]** | **Multiple [1],[2],[3],[4]** |

[1] Residential line loss factor of 8.33%
[2] Small C&I line loss factor of 8.33%
[3] Large C&I line loss factor of 4.12%
[4] GNE line loss factor of 6.23%. The GNE line loss factor is the average of Small/Large C&I and is consistent with the line loss used in PPL Electric Utilities' EE&C Plan. Going forward, the actual participant rate class will be used to determine the blended GNE line loss factor.
[5] Total will not equal sum of column due to rounding.

## 1.10 COMPARISON OF PHASE II PERFORMANCE TO APPROVED EE&C PLAN

Table 1-23 shows Phase II expenditures compared to the estimates set forth in the EE&C Plan.

**Table 1-23: Comparison of Phase II Program Expenditures to Phase II EE&C Plan Estimates**

| Program | Phase II Estimate from EE&C Plan ($1,000) | Phase II Actual Expenditures ($1,000) | % Difference from Phase II EE&C Plan [(Actual-Planned)/Planned] |
|---|---|---|---|
| Appliance Recycling | $5,212 | $4,026 | -23% |
| Continuous Energy Improvement | $1,073 | $993 | -7% |
| Custom Incentive | $8,268 | $7,373 | -11% |
| E-Power Wise | $1,539 | $1,237 | -20% |
| Low-Income Energy-Efficiency Behavior & Education | $1,637 | $1,523 | -7% |
| Low-Income WRAP | $16,782 | $16,538 | -1% |
| Master Metered Multifamily Housing | $3,110 | $2,172 | -30% |
| Prescriptive Equipment | $58,447 | $54,268 | -7% |
| Residential Energy-Efficiency Behavior & Education | $2,948 | $2,463 | -16% |
| Residential Home Comfort | $10,031 | $10,330 | 3% |
| Residential Retail | $32,848 | $25,960 | -21% |
| School Benchmarking | $389 | $370 | -5% |
| Student & Parent Education | $5,930 | $5,345 | -10% |
| **Total Direct Costs** | **$148,214** | **$132,598** | **-11%** |
| Common Costs | $36,062 | $28,709 | -20% |
| **Total** | **$184,276** | **$161,307** | **-12%** |
| [1] Planned common costs were estimated for Phase II, not by program year. | | | |

Table 1-24 shows Phase II program savings compared to the energy and demand savings estimates filed in the EE&C Plan.

**Table 1-24: Comparison of Phase II Reported Program Savings to Phase II EE&C Plan Estimates**

| Program | Phase II Savings Estimated in EE&C Plan (MWh/yr) | Phase II Reported Gross Energy Savings (MWh/yr) | Energy % Difference [(Phase II Actual-Planned)/ Phase II Planned] | Phase II MW Savings Estimated in EE&C Plan [1] | Phase II Reported Gross Demand Savings (MW) [1] | Demand % Difference [(Phase II Actual-Planned)/ Phase II Planned] |
|---|---|---|---|---|---|---|
| Appliance Recycling | 25,224 | 25,668 | 2% | 3.50 | 4.19 | 20% |
| Continuous Energy Improvement | 3,150 | 4,808 | 53% | 0.52 | 0.55 | 6% |
| Custom Incentive | 62,793 | 57,610 | -8% | 10.30 | 6.96 | -32% |
| E-Power Wise | 5,611 | 7,920 | 41% | 0.73 | 0.96 | 32% |
| Low-Income Energy-Efficiency Behavior & Education | 8,280 | 10,833 | 31% | 1.42 | 14.82 | 943% |
| Low-Income WRAP | 10,411 | 12,135 | 17% | 1.33 | 1.28 | -4% |
| Master Metered Multifamily Housing | 6,885 | 6,012 | -13% | 1.14 | 0.69 | -39% |
| Prescriptive Equipment | 253,466 | 317,057 | 25% | 47.69 | 43.65 | -8% |
| Residential Energy-Efficiency Behavior & Education | 30,749 | 39,786 | 29% | 5.40 | 39.18 | 626% |
| Residential Home Comfort | 15,268 | 18,354 | 20% | 2.34 | 5.03 | 115% |
| Residential Retail | 191,863 | 203,802 | 6% | 35.45 | 25.49 | -28% |
| School Benchmarking | - | - | 0% | - | 0.00 | 0% |
| Student & Parent Education | 15,628 | 16,108 | 3% | 2.02 | 1.65 | -19% |
| **Program Total [2]** | **629,328** | **720,094** | **14%** | **111.84** | **144.45** | **29%** |

[1] Planned MW reductions include T&D losses; reported gross MW reductions do not include T&D losses.
[2] Total will not equal sum of column due to rounding.

Table 1-25 shows actual verified program savings compared to the energy and demand savings estimates filed in PPL Electric Utilities' EE&C plan. The percentage difference column shows the percentage by which the verified gross savings differed from planned savings.

**Table 1-25: Comparison of Phase II Verified Program Savings to Phase II EE&C Plan Estimates**

| Program | Phase II Savings Estimated in EE&C Plan (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Energy % Difference [( Phase II Actual-Planned)/ Phase II Planned] | Phase II MW Savings Estimated in EE&C Plan [1] | Phase II Verified Gross Demand Savings (MW) [1] | Demand % Difference [(Phase II Actual-Planned)/ Phase II Planned] |
|---|---|---|---|---|---|---|
| Appliance Recycling | 25,224 | 25,012 | -1% | 3.50 | 4.45 | 27% |
| Continuous Energy Improvement | 3,150 | 4,697 | 49% | 0.52 | 0.77 | 48% |
| Custom Incentive | 62,793 | 56,852 | -9% | 10.30 | 7.39 | -28% |
| E-Power Wise | 5,611 | 5,933 | 6% | 0.73 | 0.74 | 2% |
| Low-Income Energy-Efficiency Behavior & Education | 8,280 | 10,622 | 28% | 1.07 | 2.07 | 45% |
| Low-Income WRAP | 10,411 | 11,832 | 14% | 1.33 | 1.44 | 8% |
| Master Metered Multifamily Housing | 6,885 | 6,488 | -6% | 1.14 | 0.77 | -32% |
| Prescriptive Equipment | 253,466 | 303,542 | 20% | 47.69 | 47.33 | -1% |
| Residential Energy-Efficiency Behavior & Education | 30,749 | 39,078 | 27% | 3.98 | 7.30 | 35% |
| Residential Home Comfort | 15,268 | 18,649 | 22% | 2.34 | 6.15 | 163% |
| Residential Retail | 191,863 | 206,018 | 7% | 35.45 | 26.55 | -25% |
| School Benchmarking | - | - | 0% | - | 0.00 | 0% |
| Student & Parent Education | 15,628 | 13,397 | -14% | 2.02 | 1.30 | -36% |
| Adjustment for Residential Energy-Efficiency Behavior & Education Double-Counted Savings | | (2,127) | | | | |
| Adjustment for Low-Income Energy-Efficiency Behavior & Education Double-Counted Savings | | (1,258) | | | | |
| **Program Total [2]** | **629,328** | **698,736** | **11%** | **110.07** | **106.27** | **-3%** |

[1] Planned and actual MW reductions include T&D losses.
[2] Total will not equal sum of column due to rounding.

Table 1-25 compares Phase II verified program savings to the energy and demand savings estimates filed in the EE&C plan. About half of the programs (six programs) offered achieved the projected energy savings for Phase II, with all six exceeding projected savings by 6% or more. Four of the six programs achieved 99% to 94% of projected savings. The Custom Incentive Program achieved 91% of Phase II project savings. The Student & Parent Energy Education Program achieved 86% of project savings.

- The Custom Incentive Program was designed primarily for larger commercial and industrial (C&I) customers. Typical projects involve complex decision-making and have a long lead time from conception to implementation. The program achieved 125% of PY7 planned energy savings and 91% of Phase II savings. Several projects that commenced in Phase II were not fully installed or commissioned until the start of Phase III. Those project's savings could not count toward PY7 and Phase II planned savings.
- The Student & Parent Energy Efficiency Program achieved 86% of Phase II energy savings projections. PPL Electric Utilities increased the projected participation rate during Phase II, reflected in the final EE&C plan, but the program served fewer participants in Phase II than planned, reducing the potential to achieve energy savings. Several products distributed in the energy efficiency kit had low-installation

rates, which reduced projected energy savings. Additionally, a change in the TRM from fixed-installation rates for two products led to a reduction in energy savings, given the survey-verified installation rates.

- The Master Metered Multifamily Program achieved 119% of PY7 planned savings and 94% of the Phase II planned savings. In Phase II, the program retrofits focused primarily on lighting installations because they were easy to install and had relatively low incremental cost to participants upgrading common areas. A primary barrier to installing HVAC equipment or comprehensive retrofits that could result in larger energy savings is the large upfront cost required to bridge the financial gap between program incentives and actual retrofit costs, including labor and equipment.

The actual Phase II TRC ratio of 1.59 for the portfolio was 7% higher than the 1.49 estimated in the EE&C plan. The actual Phase II TRC ratios for each program were close to the estimates in the EE&C plan. Beyond the variation in estimated savings and EDC costs listed in the previous tables, TRC components including incremental measure costs, measure life (effective useful life [EUL]), operations and maintenance (O&M) savings, and secondary fuel impacts will vary from planning estimates.

Table 1-26 shows Phase II TRC ratio compared to the TRC estimates filed in the EE&C plan.

**Table 1-26: Phase II TRC Ratio Compared to TRC Estimates Filed in EE&C Plan**

| Program | TRC Ratio Estimated in EE&C Plan | Phase II TRC Ratio |
|---|---|---|
| Appliance Recycling | 2.96 | 3.68 |
| Continuous Energy Improvement | 0.60 | 1.25 |
| Custom Incentive | 1.65 | 1.32 |
| E-Power Wise | 2.01 | 3.16 |
| Low-Income Energy-Efficiency Behavior & Education | 0.65 | 0.65 |
| Low-Income WRAP | 0.66 | 0.75 |
| Master Metered Multifamily Housing | 1.83 | 1.52 |
| Prescriptive Equipment | 1.51 | 1.50 |
| Residential Energy-Efficiency Behavior & Education | 1.33 | 2.50 |
| Residential Home Comfort | 0.63 | 0.66 |
| Residential Retail | 2.74 | 3.75 |
| School Benchmarking | 0.00 | 0.00 |
| Student & Parent Education | 2.19 | 2.05 |
| **Total** | **1.49** | **1.59** |

Results show six programs had higher Phase II TRC results and six programs had lower TRC ratios than estimated in the Phase II EE&C plan. No program with Phase II TRC results lower that the EE&C plan shifted from being cost-effective to not cost-effective. Only five programs have TRC ratios that varied by more than 20% from the Phase II EE&C plan, all of which increased TRC ratios.

- Appliance Recycling increased 24% (EDC costs decreased 23%, and the verified demand savings were 27% higher than the EE&C plan).
- Continuous Energy Improvement increased 107% (EDC costs were 7% lower, and verified energy savings were 49% higher than the EE&C plan).
- E-Power Wise increased 58% (EDC costs were 20% lower, and verified energy savings were 6% higher than the EE&C plan).

- Residential Home Comfort increased 87% (EDC costs were 3% higher, while verified energy savings were 22% higher than the EE&C plan).
- Residential Retail increasing 37% (EDC costs were 21% lower, while verified energy savings were 7% higher than the EE&C plan).

The Phase III PY8 Final Annual Report will discuss any changes to Phase III programs that were implemented based on the Program Year 7 TRC ratios.

## 1.11 PORTFOLIO LEVEL/CROSS-CUTTING PROCESS AND IMPACT EVALUATION SUMMARY FOR PY7

Cadmus evaluated PPL Electric Utilities' portfolio of energy efficiency programs, as described in the Phase II EE&C Plan for the PY7 under Pennsylvania Act 129.[5] Phase II of Act 129 covers June 2013 through May 2016. PY7 covers June 2015 through May 2016.

### 1.11.1 Impact Evaluation Activities

Impact evaluation activities varied by program in PY7. More detailed explanations of each programs' impact evaluation methodology and analyses are contained in the program chapters and their respective addendums. The main activities that Cadmus, the EM&V CSP, conducted were these:

- Database and records review for quality assurance and quality control (QA/QC)
- Records review
- Engineering analyses
- Billing analyses
- Site visits

Table 1-27 lists the impact evaluation activities conducted for each program in PY7. The individual program chapters discuss the impact evaluation activities, methodology, and findings.

[5] PPL Electric Utilities. *PPL Electric Utilites Corporation Energy Efficiency and Conservation Plan Act 129 Phase II.* Prepared for Pennsylvania Public Utility Commission. Docket Number M-2012-2334388. April 7, 2014. Revised and approved by the Pennsylvania Public Utility Commission on June 5, 2015.

**Table 1-27: Impact Evaluation Activities by Program**

| Program | Impact Evaluation Activity | | | | | |
|---|---|---|---|---|---|---|
| | QA/QC Review | Records Review | Site Visits [1] | Metering | Engineering Analysis | Billing Analysis |
| Appliance Recycling | | ✓ | | | ✓ | |
| Continuous Energy Improvement | ✓ | ✓ | | | | ✓ |
| Custom Incentive | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E-Power Wise | ✓ | ✓ | | | ✓ | |
| E-Power Wise – Wise Home Pilot | ✓ | | ✓ | | | ✓ |
| Low-Income Energy Efficiency Behavior & Education | ✓ | ✓ | | | | ✓ |
| Low-Income WRAP | ✓ | ✓ | ✓ | | ✓ | ✓ |
| Low-Income WRAP - De Facto Heating Pilot | ✓ | ✓ | ✓ | | ✓ | ✓ |
| Master Metered Low-Income Multifamily Housing | ✓ | ✓ | ✓ | | ✓ | |
| Prescriptive Equipment | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Residential Energy Efficiency Behavior & Education | ✓ | ✓ | | | | ✓ |
| Residential Home Comfort | ✓ | ✓ | ✓ | | ✓ | |
| Residential Retail (Efficient Equipment and Lighting) | ✓ | ✓ | | | ✓ | |
| School Benchmarking [2] | | | | | | |
| Student & Parent Education | ✓ | ✓ | | | ✓ | |

[1] Site visits completed by Cadmus, PPL Electric Utilities or the ICSP.
[2] Cadmus did not complete an evaluation for this program in PY7.

### 1.11.2 Process Evaluation Activities

This section summarizes the process evaluation of PPL Electric Utilities' PY7 portfolio.

The individual program process evaluations identify opportunities and offer recommendations to improve the overall effectiveness of the design, implementation, enrollment process, quality assurance, and other elements for all of PPL Electric Utilities' energy efficiency programs. These evaluations examine the portfolio's overall achievement and planned savings for each program. They also explore participant feedback, energy efficiency attitudes and behaviors, and challenges to energy efficiency improvements.

Process evaluation activities varied by program in PY7. The main activities that Cadmus, the EM&V CSP, conducted were these:

- Program staff and ICSP interviews
- Participant surveys
- Treatment and control group surveys
- General residential population survey
- Surveys and interviews of vendors, contractors, manufacturers, and others
- Key performance indicators (KPIs) reviews

Each program assessment is discussed in more detail in individual chapters of this report. The chapters summarize the program's achievements against planned savings and discuss the findings from the program-specific evaluation activities. Any modifications to individual program evaluation activities from Cadmus' approved evaluation plans are noted in each program chapter.

Table 1-28 lists the process evaluation activities conducted for each program in PY7 along with the total number of survey and interview respondents reached for each program. A more detailed explanation of each programs' survey methodology is contained in the program chapters and their respective addendums. For three programs—Appliance Recycling, Residential Retail, and Residential Home Comfort—Cadmus conducted a cross-program survey.

**Table 1-28: PY7 Process Evaluation Activities by Program**

| Program | Process Evaluation Activity | | | | | |
|---|---|---|---|---|---|---|
| | Participant Survey | Nonparticipant or Partial Participant Survey | KPIs | Satisfaction | Stakeholder Interview | Trade Ally Interview |
| Appliance Recycling [1] | 62 [2] | - | - | ✓ | - | - |
| Continuous Energy Improvement | 23 [3] | - | ✓ | ✓ | 2 | - |
| Custom Incentive | 24 | - | ✓ | ✓ | 2 | - |
| E-Power Wise | 776 [4] | - | ✓ | ✓ | 2 | 5 |
| E-Power Wise – Wise Home Pilot | 327 [5] | - | ✓ | ✓ | 3 | 1 |
| Low-Income Energy Efficiency Behavior & Education | 151 (treatment group) | 150 (control group) | ✓ | ✓ | 2 | - |
| Low-Income WRAP | 141 | - | - | ✓ | 1 | - |
| Low-Income WRAP – De Facto Heating Pilot | 3 | - | ✓ | ✓ | 1 | 1 |
| Master Metered Low-Income Multifamily Housing | 200 [6] | - | ✓ | ✓ | 2 | - |
| Prescriptive Equipment | 80 | - | ✓ | ✓ | 2 | - |
| Residential Energy Efficiency Behavior & Education | - | - | ✓ | - | 2 | - |
| Residential Home Comfort | 286 [2] | - | ✓ | ✓ | 2 | - |
| Residential Retail (Efficient Equipment and Lighting) | 132 [2] | 337 (general residential population survey) | ✓ | ✓ | 2 [8] | - |
| School Benchmarking [7] | - | - | - | - | - | - |
| Student & Parent Education | 24,411 [9] | - | ✓ | ✓ | 2 | - |
| **Total** | **26,616** | **487** | | | **25** | **7** |

[1] The results were reported in the portfolio level findings but not in the process evaluation of the Appliance Recycling Program chapter.
[2] Includes surveys completed as part of the cross-program survey, which included participants of the Residential Retail, Residential Home Comfort, and Appliance Recycling programs.
[3] Includes eight surveys with school district representatives and 15 with school-level energy champions.
[4] Includes customer surveys returned from the energy-savings kits.
[5] Includes Cadmus-administered surveys (n=44), leave-behind postcard surveys (n=40), and 243 enrollment surveys.
[6] Includes tenant leave-behind surveys (n=44) and ICSP-administered tenant education workshop surveys (n=156).
[7] Cadmus did not complete a process evaluation for the School Benchmarking Program in PY7.
[8] The same program managers were interviewed about both equipment and lighting.
[9] Includes ICSP-administered home energy worksheets (HEWs) (n=19,249); parent workshop HEWs (n=1,015); ICSP-administered parent surveys (n=2,229); and ICSP-administered classroom teacher, teacher workshop, and parent workshop evaluation surveys (n=1,918).

#### 1.11.2.1 Survey Scales

In its PY6 review, the SWE suggested that a midpoint be added to many of the survey questions with response scales. Where possible, Cadmus adjusted response choices as suggested. In surveys with new questions, a midpoint was added where reasonable. But in some cases the scale was not changed. For example, PPL Electric Utilities uses some satisfaction questions for its internal metrics so response scales for these questions were not adjusted. In another example, some questions asked in PY6 (and prior years) are used to track changes over time; therefore, Cadmus kept the scales (typically a four-word scale) consistent through PY7.

### 1.11.3 Participant Experience

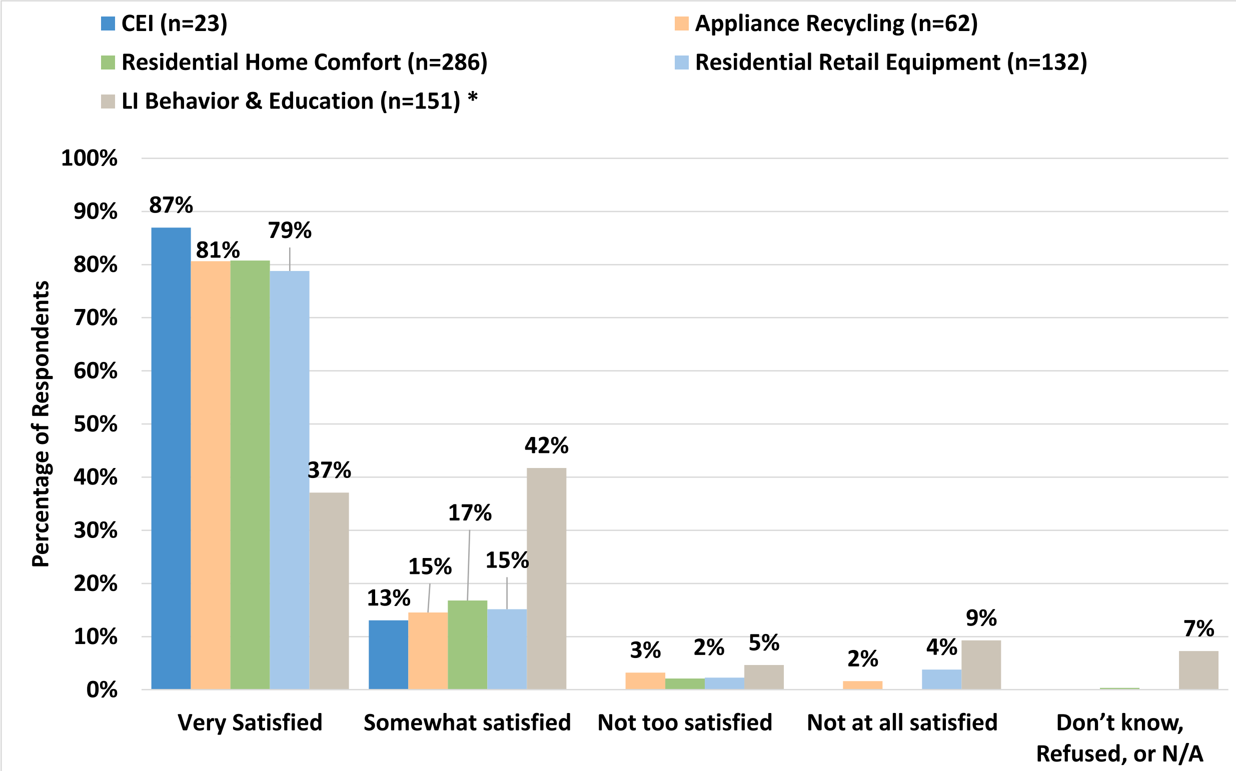
#### 1.11.3.1 Program Satisfaction

Cadmus asked respondents how satisfied they were with the program and found that overall customer satisfaction (numerical average of all programs) was > 89% (*very* or *somewhat satisfied* on a 4-point word scale; 8-10 rating on a 10-point scale; or 4 or 5 rating on a 5-point scale). The high customer satisfaction is especially notable because the nonresidential programs were closed to new applicants for the entire program year, and closed programs usually lower customer satisfaction. Respondents in the Appliance Recycling, Continuous Energy Improvement, Residential Home Comfort, and Residential Retail programs rated their satisfaction higher than respondents in the Low-Income Energy-Efficiency Behavior & Education Program.

Cadmus used three different scales when researching overall program satisfaction. For the Custom Incentive Program, Prescriptive Equipment Program, and WRAP surveys, Cadmus used different response scales to match the response scales used by PPL Electric Utilities in previous surveys.

Figure 1-8 shows program satisfaction for the respondents who rated their satisfaction using a word scale.

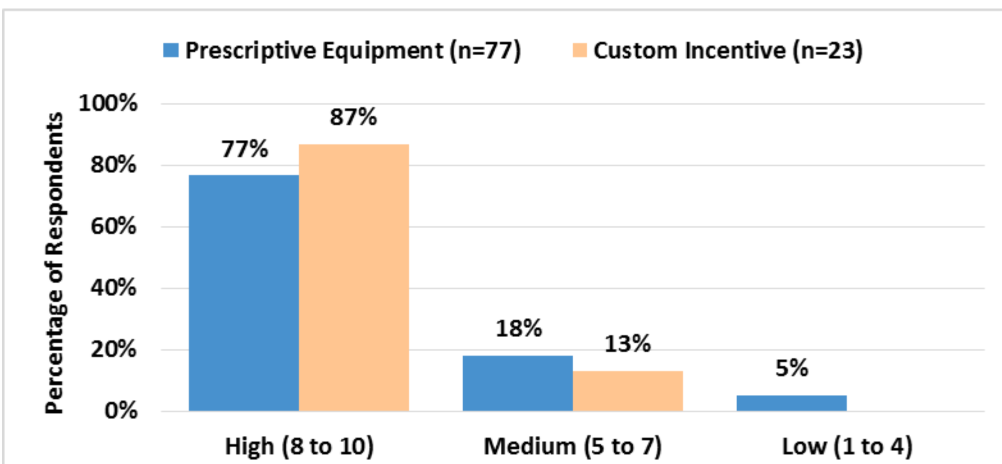
Figure 1-8: PY7 Program Satisfaction




Source: Survey questions, "Thinking about your overall experience with the program, how would you rate your satisfaction?" and "How satisfied were you overall with [program name]?"** Some percentages do not total 100% due to rounding.

Figure 1-9 shows the 10-point scale used for the Custom Incentive and Prescriptive Equipment programs in PY7. Cadmus used this scale because it matched the response scale PPL Electric Utilities used in online surveys conducted in prior years.

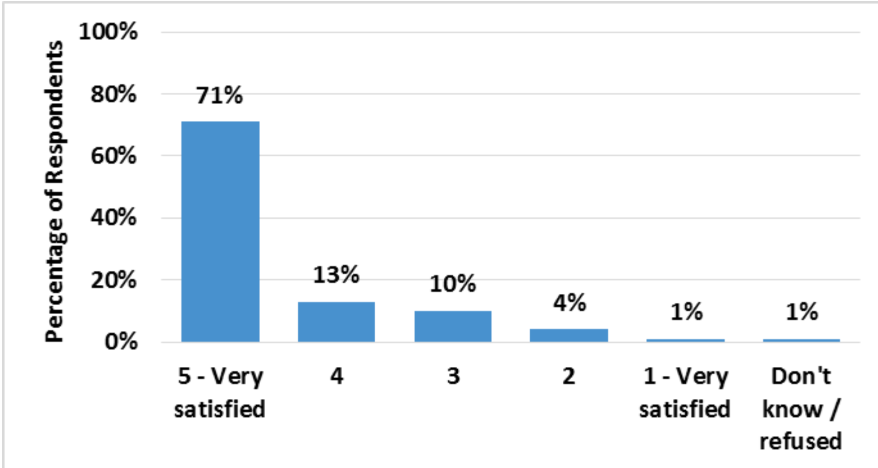
Figure 1-9: PY7 Custom Incentive Program and Prescriptive Equipment Program Satisfaction




Source: Question, "Thinking about your overall experience with the program, how would you rate your satisfaction using a 1 to 10 scale where 10 means "outstanding" and 1 means "unacceptable"?

In PY7, as in previous program years, PPL Electric Utilities conducted the WRAP survey using the 5-point scale, as shown in Figure 1-10.

**Figure 1-10: PY7 WRAP Participant Satisfaction**

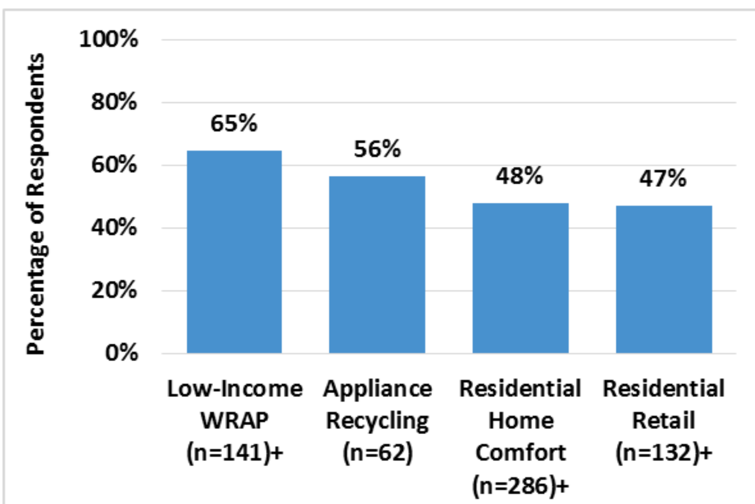



Source: Question, "How satisfied are you with the WRAP program?" (n=141)

Over half the respondents (53%; n=635) in the Appliance Recycling, WRAP, Residential Home Comfort, and Residential Retail programs said they had recommended the program to a friend, relative, or colleague. This is consistent with PY5 findings, where 57% (n=615) said they recommended the program, and PY6 findings, where 56% (n=540) said they recommended the program. The difference between program years is not statistically significant.

In PY7, 65% of WRAP participants said they recommended the program to someone else. This is significantly higher than the percentage of participants in the Residential Home Comfort and Residential Retail programs who said they recommended the program in PY7 (Figure 1-11).[6]

**Figure 1-11: PY7 Participants Who Have Recommended the Program to Someone Else**




Source: Survey question, "Since receiving your rebate, have you recommended the program to any friends, relatives, or colleagues?" Difference between WRAP and Residential Home Comfort and LI WRAP and Residential Home Comfort is significant at the 95% confidence interval (p≤0.05).

6 The difference between LI WRAP and Residential Home Comfort and LI WRAP and Residential Home Comfort is significant at the 95% confidence interval (p≤0.05).

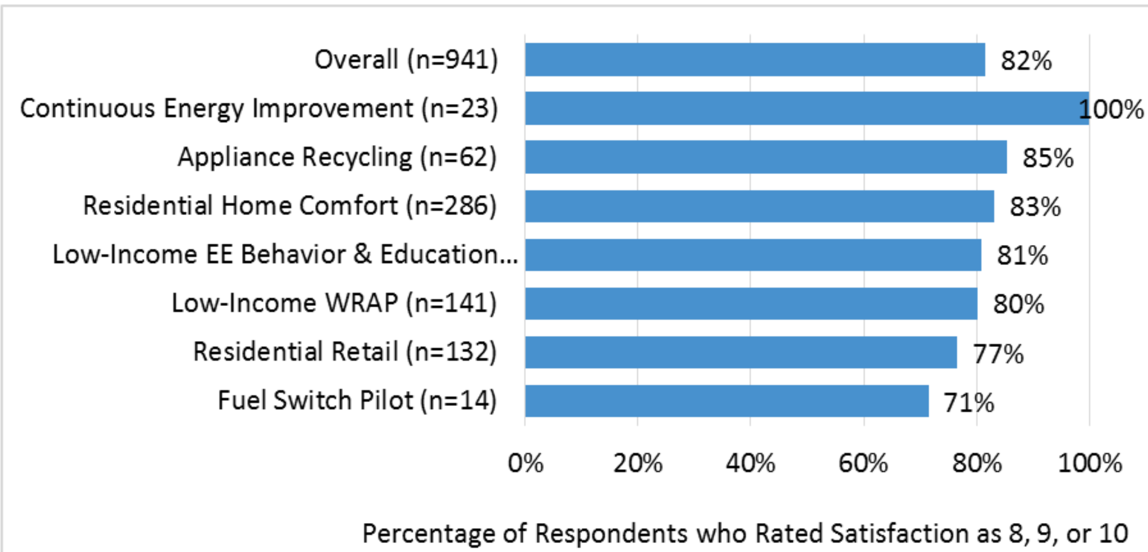
#### 1.11.3.2 Reasons for Dissatisfaction with a Program

Cadmus asked survey respondents about their experiences with specific aspects of the programs. Although the vast majority reported high satisfaction with their overall program experience, a small number of respondents said they were dissatisfied with some aspect of the program. Their reasons are discussed in greater detail in the program-specific chapters of this annual report.

#### 1.11.3.3 Satisfaction with PPL Electric Utilities as a Utility

Most program participants were very satisfied with PPL Electric Utilities as an electric service provider (Figure 1-12). In PY7 the majority of all survey respondents (82%; n=941) who answered this question rated their satisfaction with PPL Electric Utilities as an 8, 9, or 10 on a scale of 1 to 10, with 10 meaning *outstanding*. This is slightly higher than in the previous two program years—79% of respondents (n=1,370) in PY6 and 72% of respondents (n=1,133) in PY5 rated their satisfaction with PPL Electric Utilities as an 8 or higher.

**Figure 1-12: PY7 Satisfaction with PPL Electric Utilities as a Provider of Electricity**




Source: Survey Question, "Using a 10-point scale where 1 means unacceptable and 10 means outstanding, using any number from 1 to 10, how do you rate PPL Electric Utilities overall as a provider of Electric Utilities service to your home?"

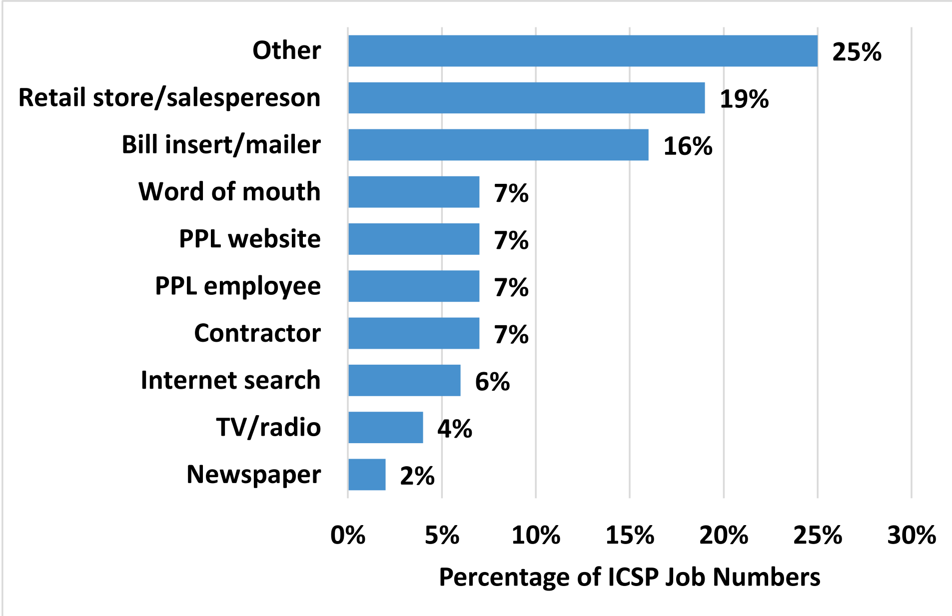
Cadmus also asked survey respondents if their experiences with the programs had changed their opinion of PPL Electric Utilities. Over half of PY7 respondents (54%; n=908) said their opinion of PPL Electric Utilities had not changed as a result of their participation in one of its incentive programs; 39% said their opinion had *improved significantly* or *somewhat*.

### 1.11.4 Phase II Summary

#### 1.11.4.1 Program Awareness

Cadmus reviewed the answers participants selected on their rebate forms for how they learned about the program. One-quarter of participants (unique CSP Job numbers) selected "Other" on the rebate form (and did not provide detail), 19% learned about the program from a retail store, and 16% learned about the program from a bill insert or mailer. Figure 1-13 shows all of the responses.

**Figure 1-13: How Participants Learned About the Program in PY7**




Source: PPL Electric Utilities database (EEMIS) (n=16,175)

### 1.11.4.2 Program Participation

Cadmus reviewed the participant data in the energy efficiency management information system (EEMIS), PPL Electric Utilities' database, and completed an analysis of the percentage of customers who participated in at least one other program. Customers in the Continuous Energy Improvement, WRAP, and School Benchmarking programs are the most likely to participate in at least one other program. Customers in the Prescriptive Equipment and the Low-Income and Residential Energy-Efficiency Behavior & Education programs are the least likely to participate in at least one other program. Table 1-29 shows the results for all programs.

**Table 1-29: PY7 Program Participation**

| Program Name | Percentage of Customers Who Participated in Other Programs | | | |
|---|---|---|---|---|
| | One Other Program | Two Other Programs | Three Other Programs | Four or More Other Programs |
| Appliance Recycling (n=25,866) | 41% | 36% | 5% | 0% |
| Continuous Energy Improvement (n=46) | 80% | 39% | 39% | 2% |
| Custom Incentive (n=179) | 43% | 39% | 3% | 1% |
| E-Power Wise (n=11,421) | 52% | 42% | 10% | 0% |
| Low-Income EE Behavior & Education (n=126,870) | 10% | 9% | 1% | 0% |
| Low-Income WRAP (n=10,358) | 66% | 54% | 11% | 0% |
| Master Metered Multifamily Housing (n=123) | 15% | 15% | 1% | 0% |
| Prescriptive Equipment (n=5,953) | 4% | 3% | 0% | 0% |
| Res. EE Behavior & Education (n=245,709) | 6% | 6% | 1% | 0% |
| Residential Home Comfort (n=13,320) | 46% | 41% | 4% | 0% |
| Residential Retail (n=15,294) | 47% | 38% | 8% | 1% |
| School Benchmarking (n=85) | 66% | 40% | 25% | 1% |
| Source: PPL Electric Utilities database (Energy Efficiency Management Information System) | | | | |

### 1.11.5 Process and Impact Evaluation Recommendations for Program Year 7

Table 1-30 includes all process and impact recommendations for each PPL Electric Utilities program and the portfolio. These recommendations are also discussed in the individual program chapters. The status of each recommendation is also included in the individual program chapters.

**Table 1-30: Phase II Process and Impact Evaluation Recommendations from PY7 Evaluations**

| Applicability | Recommendations |
|---|---|
| **Continuous Energy Improvement** | Consider maintaining the same baseline period for all schools. |
| **Continuous Energy Improvement** | Consider using at least 12 months for school baselines. |
| **Continuous Energy Improvement** | Ensure baseline periods for schools do not overlap with implementation periods for other schools within the same district. |
| **Continuous Energy Improvement** | Encourage CEI participants to enroll in other PPL Electric Utilities programs. |
| **Continuous Energy Improvement** | Provide schools with a timeline of CEI activities, and communicate how incentive money is being distributed throughout the district. |
| **Continuous Energy Improvement** | Ask that participants conduct at least yearly updates to all program documents. |
| **Custom Incentive** | Consider providing customers with a tool to track the real time progress of their application through each application milestone. |
| **Custom Incentive** | Consider providing additional detail regarding the waitlist and what customers should expect during this period. |
| **Custom Incentive** | Consider allowing the evaluator to review standard calculators to determine if the correct baseline is being used. |
| **Custom Incentive** | Continue to request evaluator support to determine if certain projects that fall below the 500,000 kWh/yr threshold should be elevated to the large stratum when there is high uncertainty in the measure, baseline, or calculation approach for new or overly complicated measures. |
| **Custom Incentive** | Consider allowing for the ICSP and evaluator to review data collection protocols collaboratively. |
| **E-Power Wise** | Consider removing the furnace whistle from the energy-savings kit and explore offering a rebate for furnace filters instead. |
| **E-Power Wise** | Monitor progress and identify any early issues with the two-kit delivery system. Include questions in the agency interviews as a part of the PY8 evaluation to gather feedback. |
| **E-Power Wise** | Ensure that the program provides sufficient training and materials geared toward one-on-one interactions between clients and agencies. |
| **E-Power Wise – Wise Home Pilot** | Include an additional low-cost screening step, such as a phone call, to verify self-reported customer information, e.g, heating and cooling system and fuel type. |
| **E-Power Wise – Wise Home Pilot** | Include information about low-income programs in customers' monthly energy bills. |
| **E-Power Wise – Wise Home Pilot** | Provide more clear information regarding the conditional nature of program or pilot offerings. |
| **E-Power Wise – Wise Home Pilot** | Train technicians about other program offerings so they can inform participants. |
| **Low-Income Energy-Efficiency Behavior & Education** | Consider sending additional paper home energy reports and/or developing print versions of some of the digital content to send to low-income customers. |
| **Low-Income Energy-Efficiency Behavior & Education** | Consider using other channels (e-mail, billing statements, and programs) to encourage all treatment customers (low-income and non-low-income) to visit the new Phase III program's web portal. |
| **Low-Income Energy-Efficiency Behavior & Education** | Investigate whether the home energy reports convince treatment customers (low-income and non-low-income) to visit the Phase III Customer Engagement Hub and the program's web portal and to complete the online home energy assessment. |
| **Low-Income WRAP** | Consider emphasizing to contractors the importance of clearly explaining to customers which products and services will be installed or conducted after the audit takes place and when installations will occur. |
| **Low-Income WRAP** | Consider emphasizing the energy education portion of the audit, and take time to explain ways to save energy. |

| Applicability | Recommendations |
|---|---|
| **Low-Income WRAP – De Facto Heating Pilot** | Consider conducting an assessment of the market and technology in future pilot programs and adjust the evaluation plan accordingly. |
| **Low-Income WRAP – De Facto Heating Pilot** | Consider establishing the contractor scheduling process earlier to reduce (or eliminate) effects of non-performing contractors. |
| **Low-Income WRAP – De Facto Heating Pilot** | Encourage future implementers to provide leave-behind materials describing the programs and how to contact the utility. |
| **Master Metered Multifamily Housing** | In Phase III, consider recruiting low-income nursing home buildings to reach the low-income WRAP planned savings for master metered multifamily buildings. Likewise, consider recruiting nursing homes that are not income-eligible into the Phase III Prescriptive Equipment program. |
| **Master Metered Multifamily Housing** | In Phase III, explore options to increase incentives for HVAC equipment and comprehensive building retrofits in the master metered multifamily market segment, to reduce the gap between the incentives and the actual cost of these retrofits to program participants. |
| **Master Metered Multifamily Housing** | In Phase III, continue to offer tenant education under the low-income WRAP to recommend energy-efficiency actions tenants and householders can take to improve the energy performance of their buildings. |
| **Prescriptive Equipment** | Consider providing more support in filling out the applications with examples of completed applications on the website and a point of contact available to answer questions about the application forms. |
| **Prescriptive Equipment** | Consider incorporating a way for applicants to track the status of their application online. |
| **Prescriptive Equipment** | Consider reaching out to trade allies who are active in the program and explain, at the beginning of the year, that a wait list could occur in the future. |
| **Prescriptive Equipment** | Consider posting an update on the website explaining why a wait list was implemented and when the wait list is expected to be removed. |
| **Prescriptive Equipment** | Consider requiring the ICSP to add a QA/QC protocol for lighting projects to ensure Appendix C inputs and results match EEMIS. |
| **Prescriptive Equipment** | Consider enhancing QC processes to identify record duplicates, out-of-range values, and flag entries when data fields are populated that are not applicable to the rebated equipment (e.g., heating capacities for air conditioners). |
| **Residential Energy-Efficiency Behavior & Education** | Closely monitor the monthly savings and customer support calls and e-mails of the new behavior program in Phase III by setting up some key performance indicators derived from observations of Phase II. |
| **Residential Energy-Efficiency Behavior & Education** | Compare the energy-savings performance between Phase II and Phase III to note program design impacts and any transition challenges, especially through comparisons of PY7 and PY8 results. |
| **Residential Home Comfort** | Require the AHRI certificate and the two heating capacity values of the existing equipment and the new equipment for fuel-switching rebate forms. |
| **Residential Home Comfort** | Strengthen cross-program awareness initiatives in Phase III, such as adding banners to rebate forms, clear infographics to program materials, and PPL Electric Utilities' contact information to program materials. |
| **Residential Home Comfort** | Add instructions and helpful information on rebate forms to assist participants in filling them out. |
| **Residential Home Comfort** | Explore opportunities to involve manufactured homes dealers in the program, such as offering incentives for each qualifying manufactured home sold. |
| **Residential Home Comfort** | Consider further study of other manufactured homes programs to determine if other program delivery and incentive structures are successful in realizing participation. |
| **Residential Home Comfort** | Consider further study to assess the potential market for electrically heated manufactured homes. |
| **Residential Retail Equipment** | Consider implementing an online model-number lookup mechanism for customers, including incentive levels, to minimize confusion when tiered rebates are offered for the same type of appliance. |
| **Residential Retail Equipment** | Consider replacing refrigerators with another common household appliance that will have a larger impact in terms of both savings and customer satisfaction with the program and with PPL Electric Utilities. |

| Applicability | Recommendations |
|---|---|
| **Residential Retail Upstream Lighting** | Work with retailers to use product placement as a lower-cost mechanism for generating sales lift rather than more aggressive incentives throughout the year. Additionally, PPL Electric Utilities could consider working with the ICSP to track product placement across all retailers, to the greatest degree practical, so that the program is credited for all activities that increase sales. |
| **Residential Retail Upstream Lighting** | Consider ways to organize the program to decrease freeridership by focusing on the products or retailers with less competition from non-program-eligible LEDs and products where demand is more elastic in response to price changes. |
| **Residential Retail Upstream Lighting** | Work with the ICSP to identify opportunities to increase variation in program activity specifically within hard-to-reach retailers, by introducing new products with lower price points, special promotions, or pricing experiments, if possible. |
| **Residential Retail Upstream Lighting** | Watch market trends and purchasing patterns during Phase III. This includes monitoring the pricing of program and non-program bulbs, as well as consumer attitudes about quality versus price, to maintain the impact of program incentives. |
| **Residential Retail Upstream Lighting** | Consider bundling advertising of CFL recycling bin locations with other promotional materials as a cost-effective method to increase awareness. |
| **Student & Parent Education** | Monitor LED bulb installation rates in PY8 and consider reducing the number of LEDs included in the kits in PY9 if ISRs continue to decrease. |
| **Student & Parent Education** | Review student guides and education and installation materials to assess opportunities to further highlight LED benefits (compared to both incandescent and CFLs) and encourage installation. |
| **Student & Parent Education** | Consider increasing the grade-appropriate classroom instructions and discussion about the furnace whistle, showerhead, and faucet aerator items to encourage installation. Consider other ideas to increase installation rates, other than, or in addition to, changing the products in the kit. |
| **Student & Parent Education** | Consider a streamlined HEW data collection process where all student cohorts can input the data online instead of filling out a Scantron form. |

## 1.12 SITE INSPECTIONS SUMMARY

Table 1-31 summarizes programs receiving verification site visits by Cadmus, PPL Electric Utilities, or the ICSP (listed in the column “Inspection Firm”). The table includes the number of inspections, and resolution of discrepancies.

**Table 1-31: Summary of PY7 Site Visits**

| Program | Measure | Inspection Firm | Inspections Planned | Inspections Conducted | Sites with Discrepancies from Reports | Resolution of Discrepancies |
|---|---|---|---|---|---|---|
| **Custom Incentive** | HAVC Equipment upgrades, process controls, process upgrades, CHP installations, HVAC controls upgrades | Warren Energy Engineering | 31 | 31 | 10 | Discrepancies only found on small sample sites (10 visits). Corrections made to verified reports |
| **E-Power Wise – Wise Home Pilot** | Treated manufactured homes | Franklin Energy | 10% (50 total) | 8 | 1 | 1 (minor repair to socket) |
| **LI WRAP** | Baseload Job | N/A | 0 | 0 | N/A | N/A |
| | Low-Cost Job | N/A | 0 | 0 | N/A | N/A |
| | Full-Cost Job | PPL Electric Utilities | 0 [1] | 288 | 29 | CO detector installed |
| | | | | | | Billing (credit) adjustment |
| | | | | | | Replaced dryer vent |
| | | | | | | Billing (credit) adjustment |
| | | | | | | Drain pipe installed |
| | | | | | | Windows repaired |
| | | | | | | Freezer or refrigerator replaced |
| | | | | | | Weather-stripping installed |
| | | | | | | Bathroom fan vented |
| | Heat Pump Water Heater Job | PPL Electric Utilities | 0 | 93 | 3 | Contractor contacted GE for repairs |
| | | | | | | Contractor cleaned condensate port |
| **LI WRAP – De Facto Heating Pilot** | LED bulbs | Green Kite, Inc. | 11 | 11 | 1 | Customer did not receive the number of measures billed. PPL notified the contractor that some of the measures were missing. The contractor went back to complete the measures. |
| **Master Metered Multifamily** | All | Warren Energy Engineering | 19 [2] | 20 | 20 | Inputs adjusted for verified savings calculation based on site-specific data |
| **Prescriptive Equipment - Lighting** | Lighting retrofits, lighting controls upgrades, new construction, direct incentive | Warren Energy Engineering | 35 | 35 | 22 | Corrected and are reported as verified savings |
| **Prescriptive Equipment - Equipment** | HVAC, refrigeration, and agriculture measures | Cadmus | Meet 85/15 confidence and precision | 0 [3] | N/A | No equipment installed requiring site verification[3] |

| Program | Measure | Inspection Firm | Inspections Planned | Inspections Conducted | Sites with Discrepancies from Reports | Resolution of Discrepancies |
|---|---|---|---|---|---|---|
| **Residential Home Comfort** | Pool Pumps | CLEAResult | 5% of all projects completed in PY7 | 12 | 0 | N/A |
| | Air Source Heat Pump | | | 387 | 0 | N/A |
| | ECM Fan | | | 0 | 0 | N/A |
| | Ductless Heat Pump | | | 69 | 0 | N/A |
| | Central Air Conditioner | | | 140 | 0 | N/A |
| | Weatherization | | | 89 | 0 | N/A |
| | Survey | | | 52 | 1 | Surveyor sent energy report |
| | Audit | | | 37 | 2 | ▪ Customer contacted contractor<br>▪ Determined blower door test variance |
| | New Home | | | 13 | 0 | N/A |
| | Manufactured Home | | | 8 | 0 | N/A |
| | Fossil Fuel Furnace or Boiler | | | 7 | 1 | Contractor could not be identified |
| **Total** | | | | **1,292** | **89** | |

[1] There were no on-site inspection goals in the evaluation plan; however, PPL had an internal inspection goal of 390 full-cost jobs and 109 HPWH jobs for PY7.
[2] Cadmus estimated verification sample size to reach the stipulated levels of 85% confidence with 15% precision at the program level.
[3] Cadmus did not complete any site visits because the majority of savings came from efficient evaporator fans where the only variable that can be verified on site is whether the refrigeration case is a freezer or refrigerator. Instead, Cadmus verified equipment by telephone.

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# 2 PRESCRIPTIVE EQUIPMENT PROGRAM

The Prescriptive Equipment Program promotes the purchase and installation of high-efficiency equipment and lighting by offering customers financial incentives to offset the higher purchase costs of such equipment and providing information on their features and benefits. This program targets small C&I, large C&I, GNE, and agricultural customers.

The program offers incentives for lighting, non-lighting, and agriculture equipment through two channels. In the standard incentive channel, the customer obtains preapproval from PPL Electric Utilities before ordering the energy-efficient equipment, installs the equipment, submits the rebate application, and receives the rebate.

The direct discount delivery channel was designed to make it easier and more economical for small businesses and institutions to install energy-efficient lighting and commercial refrigeration upgrades. Through this channel, a contractor evaluates possible upgrades and makes recommendations. The customer chooses which projects to install, and the contractor completes and submits the required paperwork on the customer's behalf to PPL Electric Utilities. As with the standard incentive channel, the customer must obtain preapproval from PPL Electric Utilities before ordering energy-efficient equipment. The customer pays the discounted amount to the contractor up front, thereby lowering the overall cost burden; PPL Electric Utilities awards the incentive to the contractor who has already passed the savings to the customer.

The objectives of the Prescriptive Equipment Program are these:[7]

- Provide energy-saving opportunities to qualified customers
- Increase the market penetration of high-efficiency technologies and building systems for customers by offering incentives for high-efficiency and ENERGY STAR®-rated appliances, lighting equipment, and HVAC systems
- Approve and train contractors to pass along PPL Electric Utilities' financial incentives for energy-efficient refrigeration and upgrades for lighting and lighting controls to the customer through a direct discount delivery channel
- Engage contractors to provide high-efficiency technology options to customers
- Promote other PPL Electric Utilities energy efficiency programs
- Obtain participation of approximately 4,000 small C&I customers through 2016, with a total reduction of approximately 190,446 MWh/yr
- Obtain participation of approximately 300 large commercial and industrial customers through 2016, with a total reduction of approximately 102,126 MWh/yr
- Obtain participation of approximately 4,500 GNE customers through 2016, with a total reduction of approximately 81,132 MWh/yr

A summary of program metrics can be found in Table 2-1.

7 Program objectives are stipulated on PPL Electric's revised EE&C Plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, p.107, 128, and 145.

**Table 2-1: Phase II Prescriptive Equipment Program Summary**

| Program | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Net-to-Gross Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) | Program Acquisition Cost[1] ($/Annual kWh) | Cost of Conserved Energy[2] (TRC $/kWh) | Phase II Participants |
|---|---|---|---|---|---|---|---|---|---|
| **Prescriptive Equipment** | **317,057** | **316,883** | **303,542** | **0.82** | **1.50** | **$54,268** | **$0.18** | **$0.06** | **7,863** |

[1] Total EDC costs divided by first year kWh savings.
[2] Total TRC costs divided by levelized lifetime kWh savings.

## 2.1 PROGRAM UPDATES

Two changes were made to the Prescriptive Equipment Program from PY6 to PY7.

At the end of PY6, PPL Electric Utilities discontinued the direct discount channel because funding was no longer available and a wait list had begun for the program.

To encourage participation, PPL Electric Utilities initiated a limited time offer near the end of PY6 that increased the incentive amounts for HVAC and heat pump water heaters. The offer was discontinued after three months because the program appeared fully subscribed and initiated a wait list.

### 2.1.1 Definition of Participant

Participants are PPL Electric Utilities customers in the small C&I, large C&I, and GNE sectors. These customers are required to sign a participation agreement or rebate application and may submit one or more applications, depending on the project. Participants are identified in EEMIS, the PPL Electric Utilities' program tracking database, by a CSP Job ID that is unique to each project.

## 2.2 IMPACT EVALUATION GROSS SAVINGS

### 2.2.1 Reported Gross Savings

Table 2-2 shows the cumulative reported results for Phase II for the entire program. Table 2-3 shows the cumulative reported results for Phase II by sector for lighting. Table 2-4 shows the cumulative reported results for Phase II by sector for equipment.

**Table 2-2: Phase II Prescriptive Equipment Reported Results by Customer Sector**

| Sector | Phase II Participants | Phase II Reported Gross Energy Savings (MWh/yr) | Phase II Reported Gross Demand Reduction (MW) | Incentives Paid ($1,000) |
|---|---|---|---|---|
| Government/Nonprofit/Education – Equipment | 88 | 654 | 0.10 | $12,383 |
| Government/Nonprofit/Education – Lighting | 3,004 | 76,317 | 10.43 | - |
| Large C&I – Equipment | 4 | 420 | 0.05 | $7,249 |
| Large C&I – Lighting | 345 | 79,169 | 8.96 | - |
| Low-Income – Equipment | - | - | - | - |
| Residential – Equipment | 71 | 340 | 0.11 | $111 |
| Residential – Lighting | 20 | 456 | 0.07 | - |
| Small C&I – Equipment | 142 | 3,853 | 0.52 | $19,083 |
| Small C&I – Lighting | 4,189 | 155,849 | 23.42 | - |
| **Phase II Total [1]** | **7,863** | **317,057** | **43.65** | **$38,825** |

[1] Total may not equal sum of column due to rounding.

**Table 2-3: Phase II Prescriptive Equipment (Lighting Products) Reported Results by Customer Sector**

| Sector | Phase II Participants | Phase II Reported Gross Impact (MWh/yr) | Phase II Reported Gross Demand Reduction (MW) |
|---|---|---|---|
| Residential | 20 | 456 | 0.07 |
| Small C&I | 4,189 | 155,849 | 23.42 |
| Government/Nonprofit/Education | 3,004 | 76,317 | 10.43 |
| Large C&I | 345 | 79,169 | 8.96 |
| **Phase II Total** | **7,558** | **311,791** | **42.88** |

**Table 2-4: Phase II Prescriptive Equipment (Equipment Products) Reported Results by Customer Sector**

| Sector | Phase II Participants | Phase II Reported Gross Impact (MWh/yr) | Phase II Reported Gross Demand Reduction (MW) |
|---|---|---|---|
| Residential | 71 | 340 | 0.11 |
| Small C&I | 142 | 3,853 | 0.52 |
| Government/Nonprofit/Education | 88 | 654 | 0.10 |
| Large C&I | 4 | 420 | 0.05 |
| **Phase II Total [1]** | **305** | **5,266** | **0.77** |

[1] Totals may not add up due to rounding.

### 2.2.2 EM&V Sampling Approach

For verification sampling, projects were stratified as lighting and non-lighting equipment (referenced as equipment for the remainder of this report).

Cadmus assigned equipment projects to one of five substrata—HVAC, ground source heat pumps, refrigeration, food service, and agricultural projects (Table 2-5). The HVAC substratum included commercial air conditioners and ductless heat pumps, refrigeration included evaporator fan motors, and food service included ice makers.

Lighting projects were assigned to one of four substrata—large, medium-small, small-medium, and small—based on *ex ante* reported savings (Table 2-5). Lighting and equipment strata are discussed separately below.

**Table 2-5: Prescriptive Equipment Program Strata Definitions**

| Stratum | Substrata | Groups Included |
|---|---|---|
| Equipment | HVAC | Ductless heat pumps, commercial air conditioners |
| | GSHPs | Ground source heat pumps |
| | Refrigeration | Evaporator fan motors |
| | Food Service | Ice makers |
| | Agriculture | All projects designed for and offered to the agricultural sector |
| Lighting | Small | Lighting, see Table 2-8 for kWh thresholds |
| | Small – Medium | Lighting, see Table 2-8 for kWh thresholds |
| | Medium - Small | Lighting, see Table 2-8 for kWh thresholds |
| | Large | Lighting, see Table 2-8 for kWh thresholds |

#### 2.2.2.1 EM&V Sampling Approach: Equipment Projects

PPL Electric Utilities issued rebates for 11 types of equipment during PY7 (although others were eligible for rebates). The non-agriculture equipment were ductless heat pumps, commercial air conditioners, ground source heat pumps, refrigeration evaporator fan motors, and ice makers. The agriculture equipment were livestock waterers, high volume low speed fans, dairy scroll compressors, heat reclaimers, variable speed drive (VSD) controllers for dairy vacuum pumps, and automatic milker takeoffs. The EEMIS database also recorded non-rebated farm audits, which were provided to encourage customers to pursue agriculture equipment rebates.

The PY7 EM&V sampling plan was designed to meet levels of 85% confidence and 15% precision (85/15) for the equipment stratum. Cadmus drew a simple random sample within each substratum, and ensured the energy savings from sampled projects accounted for 80% of the population's savings.

No site visits were conducted for equipment projects in PY7. After establishing the final number and types of projects that were issued rebates in PY7, Cadmus revised the proposed sample plan to exclude site visits because specifications for the types of rebated projects could not easily be verified on site. For example, evaporator fan motors are enclosed inside grocery refrigeration cases and their specifications cannot be accessed unless the case is emptied.

In PY7, 119 unique customers completed 125 projects (515 records).[8] Unique customers refers to unique billing accounts. Projects refers to the number of different products for which the customer submitted

8 This total does not include the 82 unique customers who participated in the farm audit program.

rebate applications. Of these, Cadmus reviewed 49 project records (desk audit), which involved verifying information from EEMIS using rebate applications, customer-submitted supporting documentation, and information recorded by DNV GL, the ICSP. Cadmus did not review farm audit records because zero savings were claimed for those audits.

Cadmus also conducted a telephone survey for one heat reclaimer project and three evaporator fan motor projects to verify installation or other information provided in EEMIS and project documentation. Cadmus attempted to conduct telephone surveys for one dairy scroll compressor project and four additional evaporator fan motor projects, but these customers did not respond.

Table 2-6 shows the target and achieved sample sizes for the equipment stratum verification activities.

**Table 2-6: PY7 Prescriptive Equipment Impact Evaluation Sampling Strategy**

| Substratum | Population Size[1] | Target Levels of Confidence & Precision | Target Sample Size | Achieved Sample Size | Evaluation Activity |
|---|---|---|---|---|---|
| HVAC | 57 | 85/15 at the substratum level | 18 | 18 | Records review |
| | | | 0 | 0 | Telephone verification |
| Ground Source Heat Pumps | 3 | | 3 | 3 | Records review |
| | | | 0 | 0 | Telephone verification |
| Refrigeration | 51 | | 17 | 17 | Records review |
| | | | 7 | 3 | Telephone verification |
| Food Service | 2 | | 2 | 2 | Records review |
| | | | 0 | 0 | Telephone verification |
| Agriculture | 12[2] | | 9 | 9 | Records review |
| | | | 2 | 1 | Telephone verification |
| **Equipment Total** | **119[2]** | **85/15** | **49** | **49** | **Records review** |
| | | | **9** | **4** | **Telephone verification** |

[1] Population size refers to the number of unique billing account numbers per measure and does not include 82 customers who participated in farm audits.
[2] Two customers submitted projects under multiple equipment categories within substratum.

### 2.2.2.2 EM&V Sampling Approach: Lighting Projects

Cadmus calculated an annual sample size for lighting projects to meet the reporting requirements of the SWE. The sample plan was based on the number and characteristics of the nonresidential lighting projects anticipated in PY7.

The sample size calculation used the same error ratio of 0.30 for MWh as in PY6. In PY6, the error ratio was increased to 0.30, from 0.17 in PY5, to improve the probability of achieving reporting results at the 90% confidence and 10% precision level. The SWE set program reporting precision levels at 85/15. However, Cadmus set a higher precision level for the lighting projects in the Prescriptive Equipment Program because these projects provided the majority of savings for the Phase II nonresidential portfolio and this conforms to the SWE's requirement that portfolio savings be verified at the 90/10 level.

Cadmus used a stratified ratio estimation approach because this results in smaller sample sizes and promotes evaluation efficiency compared to using a simple random sampling approach. Cadmus further divided lighting into four substrata:

- Small
- Small-medium
- Medium-small
- Large

Table 2-7 shows the PY7 sampling plan by quarter for a final sample size of 35 projects. Cadmus drew samples, conducted site visits, and reviewed records in Q1, Q2, and Q3. It assumed the population of PY7 projects was homogeneous and that realization rates in the first three quarters would apply to Q4. Cadmus checked this assumption by comparing Q4 project type, size, sector, and delivery channel to the previous three quarters; no significant difference was noted.

**Table 2-7: PY7 Quarterly Prescriptive Equipment Program Lighting Projects Site Visit Sampling Plan**

| Sample Count Allocation Plan | Q1 | Q2 | Q3 | Q4 | Total |
|---|---|---|---|---|---|
| Total, Planned | 12 | 12 | 11 | 0 | 35 |
| **Total, Adjusted** | **12** | **12** | **11** | **0** | **35** |

Substrata boundaries were established by the substratum's contribution to total gross reported kWh savings, following the methods in Chapter 13: Sampling in The California Evaluation Framework.[9] Cadmus determined the number of sample points for each stratum using a Neyman allocation routine that accounts for the variance in each stratum. Table 2-8 shows the substrata lighting boundaries for high and low kWh by quarter.

**Table 2-8: PY7 Quarterly Prescriptive Equipment Lighting Program by Substratum**

| Substratum | Q1 | | Q2 | | Q3 | |
|---|---|---|---|---|---|---|
| | kWh High | kWh Low | kWh High | kWh Low | kWh High | kWh Low |
| Small | 94,842 | 307 | 62,091 | (13,870) | 59,590 | - |
| Small-Medium | 761,459 | 97,190 | 161,325 | 62,345 | 236,308 | 60,112 |
| Medium-Small | 1,092,919 | 789,485 | 850,629 | 197,149 | 978,048 | 247,278 |
| Large | 4,665,079 | 1,095,801 | 1,745,397 | 903,181 | 4,809,211 | 1,122,884 |

A breakdown of reported savings by substratum is shown in Table 2-9.

**Table 2-9: PY7 Prescriptive Equipment Lighting Program, Summary by Substratum**

| Substratum | Reported Projects[1] | Reported Savings (MWh/yr) | Percent Reported Savings |
|---|---|---|---|
| Small | 1,080 | 17,063 | 14% |
| Small-Medium | 199 | 24,510 | 20% |
| Medium-Small | 61 | 32,395 | 27% |
| Large | 25 | 46,667 | 39% |
| **Total** | **1,365** | **120,635** | **100%** |
| [1] Defined by CSP Job ID. | | | |

9 TecMarket Works. *The California Evaluation Framework*. 2004. Pages 368-371.

Table 2-10 presents annual population and sample sizes by substrata.

**Table 2-10: PY7 Prescriptive Equipment Lighting Impact Evaluation Sampling Strategy**

| Substratum | Population Size | Target Levels of Confidence & Precision | Target Sample Size | Achieved Sample Size | Evaluation Activity |
|---|---|---|---|---|---|
| Small | 1,080 | N/A[1] | N/A[1] | 10 | File review and site visit |
| Small-Medium | 199 | N/A[1] | N/A[1] | 7 | File review and site visit |
| Medium-Small | 61 | N/A[1] | N/A[1] | 6 | File review and site visit |
| Large | 25 | N/A[1] | N/A[1] | 12 | File review and site visit |
| **Program Total** | **1,365** | **90/10** | | **35** | **File review and site visit** |

[1] Sample size was set at the program level then allocated to strata according to Neyman routine. Each stratum does not have a target sample size.

### 2.2.3 *Ex Ante* Savings Methodology and Findings

Cadmus adjusted EEMIS' reported savings for efficient equipment to align with the assumptions specified in the Pennsylvania TRM in effect in the year the project was installed. The resulting adjusted *ex ante* savings were for these five types of equipment—ductless heat pumps, ground source heat pumps, commercial air conditioners, high-volume low-speed fans, and ice makers.

TRM *ex ante* adjustments modify savings reported in EEMIS (when reported *ex ante* savings are placeholders) to reflect the specifications of products. Adjustments are made to the population and account for differences among planning assumptions, the TRM assumptions, and specifications of the equipment rebated to participants. The results of these adjustments to the population are the adjusted *ex ante* savings used to determine the program's realization rate.

#### 2.2.3.1 *Ex* Ante Savings Methodology and Findings: Equipment

Cadmus calculated the TRM-adjusted *ex ante* savings for equipment, using the features recorded in EEMIS and listed in Table 2-11. All inputs are the same in all versions of the Pennsylvania TRM, but the baseline and efficient default values may vary. All 515 records were assigned an *ex ante* adjusted savings.

**Table 2-11: PY7 Prescriptive Equipment Program EEMIS Features Used for TRM-Adjusted *Ex Ante* Savings**

| Product | Features |
|---|---|
| Ductless Heat Pumps | Capacity, HSPF, SEER, EER, facility type, and location (EFLH) |
| HE Evaporator Fan Motors | Baseline motor type, new motor type, cooler or freezer, motor wattage, operating hours |
| Commercial Air Conditioners | Cooling and heating capacity, facility type and location (EFLH), cooling and heating performance (EER, SEER, COP) |
| Ground Source Heat Pumps | Cooling and heating capacity, facility type and location (EFLH), cooling and heating performance (EER, SEER, HSPF), circulation pump motor horsepower, pump motor type, number of poles, speed (RPM) |
| High Volume Low Speed Fans | Make, model, fan size (baseline and efficient fan wattages), location (operating hours) |
| Livestock Waterers | Make, model, location (operating hours) |
| Heat Reclaimers | Make, model, number of cows milked per day, type of water heater, presence of pre-cooler |
| Dairy Scroll Compressors | Make, model, scroll compressor performance (EER), operating hours per day, presence of pre-cooler, number of cows milked per day |
| Automatic Milker Takeoffs | Make, model, number of cows milked per day, average number of milkings per day |
| VSD Controller for Dairy Vacuum Pumps | Make, model, rated pump motor horsepower, pump efficiency, operating hours |
| Ice Makers | Ice maker type, make, model, ice harvest rate |

The following describes the equipment for which the TRM-adjusted *ex ante* savings varied from the reported savings. Because these are *ex ante* adjustments, no *ex post* project documentation was used to inform adjustments. Cadmus calculated *ex ante* savings for all 119 equipment projects (see Table 2-6 for projects by equipment type).

**Ductless Heat Pumps.** The savings reported in EEMIS did not match the savings calculated using the TRM algorithm and features reported in EEMIS. The adjustments were 96% for energy savings and 94% for demand reduction. It is unclear why reported and adjusted savings differed because Cadmus used the same features reported in EEMIS, but a possibility was that different default values, such as building type and full load cooling and heating hours, were chosen from the TRM.

**Commercial Air Conditioners.** The savings reported in EEMIS did not match the calculated *ex ante* adjusted savings. The adjustments were 347% for energy savings and 120% for demand reduction. It appears the reported savings used the TRM calculations for air conditioners for all records. The adjusted savings used the TRM calculations for air source and packaged terminal heat pumps because EEMIS reported both a heating capacity and coefficient of performance (COP) for each record, which was an indication that these were heat pumps not air conditioners.

**Ground Source Heat Pumps.** The savings reported in EEMIS did not match the savings calculated using the TRM algorithm and features reported in EEMIS. The adjustments were 50% for energy savings and 158% for demand reduction. The reported savings used default energy savings of 1,396 kWh/yr and demand reduction of 0.17 kW for all ground source heat pump applications, regardless of capacity and performance. The adjusted *ex ante* savings used the TRM algorithm for water and ground source heat pumps, rather than the default, because cooling and heating capacities and performance values (EER and COP) for each application were submitted in the EEMIS data.

The EEMIS data did not include baseline or existing equipment information, so the adjusted savings assumed that all of the installed ground source heat pumps replaced baseline efficiency ground source heat pumps and therefore did not calculate a circulation pump penalty. Cadmus also determined that the quantity reported in EEMIS for the applications submitted in Q4 was actually the rounded value of the heat pump cooling capacity and that each record in EEMIS represented one heat pump.

**High-Volume Low-Speed Fans.** The savings reported in EEMIS did not match the savings calculated using the TRM algorithm and the features reported in EEMIS. The adjustments were 96% for energy savings and 96% for demand reduction. It is unclear why these were different because Cadmus used the same TRM algorithm and features reported in EEMIS to calculate *ex ante* savings, but a possibility was that different default values, such as annual operating hours and baseline and efficient fan wattage, were chosen from the TRM.

**Ice Makers.** The savings reported in EEMIS did not match the savings calculated using the TRM algorithm and the features reported in EEMIS. The adjustments were 163% for energy savings and 163% for demand reduction. The reported energy savings and peak demand reductions in the EEMIS data were based on deemed savings of 514 kWh/yr and 0.113 kW, which were average values from previous evaluation years. These deemed savings were reported for all ice makers, regardless of type and ice harvest rate. Cadmus calculated the *ex ante* savings using the TRM algorithm, which varied by ice maker type and ice harvest rate.

#### 2.2.3.2 *Ex Ante* Savings Methodology and Findings: Lighting Measures

No *ex ante* adjustments were made for lighting measures because all reported savings were calculated by following the TRM methodology and the TRM Appendix C.

### 2.2.4 *Ex Post* Savings Methodology and Findings

The *ex post* savings adjustments incorporated installation rates, adjustments for nonqualifying equipment, and adjustments for equipment details determined through the sample of projects selected for records review (desk audits) and site visits. Cadmus verified installation and qualification rates for all sampled records. The sample was chosen by selecting random projects within each equipment substratum.

#### 2.2.4.1 *Ex Post* Savings Methodology and Findings: Equipment

*Records Review for Rebated Equipment*

Cadmus chose the records review sample for equipment by selecting random projects within each equipment substratum. Table 2-6 and Table 2-12 show the equipment sample sizes. Cadmus verified information recorded in EEMIS for the records review sample by comparing it to corresponding rebate applications, customer-submitted supporting documentation, and information recorded by the ICSP. Cadmus conducted a desk audit of 49 records for the 125 equipment projects; projects were reviewed quarterly as they became available in EEMIS.

Table 2-12 summarizes the sampling for the records review.

**Table 2-12: Prescriptive Equipment Records Review**

| Substratum | Population Size | Assumed Levels of Confidence & Precision | Target Sample size | Achieved Sample Size | Evaluation Activities |
|---|---|---|---|---|---|
| **Equipment** | **119[1]** | **85/15** | | **49** | **Records review, process, impact** |
| HVAC | 57 | 85/15 | 17 | 18 | |
| GSHPs | 3 | 85/15 | 3 | 3 | |
| Refrigeration | 51 | 85/15 | 17 | 17 | |
| Food Service | 2 | 85/15 | 2 | 2 | |
| Agriculture | 12[2] | 85/15 | 9 | 9 | |
| **Total** | **119** | **85/15** | **48** | **49** | |

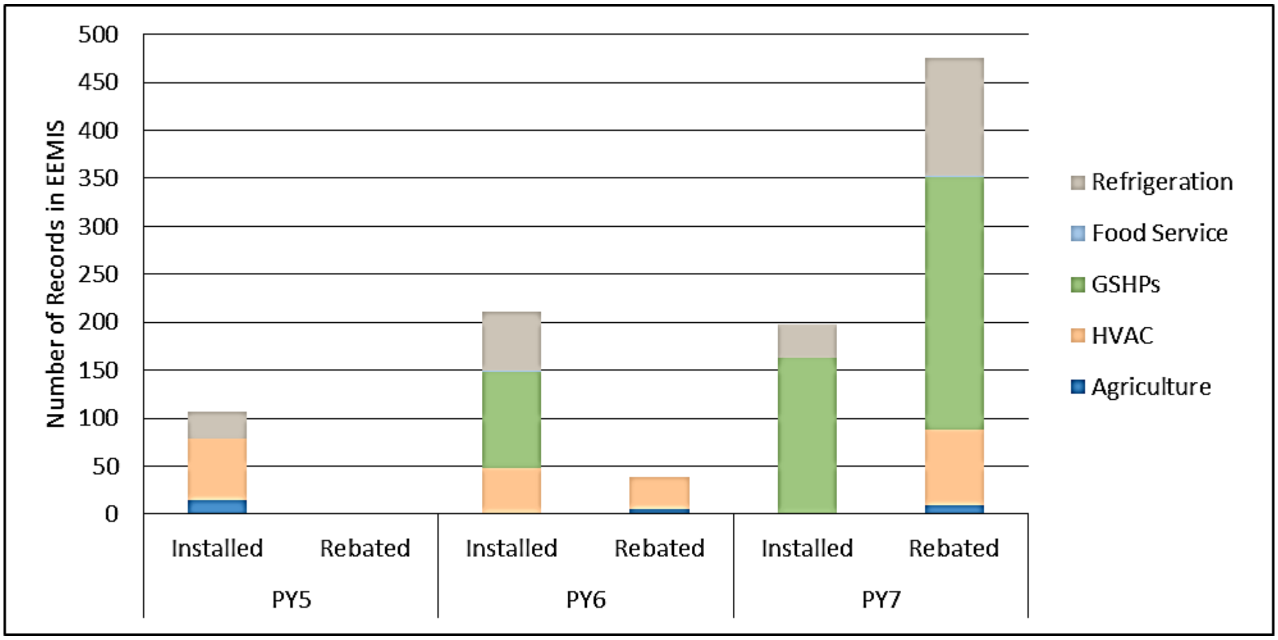
[1] Equipment population size refers to the number of unique billing account numbers that received rebates.
[2]] Two customers submitted projects under multiple equipment categories.

In PY7, the program required completion of eligible equipment before the end of the program year (May 31, 2016). Cadmus found that 62% of PY7 equipment records in EEMIS (318 of the 515) had installation dates before the start of the program year. Twenty-one percent (107 records) were for equipment installed in PY5, 41% (211 records) were for equipment installed in PY6, and 38% (197 records) were for products installed in PY7. All agriculture, food service, and HVAC products were installed in PY5 or PY6.

Cadmus also reviewed the CSP Job invoice date for each of the records in EEMIS and found that 92% of the projects were rebated during PY7. The remaining 8% of projects were rebated during PY6.

Figure 2-1 shows the number of PY7 records for products installed and rebated in each project year (PY5 through PY7) for each of the equipment substrata according to the dates in the EEMIS data.

**Figure 2-1: Installation and Rebate Invoice Dates for Equipment Records by Program Year and Equipment Substrata**




Source: EEMIS project installation date and CSP invoice date data.

Table 2-13 shows that the majority of projects installed in PY5 (81 of 107) and projects installed in PY6 (198 of 211) received rebates in PY7.

**Table 2-13: Installation and Rebate Invoice Dates for PY7 EEMIS Equipment Records**

| Installed | Rebated | | |
|---|---|---|---|
| | PY5 | PY6 | PY7 |
| PY5 (n=107) | - | 26 | 81 |
| PY6 (n=211) | - | 13 | 198 |
| PY7 (n=197) | - | - | 197 |
| Source: EEMIS project installation date and CSP invoice date data. | | | |

Cadmus also verified that the rebated equipment qualified for the program and checked installed quantities. Table 2-14 shows the elements verified through records review for HVAC, ground source heat pump, refrigeration, food service, and agriculture equipment rebated in PY7.

**Table 2-14: Prescriptive Equipment Program Record-Verified Features**

| Equipment | Record-Verified Features |
|---|---|
| Ductless Heat Pumps | Make, model, capacity, HSPF, SEER, facility type and location (EFLH) |
| Commercial Air Conditioners | Capacity, facility type and location (EFLH), EER, SEER, COP |
| Ground Source Heat Pumps | Capacity, facility type and location (EFLH), EER, SEER, HSPF, circulation pump motor HP pump motor type, number of poles, speed (RPM) |
| High-Efficiency Evaporator Fan Motors | Baseline motor type, new motor type, cooler or freezer, motor wattage, operating hours |
| High-Volume Low-Speed Fans | Fan size (baseline and efficient fan wattages), location (operating hours) |
| Livestock Waterers | Location (operating hours) |
| Heat Reclaimers | Number of cows milked per day, type of water heater, presence of pre-cooler |
| Dairy Scroll Compressors | Scroll compressor EER, operating hours per day, presence of pre-cooler, number of cows milked per day |
| Automatic Milker Takeoffs | Number of cows milked per day, average number of milkings per day |
| VSD Controller for Dairy Vacuum Pumps | Rated pump motor horsepower, pump efficiency, operating hours |
| Ice Makers | Ice maker type, make, model, ice harvest rate |

Cadmus identified differences between the *ex ante* adjusted savings and the *ex post* savings for ductless heat pumps, commercial air conditioners, ground source heat pumps, high volume low speed fans, heat reclaimers, dairy scroll compressors, and automatic milker takeoffs.

Cadmus determined the realization rates for the sampled projects (see Table 2-6 for the sample sizes by equipment type). The realization rates were 100% for evaporator fan motors, livestock waterers, VSD controllers for dairy vacuum pumps, and ice makers.

The following explains why *ex post* and *ex ante* adjusted savings calculations varied for equipment where the realization rates were not 100%.

**HVAC.** For ductless heat pumps, the realization rates were 101% for energy savings and 15% for demand reduction. Cadmus used the actual performance values provided in the Air Conditioning, Heating, and Refrigeration Institute (AHRI) database in the *ex post* calculations, whereas the adjusted and reported savings calculations used a formula from the 2014 Pennsylvania TRM. The performance values listed in the AHRI database tended to be lower than the result using the TRM formula.

For commercial air conditioners, the realization rates were 13% for energy savings and 21% for demand reduction. Cadmus collected the application records for two of the commercial air conditioner projects; for both, the specification sheets confirmed that the units were actually heat pumps and the application quantity was one unit. However, EEMIS data showed two records for each CSP Job number, that is, two units. Cadmus concluded that the second record was a duplicate, which resulted in energy savings and demand reduction realization rates of 50%.

**Ground Source Heat Pumps.** Cadmus reviewed all three ground source heat pump applications. The realization rates were -51% for energy savings and -45% for demand reduction. The negative realization rates occurred for a number of reasons, such as inconsistencies between the EEMIS data and final applications and issues with the TRM calculations. The realization rates were affected for these reasons:

- EEMIS appeared to have duplicated the application records for heat pumps submitted late in the program year. For example, the quantity of heat pumps on the project applications provided in the records was significantly fewer than the quantity recorded in EEMIS.
- The TRM did not offer an appropriate baseline for products involving fuel-switching (e.g., where the existing equipment was a gas boiler). All retrofits that did not replace similar ground source heat

pumps were assumed to replace air source heat pumps. This impacted the realization rates because Cadmus included the TRM's energy penalty for ground source loop circulation pumps in the *ex post* savings calculations. Air source heat pumps do not require circulation pumps.

- The TRM savings calculations included an energy penalty for the ground source loop circulation pumps, which meant the overall savings were negative for many of the applications (because the baseline was an air source heat pump). For example, for one project, three 60-horsepower (hp) circulation pumps were submitted with 48 ground source heat pumps, resulting in overall negative energy savings and demand reduction. Although not noted on the application or supporting documentation, this site could have been planning to install additional ground source heat pumps for the system, which would have reduced the circulation pump penalty per project. Cadmus recorded this issue and during future reviews of ground source heat pump records will avoid penalizing this site twice.

**Agriculture.** *Ex post* savings calculations varied from the *ex ante* adjusted savings for high-speed low-volume fans, heat reclaimers, dairy scroll compressors, and automatic milker takeoffs. For high-speed low-volume fans, the realization rates were 103% for energy savings and 78% for demand reduction. Cadmus calculated the verified savings using the wattage from the fan's specification sheet rather than the default wattage in the TRM.

For heat reclaimers, the realization rates were 35% for energy savings and 35% for demand reduction. The water heater information on the final application for one project was conflicting, so Cadmus called the customer who verified that the facility used a propane-fired water heater. Therefore, there were no electric savings from the equipment.

For dairy scroll compressors, the realization rates were 46% for energy savings and 46% for demand reduction. Cadmus collected the application records for both dairy scroll compressor projects and found that the reported parameters and savings matched the verified savings for one of the projects. The other project had submitted a 5-hp scroll air compressor as a dairy scroll compressor. Cadmus attempted but was unable to contact the customer to confirm the type of equipment installed. Because the documentation indicated the equipment was an air compressor, Cadmus verified 0 kWh/yr energy savings and 0 kW demand reduction, which resulted in overall energy and demand realization rates of 46%.

For automatic milker takeoffs, the realization rate was 159% for both energy savings and demand reduction. Cadmus collected the application records for one of the two automatic milker takeoffs projects. The verified savings used the average number of milkings submitted in the application (three per day), while the reported and adjusted savings used the TRM default of two per day.

### *Surveys for Rebated Equipment*

Three customers who received rebates for equipment completed online satisfaction surveys, but their responses were not used in the impact evaluation.

Cadmus conducted telephone verifications for four projects. Cadmus verified that three evaporator fan projects were installed and verified project details for one heat reclaimer project.

### *Site Visits for Rebated Equipment*

No site visits were completed for customers who received rebates for equipment projects because specifications for evaporator fan projects, which make up 66% of the reported savings for all equipment projects, cannot easily be verified on site. Evaporator fan motors are enclosed inside grocery refrigeration cases, and their specifications cannot be accessed unless the case is emptied.

### 2.2.4.2 *Ex Post* Savings Methodology and Findings: Lighting Projects

Cadmus verified savings for a sample of 35 lighting projects. The sample size was based on the PY6 realization rate error ratio of 0.30. One-third of the sample was drawn at the close of each of the first three quarters in PY7. Cadmus reviewed all applications, ICSP documentation, EEMIS records, and payment records for each sampled project for eligibility and compliance with the 2015 Pennsylvania TRM. Site visits were conducted for all the sampled projects to verify a sample of lamps (90/20 confidence/precision within a project) for installation, fixture counts, fixture types, hours of use and coincidence factors, interactive factors, and building type. Building square footage was also verified on site for new construction projects.

#### *Records Review for Lighting*

The records review consisted of a desk review of the file record for each of the 35 projects in the sample. The purpose of the review was to check for data accuracy and compliance with the 2015 Pennsylvania TRM requirements. Logger files and analysis were also reviewed if the ICSP based hours of use on a light metering study. *Ex post* adjustments were made when discrepancies were found. The results of the records review were combined with the site visits findings to determine the verified savings for each of the sampled projects.

Cadmus developed a site visit verification version of the TRM Appendix C for each project.

Cadmus conducted desk reviews and site visits for 35 lighting projects. Table 2-15 summarizes the sampling for the database review.

**Table 2-15: Prescriptive Equipment Database Review**

| Stratum | Population Size | Assumed Levels of Confidence & Precision | Target Sample size | Achieved Sample Size | Evaluation Activities |
|---|---|---|---|---|---|
| Lighting | 1,365 | 90/10 | | 35 | Database review, process, impact |
| Small | 1,080 | N/A[1] | N/A[1] | 10 | |
| Small-Medium | 199 | N/A[1] | N/A[1] | 7 | |
| Medium-Small | 61 | N/A[1] | N/A[1] | 6 | |
| Large | 25 | N/A[1] | N/A[1] | 12 | |
| **Program Total** | **1,365** | | | **35** | |

[1] Sample size was set at the program level then allocated to strata according to Neyman routine. Each stratum does not have a target sample size.
[2] Equipment population size refers to the number of unique billing account numbers that received rebates.
[3] Two customers submitted projects under multiple equipment categories.

#### *Surveys for Lighting*

No surveys were conducted for the impact evaluation data collection or analysis.

#### *Site Visits for Lighting*

Site visits were conducted for each of the 35 projects in the impact evaluation sample. The sample size was based on the PY6 realization rate error ratio of 0.30. The purpose of the site visit was to verify the as-built conditions for each project and correct any discrepancies reported by the ICSP in the project file. If a project had a large number of records (approximately 20 or more) in the Appendix C then Cadmus selected a sample and inspected the sample. The sample size for the Appendix C sample used 90/20 criteria to determine the sample size. Cadmus also interviewed facility representatives to determine operating schedules and to estimate lighting hours of use. Findings from the site visits were captured in the verification versions of Appendix C and verified savings were calculated.

*Ex post* adjustments were based on site-specific data. Reasons for adjustments included corrections to:

- Fixture type, fixture count
- Annual lighting hours of use
- Building type and associated stipulated lighting hours of use and/or coincidence factor
- Space cooling type

Table 2-16 lists high-level information about the review and results of the site visits.

**Table 2-16: PY7 Prescriptive Equipment Lighting Projects – Summary of Site Visits**

| Substratum | Measure | Inspection Firm | Inspections Planned | Inspections Conducted | Sites with Discrepancies from Reports | Resolution of Discrepancies |
|---|---|---|---|---|---|---|
| Small | Lighting | Cadmus | 10 | 10 | **3** | Updated savings based on as-built hours of use, fixture type and counts, space cooling, and building type |
| Small-Medium | Lighting | Cadmus | 7 | 7 | 6 | Updated savings based on as-built hours of use, fixture type and counts, space cooling, and building type |
| Medium-Small | Lighting | Cadmus | 6 | 6 | 4 | Updated savings based on as-built hours of use, fixture type and counts, space cooling, and building type |
| Large | Lighting | Cadmus | 12 | 12 | 9 | Updated savings based on as-built hours of use, fixture type and counts, space cooling, and building type |
| **Total** | | | **35** | **35** | **22** | |

### *Billing Analysis for Lighting Projects*

In July 2014, the SWE granted a partial waiver of the lighting hours of use metering requirement for lighting retrofits in 18 grocery stores within the same chain. Savings in each store were estimated at 800 MWh/yr to 1300 MWh/yr and would normally require metering at each facility. Because the stores were similar in size, equipment, and operating schedules, the SWE permitted PPL Electric Utilities to meter a sample of six stores and apply the results to the population. The SWE further required an IPMVP Option C billing analysis for all stores, with the results used to calibrate the metered hours of use savings.

As requested by the SWE, Cadmus conducted hourly and daily average billing analysis on all 18 grocery stores. The analysis was conducted by creating baseline four-parameter change point models using local outdoor temperatures. Modeled savings were calculated by subtracting the post-retrofit annual billed kWh for each store from the baseline consumption from the models run with post-retrofit temperatures. Modeled savings were 77% to 78% of Appendix C reported savings.

Cadmus also created pre- and post-retrofit hourly load profiles of the stores. The profiles showed significant schedule changes between the pre- and post-retrofit periods for fifteen of the stores. The pre-retrofit billing data exhibited a high use period from 7 a.m. to 11 p.m. and a low use period from 11 p.m. to 7 a.m., 7 days a week. The post-retrofit profiles exhibited a continuous schedule with no late night set back. The effect of the schedule change was that the baseline facility loads were less than they would have been under the continuous post-retrofit condition.

Cadmus determined that without a baseline adjustment the modeled savings were not representative of the post-retrofit condition. No information was available in the project files reviewed for this analysis that could support a baseline adjustment. Additionally, Cadmus conducted site visits at four of the six metered sites and found no discrepancies in the *ex ante* Appendix C, including fixture counts and types. Cadmus therefore used the metered hours of use savings reported in Appendix C.

### 2.2.5 Summary of Evaluation Results

Table 2-17 shows the reported and verified energy savings for the PY7 Prescriptive Equipment Program. Equipment achieved 2,066 MWh/yr of verified savings and had an 86% realization rate. Lighting products achieved 131,058 MWh/yr savings at a 98% realization rate.

**Table 2-17: PY7 Prescriptive Equipment Summary of Evaluation Results for Energy**

| Stratum | PYTD Reported Gross Impact (MWh/yr) | PYTD Adjusted *Ex Ante* Energy Savings (MWh/yr) | PYTD Energy Realization Rate (%) | PYTD Verified Gross Energy Savings (MWh/yr) [1] | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 90% C.L. | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|---|
| Lighting | 133,253 | 133,253 | 98% | 131,058 | 0.01 | 2.05% | 1.80% |
| Equipment | 2,591 | 2,415 | 86% | 2,066 | 0.07 | 3.36% | 2.94% |
| **Program Total** | **135,843** | **135,667** | **98%** | **133,124** | **N/A** | **2.02%** | **1.77%** |

[1] Adjusted *ex ante* multiplied by the realization rate will not equal verified gross energy savings due to rounding.

Table 2-18 shows the reported and verified demand savings for the PY7 Prescriptive Equipment Program. Equipment projects achieved 0.315 MW of verified demand reduction and had a realization rate of 61%. Lighting projects achieved 19.437 MW of verified savings at a realization rate of 97%.

**Table 2-18: PY7 Prescriptive Equipment Summary of Evaluation Results for Demand**

| Program | Reported Gross Demand Savings [1] (MW) | Adjusted *Ex Ante* Demand Savings [2] (MW) | Demand Realization Rate (%) | Verified Gross Demand Savings [2] (MW) | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 90% C.L. | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|---|
| Lighting | 18.844 | 20.103 | 97% | 19.437 | 0.09 | 3.25% | 3% |
| Equipment | 0.461 | 0.519 | 61% | 0.315 | 0.003 | 4.82% | 4% |
| **Program Total** | **19.306** | **20.621** | **96%** | **19.752** | **N/A** | **3.20%** | **2.80%** |

[1] Reported gross demand reductions do not include the gross-up to reflect T&D losses.
[2] Adjusted *Ex Ante* and Verified gross demand reductions include T&D losses.

Table 2-19 shows the reported and verified energy savings for the lighting stratum. Table 2-20 shows the results for demand savings for the lighting stratum.

**Table 2-19: PY7 Prescriptive Equipment Summary of Evaluation Results for Energy Savings of Lighting Stratum**

| Quarter | PYTD Reported Gross Impact (MWh/yr) | PYTD Adjusted *Ex Ante* Energy Savings (MWh/yr) | Energy Realization Rate (%) | PYTD Verified Gross Energy Savings (MWh/yr) [1] | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 90% C.L. | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|---|
| Lighting - Q1 | 38,266 | 38,266 | 94% | 36,010 | 0.09 | 2.90% | 2.53% |
| Lighting - Q2 | 18,115 | 18,115 | 97% | 17,488 | 0.08 | 3.86% | 3.38% |
| Lighting - Q3 | 37,315 | 37,315 | 104% | 38,685 | 0.15 | 5.56% | 4.87% |
| Lighting - Q4 | 39,556 | 39,556 | 98% | 38,875 | 0.12 | 2.31% | 2.31% |
| **Program Total** | **133,253[2]** | **133,253[2]** | **98%** | **131,058[2]** | **0.01** | **2.05%** | **1.77%** |

[1] Adjusted *ex ante* multiplied by the realization rate will not equal verified gross energy savings due to rounding.
[2] Program total does not match total of Q1, Q2, Q3, and Q4 due to rounding.

**Table 2-20: PY7 Prescriptive Equipment Summary of Evaluation Results for Demand Savings for Lighting Stratum**

| Quarter | PYTD Reported Gross Demand Savings [1] (MW) | PYTD Adjusted *Ex Ante* Demand Savings [2] (MW) | Demand Realization Rate (%) | PYTD Verified Gross Demand Savings [2] (MW) | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 90% C.L. | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|---|
| Lighting - Q1 | 5.014 | 5.352 | 91% | 4.886 | 0.2944 | 10.26% | 8.98% |
| Lighting - Q2 | 2.911 | 3.114 | 88% | 2.740 | 0.1748 | 7.30% | 6.39% |
| Lighting - Q3 | 5.044 | 5.387 | 108% | 5.792 | 0.0619 | 3.23% | 2.83% |
| Lighting - Q4 | 5.874 | 6.249 | 96% | 6.019 | 0.2058 | 3.95% | 3.95% |
| **Program Total** | **18.844** | **20.103** | **97%** | **19.437** | **0.09** | **3.25%** | **3.0%** |

[1] Reported gross demand reductions do not include the gross-up to reflect T&D losses.
[2] Adjusted *Ex Ante* and Verified gross demand reductions include T&D losses.

Lighting project savings from GNE customers accounted for 24% of overall reported lighting savings. The 2014 Evaluation Framework required that these savings be reported separately at the 85/15 confidence/precision level,[10] as though they were from an independent program, as stated here:

> *"The government, non-profit and institutional populations, and the low-income population should be evaluated as independent programs if their contribution to their respective sectors [the residential sector for the low-income population, and nonresidential sector for the government, non-profit, and institutional (GNI) population] is greater than 20%."*

In accordance with the framework, GNE sector lighting savings were reported as in Table 2-21 for energy and Table 2-22 for demand.

10 Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase II Energy Efficiency and Conservation Programs.* Page 56. Prepared by GDS Associates, Inc., and Nexant. June 1, 2014.

**Table 2-21: PY7 Prescriptive Equipment Program Summary of Evaluation Results for Energy (GNE Lighting Sector) [1]**

| Sector | Reported Gross Energy Savings (MWh/yr) | GNE MWh/Total Lighting (%) | Energy Realization Rate (%) | Verified Gross Energy Savings (MWh/yr)[2] | Observed Coefficient of Variation (Cv) or Error Ratio in Sample | Relative Precision at 90% C.L. | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|---|
| Government/Nonprofit/ Education | 33,187 | 33,187 | 99% | 32,826 | 0.09 | 1.13% | 0.99% |

[1] Realization rate based on sample size (n) of 7.
[2] Adjusted *ex ante* multiplied by the realization rate will not equal verified gross energy savings due to rounding.

**Table 2-22: PY7 Prescriptive Equipment Program Summary of Evaluation Results for Demand (GNE Lighting Sector) [1]**

| Sector | Reported Gross Demand Savings[2] (MW) | GNE MW/Total Lighting (%) | Demand Realization Rate[2] (%) | Verified Gross Demand Savings[3] (MW) | Observed Coefficient of Variation (Cv) or Error Ratio in Sample | Relative Precision at 90% C.L. | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|---|
| Government/Nonprofit/ Education | 4.687 | 4.979 | 97% | 4.843 | 0.22 | 6.02% | 5.27% |

[1] Realization rate based on sample size (n) of 7.
[2] Adjusted *ex ante* multiplied by the realization rate will not equal verified gross demand savings due to rounding.
[3] Verified gross demand savings for the GNE Lighting Sector do not include T&D losses.

## 2.3 IMPACT EVALUATION NET SAVINGS

The methods used to determine net savings for downstream programs are provided in the Evaluation Framework, which discusses the common methods to determine freeridership and spillover in downstream programs. Freeridership is a measure of the savings that participants would have achieved on their own in the absence of the program; these savings are subtracted from verified gross savings when calculating net savings. Participant spillover, on the other hand, credits the additional savings participants achieved on their own, where their experience with the program was highly influential in their decision to install energy-efficient equipment without the incentive of rebates. Participant spillover adds to the net savings calculations.

Net savings are determined only for future program planning purposes. Energy savings and demand reduction compliance targets are met using verified gross savings.

### 2.3.1 Net-to-Gross Ratio Methodology

Cadmus used information collected from self-report surveys with participating customers in the Prescriptive Equipment Program to determine freeridership. *Addendum B. Net Savings Common Approach* provides additional detail about the net savings methodology and survey questions used for this analysis.

Cadmus attempted to reach all unique customers who participated in the Prescriptive Equipment Program. All participants with e-mail addresses were sent an initial survey invitation and two reminder e-mail invitations. Cadmus called lighting and equipment participants who did not respond to the survey four to five times over several days at different times of the day and scheduled callbacks when possible.

### 2.3.2 Net-to-Gross Ratio Sampling

Cadmus completed online and phone surveys with 65 of 1,309 participants in the prescriptive lighting component of the program. Cadmus also completed online or phone surveys with 12 of the 114 unique participants who received rebates for installing equipment projects. Cadmus used both online and phone survey responses to assess net savings because it found no significant difference between responses.

**Table 2-23: PY7 Prescriptive Equipment Sampling Strategy for NTG Research**

| Stratum | Stratum Boundaries | Population Size | Assumed Cv or Proportion in Sample Design | Assumed Levels of Confidence & Precision | Target Sample size | Achieved Sample Size | Percent of Sample Frame Contacted [1] |
|---|---|---|---|---|---|---|---|
| Lighting | Participants | 1,309 | N/A | N/A | As many as possible | 65[2] | 86% |
| Equipment | Participants | 119 | N/A | N/A | As many as possible | 12 | 100% |
| **Program Total** | **Participants** | **1,428** | **N/A** | **N/A** | **As many as possible** | **77** | |

[1] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means the percentage of the sample frame called to complete surveys.
[2] Three of the 68 lighting survey respondents did not answer the NTG questions.

### 2.3.3 Net-to-Gross Ratio Findings

The freeridership and spillover estimates for the Prescriptive Equipment Program, estimated in accordance with the SWE's NTG guidelines, are shown in Table 2-24.

In PY7, lighting stratum freeridership was 23%, spillover was 0%, and the NTG ratio was 77%. This is an improvement over PY6, where the NTG ratio was 74% for lighting participants.

In PY7, equipment stratum freeridership was 9%. The low freeridership estimate in PY7 was largely driven by two respondents who represented 97% of the verified energy savings in the analysis sample. One of these was estimated as a 12.5% free rider and the other high-energy saver as a 0% free rider. If these two high-energy savers were removed from the equipment strata analysis, the freeridership estimate (weighted by verified program energy savings) would increase to 36% for the equipment stratum.

Cadmus last evaluated net savings for the equipment stratum in PY4 (participation was low in PY5 and PY6). In PY4, the equipment stratum freeridership was 77%. The decline in freeridership in PY7 is most likely due to the pre-application process, which required participants to obtain program approval for a rebate before installing their equipment.

The lighting stratum accounted for 98% of the Prescriptive Equipment Program's verified gross energy savings. Therefore, the overall program freeridership, spillover, and NTG estimates are heavily influenced by the lighting stratum estimates.

**Table 2-24: PY7 Prescriptive Equipment Summary of Evaluation Results for NTG Research**

| Stratum | Estimated Freeridership[1] | Estimated Participant Spillover | NTG Ratio | Observed Coefficient of Variation or Proportion | Relative Precision at 90% C.L. |
|---|---|---|---|---|---|
| Lighting | 23% | 0% | 0.77 | 0.114 | 19% |
| Equipment | 9% | 0% | 0.91 | 0.039 | 7% |
| **Program Total** | **23%** | **0%** | **0.77** | **0.122** | **20%** |

[1] Estimate is weighted by the survey sample-verified program kWh savings. This method ensures that respondents who achieved higher energy savings through the program are given a greater influence on the final freeridership estimate than those respondents who achieved lower energy savings.

## 2.4 PROCESS EVALUATION

### 2.4.1 Research Objectives

The purpose of the process evaluation was to assess the Prescriptive Equipment Program's processes and make recommendations for improved program operation. The main topics were process efficiency, delivery infrastructure, and customer response. The Phase II process evaluations (last conducted in PY6) focused on these areas:

- Effectiveness of the program (including the direct discount delivery channel) in generating awareness and disseminating information
- Effectiveness of the program (including the direct discount delivery channel) in encouraging customers to install the program products
- Customer satisfaction
- Opportunities and barriers
- Possible program enhancements

### 2.4.2 Evaluation Activities

For the Prescriptive Equipment Program, the PY7 process evaluation activities were these:

- Program staff and implementer interviews (n=2)
- Participant surveys (n=80)
  - Lighting participants (n=68)
  - Equipment participants (n=12)
- Database and QA/QC review of records

The research activities were consistent with the evaluation plan except for this:

- Cadmus planned to complete as many as possible online surveys with participants who received incentives for equipment and lighting in PY7. Due to a low response rate of 4% for online surveys (35 completes for 760 records attempted), Cadmus conducted a phone survey with participants to boost survey completes. Because some customers completed multiple projects, Cadmus generated a final survey sample of unique decision-makers to ensure that no customer was contacted more than once for the same survey. The final online survey sample contained 39 unique decision-makers for equipment and 721 unique decision-makers for lighting from the participant group. Cadmus attempted to reach all 39 equipment participants and 721 lighting participants by e-mail. Of these 760, 35 completed the online survey, 71 opted out of the survey, and 654 did not respond. Cadmus then attempted to reach these remaining participants through telephone calls and 45 more completed the survey.

- Cadmus and PPL Electric Utilities decided not to conduct agriculture trade ally interviews or surveys because participation was low, information about this equipment was not available early enough to include in the evaluation, and PPL Electric Utilities was uncertain whether it would continue offering rebates for agriculture equipment in Phase III.

### 2.4.3 Methodology

Table 2-25 summarizes the process evaluation's sampling plan for the Prescriptive Equipment Program for PY7. See *Addendum A. Participant Survey Methodology* for more details about the participant survey.

#### 2.4.3.1 Program Staff and ICSP Interviews

In March of 2016, Cadmus conducted interviews with the program managers from PPL Electric Utilities and the ICSP. The interviews focused on key performance indicators, program design changes, and implementation successes and challenges.

#### 2.4.3.2 Participant Surveys

Cadmus conducted online and telephone surveys to increase the involvement and sample size of participants. These surveys asked identical questions to assess program satisfaction and net savings with responses separated by equipment type.

Cadmus administered the online survey between February and June 2016 and the telephone survey in July and August 2016. Participants who completed the online survey were excluded from the telephone survey. When PY7 began, customers could not be contacted for a survey within a year of completing their last survey with PPL Electric Utilities or Cadmus. This policy for conducting surveys changed in April 2016. To prepare the contact list, Cadmus removed records of anyone who had completed a PPL Electric Utilities or Cadmus survey in the past three months or one year depending on the time of survey data collection. It also removed records of any participants who had also participated in the Continuous Energy Improvement and Custom Incentive programs because these programs had limited participation and their participants were in the program-specific sample. The available sample included all participants from quarters one through four but did not include Q5 because the surveys were completed before these records were available for data collection.

Some customers completed multiple projects through the Prescriptive Equipment Program. This required that Cadmus generate a final survey sample of unique decision-makers to ensure that no customer was contacted more than once for the same survey. The final survey sample contained all unique decision-makers from the participant group. Table 2-25 lists the process evaluation survey sampling strategy for the Prescriptive Equipment Program for PY7. More details about sample attrition and the outcome of each record are presented in *Addendum A. Participant Survey Attrition and Final Disposition*.

**Table 2-25: PY7 Prescriptive Equipment Process Evaluation Sampling Strategy**

| Stratum | Stratum Boundaries | Population Size | Assumed Proportion or Cv in Sample Design | Assumed Levels of Confidence & Precision | Target Sample Size | Number of Records Selected for Sample Frame[1] | Achieved Sample Size | Percent of Sample Frame Contacted to Achieve Sample [1] | Used for Evaluation Activities (Impact, Process, NTG) |
|---|---|---|---|---|---|---|---|---|---|
| PPL Electric Utilities Program and ICSP Staff | Staff | 2 | N/A | N/A | 2 | N/A | 2 | 100% | Process, impact, program staff interview |
| Lighting | Participants | 1,309 | N/A | N/A | As many as possible | 721 [2] | 68 | 86% | Process, impact, NTGparticipant survey |
| Equipment | Participants | 119 [2] | N/A | N/A | As many as possible | 39 [2] | 12 | 100% | Process, online participant survey |
| **Program Total** | | **1,430** | | | | **760** | **82** | | |

[1] Sample frame is a list of participants with contact information who have a chance to complete the survey. Percent contacted means the percentage of the sample frame called to complete surveys.
[2] Although the full population is 265, this count includes records that were available in EEMIS at the time of the final survey.
[3] The final sample frame includes unique records in the PPL database. After selecting all unique records, Cadmus removed any records from the population if the customres had participated in a survey in the last three months, were selected for Continuous Energy Improvement or Custom Incentive program surveys, did not have valid contact information (e-mail or telephone number), were on the do not call list, or opted out of the online survey.

Cadmus attempted to reach all unique customers who participated in the Prescriptive Equipment Program. All participants with e-mail addresses were sent an initial survey invitation and two reminder e-mail invitations. Cadmus called participants who did not respond to the survey four to five times over several days at different times of the day and scheduled callbacks when possible.

Potential sources of bias in the surveys include nonresponse, recall, and social desirability biases. Cadmus addressed these potential sources of bias by applying survey design and survey data collection best practices. Surveys were designed to include questions that were not leading or ambiguous, were not double-barreled, and provided clear interviewing and programming instructions so that they were implemented consistently.

Although 201 unique equipment participants installed 265 measures, some completed multiple Prescriptive Equipment projects. Cadmus generated a final survey sample of unique decision-makers with unique contact information to ensure that no customer was contacted more than once for the same survey. Additionally, 82 of these participants received farm audits that were not associated with a rebate. This resulted in a sample frame size of 39 unique participants. The response rate for equipment participants (31%, 12 of 39 participants in the sample frame) was reasonable; however, bias may have occurred in cases where participants installed equipment in earlier program years.

The participants in the lighting component of the program had a response rate to online surveys of 4.4% (32 of 721 surveys delivered). The phone surveys did slightly better with a response rate of 10.9% (36 out of 330 contacted). Altogether, the response rate for lighting participants (6.4%; 68 of 1051) was low. Even so, Cadmus achieved slightly more completed surveys in PY7 than the 60 completed surveys in PY6.

### 2.4.4 Achievements Against Plan

Table 2-26 contains the program's energy savings and the progress toward planned savings. The program exceeded its planned MWh/yr savings and MW reductions for PY7.

**Table 2-26: Prescriptive Equipment Program Savings [1]**

| | PY5 Verified | PY6 Verified | PY7 Only | | | Phase II: PY5–PY7 | | |
|---|---|---|---|---|---|---|---|---|
| | | | Planned | Verified | Percentage of Planned | Planned [1] | Verified | Percentage of Planned |
| MWh/yr | 81,170 | 89,248 | 84,469 | 133,124 | 158% | 252,326 | 303,542 | 120% |
| MW | 12.58 | 15 | 16 | 19.44 | 121% | 47.5 | 48.02 | 101% |
| Participation (Number of Projects) [2] | 2,348 | 2,694 | N/A | 1,484 | N/A | 15,460 | 6,526 | 42% |

[1] Planned savings are based on PPL Electric Utilities' revised EE&C plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, Table M6, p.119, Table O6, p. 135, and Table Q6, p. 154.
[2] Number of projects not number of participants.

### 2.4.5 Program Delivery

The Prescriptive Equipment Program has been operating for seven years and has had a robust network of contractors supporting it and driving customer participation. The program has been exceeding its planned energy savings with little marketing. Overall, in PY7, for the combined lighting and equipment survey respondents, 59 (77%; n=77) were *somewhat satisfied* or *very satisfied* with their program experience.

In PY7, there were a few minor program challenges:

- Participation rates were low throughout Phase II for equipment and agricultural products, so in late PY6 PPL Electric Utilities increased rebate levels for HVAC equipment and heat pump water heaters.

The increases appeared to have minor effects on participation. This minimal effect on participation is believed to be partially a result of the wait-list implemented early in PY7.

- In PY6, the ICSP conducted audits with 28 agricultural customers, and 17 of these occurred in the last half of PY6. Four customers received audits and then implemented projects that were rebated during PY6. All were lighting projects rather than agricultural equipment. None of the PY6 farm audits or 54 PY7 farm audits resulted in rebates for agricultural equipment during PY7.
- In PY6, the program implemented a preapproval requirement. In PY7, the ICSP reported that more effort was required to review and approve the applications than had been initially anticipated.

### 2.4.5.1 Key Performance Indicators

PPL Electric Utilities and the ICSP defined plans for energy savings for the Prescriptive Equipment Program and set levels for two other metrics they monitor—incentive processing time and customer satisfaction.

Program managers noted during interviews that the key performance indicator for incentive processing was not applicable for PY7 because the program had implemented a wait list. During PY7, the ICSP sent a regular report to PPL Electric Utilities on application processing times and stated that projects were meeting this key performance indicator.

In PY7, customer satisfaction was 77%, slightly below the program's planned 80%, a likely result of implementing the wait list.

The Prescriptive Equipment Program performance plans for these metrics in PY7 is shown in Table 2-27.

**Table 2-27: Prescriptive Equipment Program Key Performance Indicators**

| Key Performance Indicator | Metric | Goal | PY7 Result |
|---|---|---|---|
| **Incentive Processing Time** | Percentage of incentives processed within 6 weeks of receiving the final application | Process all rebates within 6 weeks of receiving the final application. | Wait list implemented for PY7. ICSP tracks rebate processing and provides weekly updates on application status to PPL. |
| **Customer Satisfaction** | Percentage of satisfied customers | 80% or more of surveyed customers participating in any PPL Electric Utilities program report they are satisfied with their experience. | 77% of participants gave high ratings of satisfaction with the program[1] |

[1] High satisfaction ratings were ratings between 8 and 10; see Figure 2-3.

### 2.4.5.2 Program Update Outcomes

Some changes were made to the Prescriptive Equipment Program in PY7. The most notable was to implement a wait list shortly after the program year began to help control oversubscription.

Near the end of PY6, PPL Electric Utilities initiated a limited time offer to increase participation in the equipment stratum by providing higher incentives for HVAC and heat pump water heaters. PPL Electric Utilities and the ICSP discontinued the offer after three months because the program was fully subscribed and PPL Electric Utilities initiated a wait list.

PPL Electric Utilities received applications for six different agricultural measures (14 records) in PY7 for the first time.

### 2.4.6 Participant Profile

Cadmus reviewed the EEMIS database and developed a profile of the 1,821 unique Prescriptive Equipment Program participants. In PY7, 265 participants (201 unique billing account numbers) received rebates for equipment and 82 participated in non-rebated farm audits. Of the 1,556 participants who received rebates for lighting equipment, 91% of projects included controls and sensors.

The majority of program participants were from the small commercial and industrial sector and the GNE sector, with only 8% large C&I customers. Table 2-28 depicts the sectors that participated in the Prescriptive Equipment Program by product group.

**Table 2-28: Prescriptive Equipment Participation by Sector (Percentage of Accounts)**

| Target Group | Population Size | Residential[2] | GNE | Large C&I | Small C&I |
|---|---|---|---|---|---|
| Prescriptive Equipment[1] [2] | 265 | 71 | 74 | 1 | 119 |
| Prescriptive Equipment Lighting | 1,556 | 17 | 442 | 137 | 960 |
| **Total Program** | **1,821** | 88 | 516 | 138 | 1079 |
| **Participation Percentage by Sector** | **100%** | 5% | 28% | 8% | 59% |
| [1] Population size includes non-rebated Farm Audit participants and reflects unique CSP Job IDs.<br>[2] Some agriculture customers have a residential rate class; all sectors are eligible for the Prescriptive Equipment program. | | | | | |

### 2.4.7 Satisfaction

The online and telephone surveys asked participants about their satisfaction with a number of program elements. Cadmus pooled online and phone survey responses; results are reported in aggregate. Satisfaction questions and responses fell primarily into four topic areas—the contractor, application process, rebate processing and timing, and overall program experience. Cadmus removed responses for "don't know," "refused," and "not applicable" from the analysis

#### 2.4.7.1 Satisfaction with the Contractor

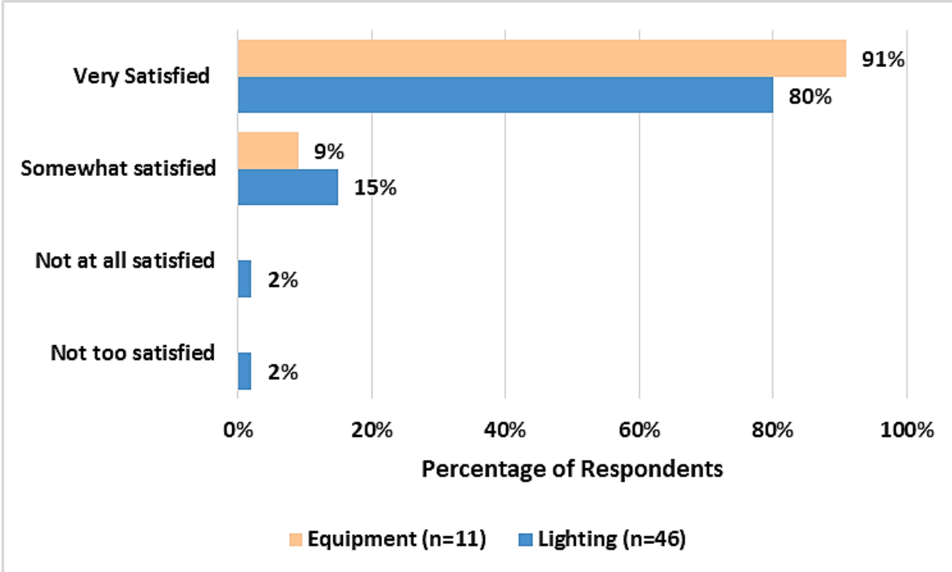
Forty-seven respondents who received lighting and equipment rebates (82%; n=57) said they were *very satisfied* with their overall experience with their contractor. Four percent said they were *not too* or *not at all satisfied* but did not provide additional details. Participant satisfaction with contractors are detailed below in Table 2-29.

**Table 2-29: Satisfaction with Contractor**

| Satisfaction Level | The contractor's knowledge of PPL Electric Utilities rebate program (n=54) | The contractor's assistance with rebate application paperwork (n=53) | Overall experience with the contractor (n=57) |
|---|---|---|---|
| Very satisfied | 76% | 81% | 82% |
| Somewhat satisfied | 20% | 13% | 14% |
| Not too satisfied | 0% | 4% | 2% |
| Not at all satisfied | 3% | 2% | 2% |
| Source: Survey questions E6a,E6b, E6c "How satisfied are you with..." Asked to equipment (n=12) and lighting (n=68). Not applicable, don't know and refused responses removed. | | | |

Figure 2-2 illustrates respondents' overall satisfaction with the contractors who implemented their efficiency projects. The number of responses (n=57 out of 80 respondents completed surveys—68 lighting and 12 equipment) to questions about contractor satisfaction were slightly lower than other categories. Nine participants who did not work directly with a contractor, 10 responded "don't know," and four refused to answer.

**Figure 2-2: Contractor Satisfaction by Stratum**




Source: Survey questions E6c/F3c "How satisfied are you with your overall experience with the contractor" Not applicable, don't know and refused responses removed.

### 2.4.7.2 Satisfaction with the Application Process and Requirements

The majority of survey respondents were either *very satisfied* or *somewhat satisfied* with the program eligibility requirements, terms and conditions, eligible equipment, and rebate forms, as shown in Table 2-30.

Lighting and equipment respondents who were dissatisfied with the application and process requirements (n=3) believed the overall process was too complex. Respondents who were dissatisfied with the application form and documentation required for submittal said that the process for determining equipment eligibility information was too complex and it took too long to complete all of the required information on the application. One respondent said the process for fixing errors and resubmitting the application also contributed to the application process being too time-consuming.

**Table 2-30: Satisfaction with Application Process and Requirements**

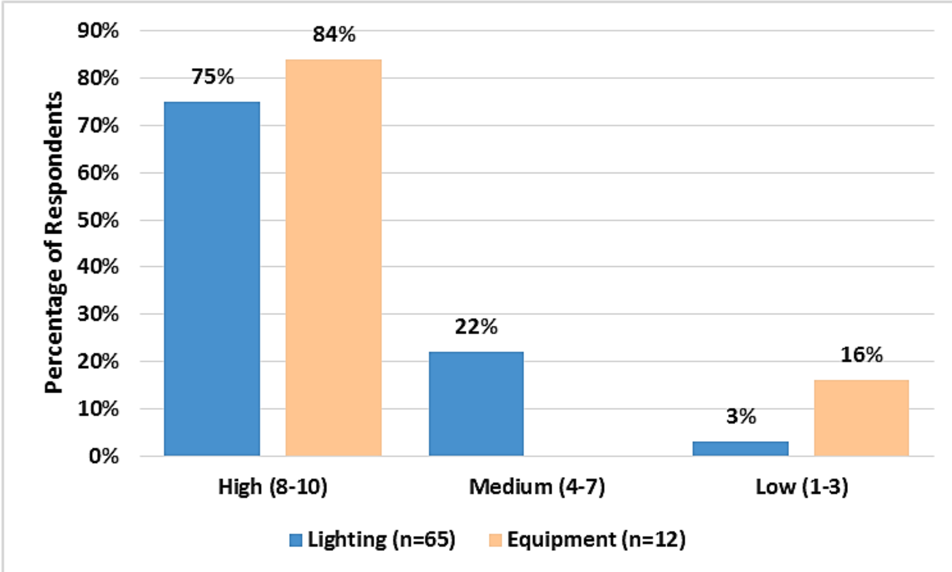
| Satisfaction Level | The eligibility requirements (n=75) | The terms and conditions of the program (n=75) | The availability of eligible equipment that qualifies for the rebate (n=73) | Time it took to complete the paperwork (n=74) | Convenience of scheduling inspections (n=66) | The simplicity of the overall process (n=76) |
|---|---|---|---|---|---|---|
| Very satisfied | 60% | 60% | 67% | 38% | 64% | 46% |
| Somewhat satisfied | 39% | 35% | 30% | 42% | 30% | 37% |
| Not too satisfied | 4% | 4% | 3% | 18% | 3% | 13% |
| Not at all satisfied | 0% | 0% | 0% | 3% | 0% | 4% |

Source: Survey questions E1g/E1h/E1i/E1j/E1k and E1e/E1f/E1g/E1h/E1i "How satisfied are you with...". Not applicable, don't know and refused responses removed. Due to rounding, responses may not add to 100%.

### 2.4.7.3 Overall Satisfaction

Overall, most respondents are satisfied with the Prescriptive Equipment Program (Figure 2-3). Seventy-five percent of lighting participants (n=65) and 84% of equipment participants (n=12) rated their satisfaction as high (rated 8, 9, or 10 on a 10-point scale where 10 means *outstanding* and 1 means *unacceptable*).

**Figure 2-3: Satisfaction with Overall Program Experience**




Source: Survey questions E7 and G1 "Thinking about your overall experience with the program, how would you rate your experience?"

Cadmus asked participants what PPL Electric Utilities and the ICSP could do to improve their program experience. Participant responses generally fell into three categories—communication about the application, wait list, and rebate and application processing times:

- **Application Communications.** Respondents who received equipment rebates wanted timely updates about the application and expected rebate of projects under consideration (four respondents; n=12 equipment respondents). One respondent wanted to *"Have project updates on the paperwork and feedback so I know that things are progressing properly, and that the rebates are going to be forthcoming."* Additionally, if a project rebate amount was changed or rejected, participants wanted more information about any inaccuracies in their calculations or paperwork as soon as possible so they could correct the issue and move the project forward. One lighting and one equipment participant said it was difficult to reach someone knowledgeable to ask about their projects, which led to longer application processing times. Four participants receiving lighting rebates (n=25 lighting respondents) said it was difficult to find a satisfactory answer about the status of their application;[11] this may have been a result of the wait list because one respondent said the application had been submitted but was uncertain about where it currently stood in the list of processed projects.
- **Wait list.** Two equipment respondents expressed confusion and displeasure with the program's wait list (n=12). Two lighting participants (n=25) said the wait list began abruptly, and they did not understand why the program initiated a wait list when their project was ready to be implemented.[12]

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[11] Only 25 of 68 lighting respondents answered question E3. "What could PPL Electric and E-Power Solutions do to improve your experience?" The remaining respondents either did not know, refused, or did not have any suggestions for the program.

[12] Only 25 of 68 lighting respondents answered question E3. "What could PPL Electric and E-Power Solutions do to improve your experience?" The remaining respondents either did not know, refused, or did not have any suggestions for the program.

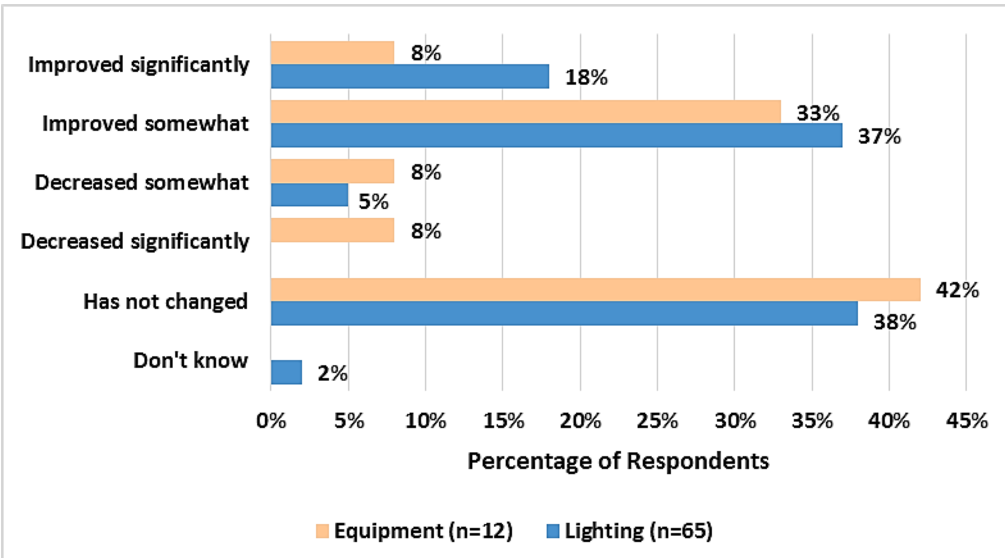
- **Rebate and Application Processing Times.** Six lighting respondents (n=25) and one equipment respondent (n=12) expressed frustration at the overall time for them to complete their participation in the program. One said the business had initiated the project with the rebate included in the business' financials, expecting the rebate by a certain date; however, delays caused worry and the business had to shift funds to cover the interim until the rebate was received.

#### 2.4.7.4 Opinion of PPL Electric Utilities

Survey respondents rated their opinion of PPL Electric Utilities following their participation in the program (Figure 2-4). More than half of lighting participants (55%; n=65) said their opinion of PPL Electric Utilities had *improved significantly* or *somewhat* as a result of participating in the program; 5% said their opinion had *decreased somewhat*.

Forty-one percent of equipment participants (n=12) said their opinion of PPL Electric Utilities had *improved significantly* or *somewhat*; 16% said their opinion had *decreased somewhat* or *significantly*. Equipment participants were more likely than lighting participants to have their experience in the program negatively affect their opinion of PPL Electric Utilities (albeit the equipment sample was small n=12).

**Figure 2-4: Opinion of PPL Electric Utilities Following Program Participation**




Source: Survey questions K2 and G3 "After participating in the PPL Electric Utilities Rebate Program, has your opinion of PPL Electric Utilities …"

### 2.4.8 Marketing and Outreach

#### 2.4.8.1 PPL Electric Utilities and CSP Marketing

PPL Electric Utilities planned a slow and steady pace for applications during Phase II to closely track program participation and monitor progress toward the planned energy savings for the program. According to program managers, with improved tracking, in PY7 PPL Electric Utilities has managed program participation rates and avoided program oversubscription. One of the ways it managed progress was to institute a project wait list in May 2015. (All existing reserved projects and completed applications received before midnight May 19, 2015, were honored and remained eligible for rebates as long as the project was completed by their reservation deadline.)

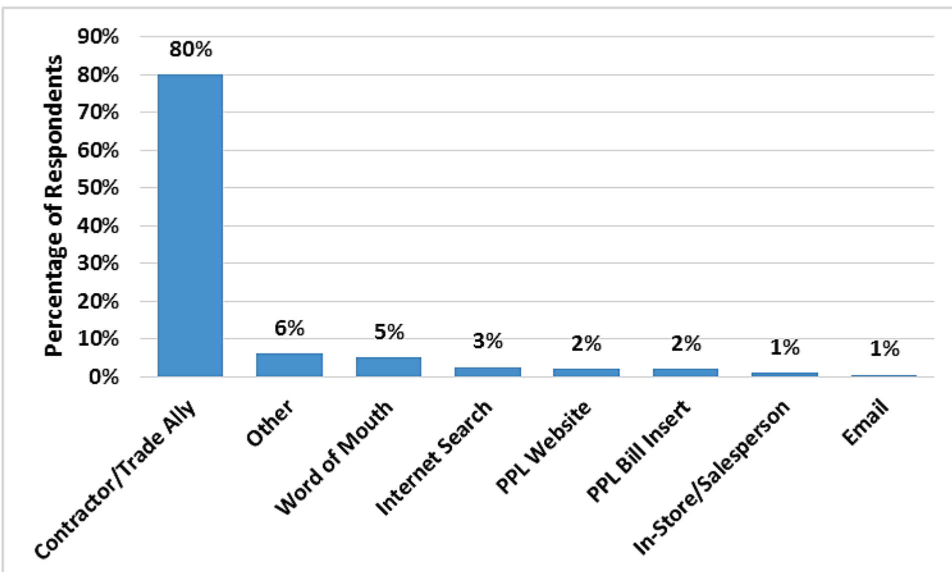
During Phase II, PPL Electric Utilities conducted limited marketing. This strategy may have led to low participation rates for equipment; however, the program met its planned energy savings in PY7. The program achieved 158% of its planned energy savings in PY7, so the limited marketing and preapproval process was successful in helping PPL Electric Utilities reach its planned savings while avoiding oversubscription.

During PY7, the ICSP conducted outreach events that targeted customers and contractors. Marketing and outreach focused heavily on the agriculture portion of the program to try to generate more participation. These outreach activities included attendance at farming events and free audits to potential participants. Additionally, the ICSP sent a newsletter to contractors about PPL Electric Utilities' programs and conducted webinars for participating contractors who were new to the program.

#### 2.4.8.2 Program Awareness

PPL Electric Utilities collected data on the rebate application form to find out how participants learned about the program and recorded the data in EEMIS. In PY7, 80% (n=1,160; respondents who answered application question) of program participants heard about the program from their contractor (Figure 2-5). This indicated that contractors were actively involved in promoting the program and that the contractor network was functioning well and generating participant awareness effectively with little to no cost to the program (PPL Electric Utilities does not offer contractor sales performance incentive funds [SPIFs]). Customers also heard about the program through word-of-mouth and Internet searches.

**Figure 2-5: PY7 Program Awareness**




Source: From application "How did you learn about the PPLs rebates?" (n=1,160; don't knows and refused removed).

## 2.5 CONCLUSIONS AND RECOMMENDATIONS

Overall, the program is operating well. A strong network of lighting contractors has kept participation steady, and the program is on track to meet its planned energy savings for Phase II. Cadmus offers the following conclusions and recommendations for PPL Electric Utilities to consider in planning and offering the program in Phase III.

**Conclusion**

Satisfaction with some aspects of the rebate application process is lower than in previous program years. The percentage of respondents who were *very satisfied* with the amount of time it took to receive the rebate after submitting the application fell to 38% in PY7 from 44% in PY6 and from 72% in PY5.

Additionally, respondents reported frustration at the time it took to receive the rebate. This change in satisfaction was likely due to the introduction of the wait list process in PY7 (see Section 2.4.7).

**Recommendation**
PPL Electric Utilities and the ICSP could improve participant satisfaction by providing more support in filling out the applications with examples of completed applications on the website and a point of contact available to answer questions about the application forms. Additionally, PPL Electric Utilities and the ICSP could consider incorporating a way for applicants to track the status of their application online. The ICSP could also set a timeframe to process rebates. This was a key performance indicator in PY6 but was not applicable in PY7 due to the waitlist. Cadmus recommends that this key performance indicator be continued in Phase III.

**Recommendation**
The ICSP could also reach out to trade allies who are active in the program and explain at the beginning of the year that a wait list could occur in the future. Additionally, once a wait list has occurred PPL Electric Utilities and the ICSP could post an update on their website explaining why a wait list was implemented and when the wait list is expected to be removed.

**Conclusion**
Realization rates for energy savings and demand reduction for lighting projects were both high. The MWh/yr gross impact realization rate was close to 100% and has been consistently greater than 90% since PY3. These high rates indicated good adherence to TRM requirements as outlined by Cadmus in annual TRM lighting guidance memos prepared for the ICSP (see Section 2.2.4.1).

**Recommendation**
In Phase III, the ICSP should continue to adhere to the TRM. Additionally, Cadmus suggests that the ICSP add a QA/QC protocol to ensure Appendix C inputs and results match EEMIS.

**Conclusion**
Cadmus found many data entry errors for equipment measures in EEMIS during its database review and when reviewing project documentation that could have been addressed by the ICSP during a QA/QC process. It appears that the QA/QC process could be improved in the data provided by the ICSP before loading into EEMIS (see Section 2.2.4.1).

**Recommendation**
In Phase III, the ICSP has a QA/QC plan in place to catch any data entry errors. Cadmus suggests enhancing QC processes to identify record duplicates, out-of-range values, and flag entries when data fields are populated that are not applicable to the rebated equipment (e.g., heating capacities for air conditioners).

**Conclusion**
Many of the equipment projects that received incentives during PY7 were installed during the PY5 or PY6 timeframes. The long span between the installation date and the survey may impact the customer's recall about decision-making, thereby biasing NTG scores or satisfaction responses (see Sections 2.2.4.1 and 2.3.3).

**Recommendation**
In Phase III, there are several changes that should minimize the time between project installation and the survey. First, customers are required to submit their rebate application within 180 days of project installation. Second, the ICSP will share participant contact data with Cadmus monthly so that online surveys can be conducted throughout the program year.

### 2.5.1 Status of Recommendations for Program

Table 2-31 contains the status of each PY7 process recommendation made to PPL Electric Utilities.

**Table 2-31: Prescriptive Equipment Program Status Report on Process and Impact Recommendations**

| Recommendations | EDC Status of Recommendation (Implemented, Being Considered, Rejected AND Explanation of Action Taken by EDC) |
|---|---|
| **Prescriptive Equipment Program** | |
| Consider providing more support in filling out the applications with examples of completed applications on the website and a point of contact available to answer questions about the application forms | Implemented. |
| Consider incorporating a way for applicants to track the status of their application online. | Implemented. |
| Consider reaching out to trade allies who are active in the program and explain at the beginning of the year that a wait list could occur in the future. | Implemented. |
| Consider posting an update on the website explaining why a wait list was implemented and when the wait list is expected to be removed. | Will be implemented if there is a waitlist in Phase III. |
| Consider requiring the ICSP to add a QA/QC protocol for lighting projects to ensure Appendix C inputs and results match EEMIS. | Implemented. |
| Consider enhancing QC processes to identify record duplicates, out-of-range values, and flag entries when data fields are populated that are not applicable to the rebated equipment (e.g., heating capacities for air conditioners). | Implemented. Additional QA/QC was implemented for Phase III and will be continually improved. |

## 2.6 FINANCIAL REPORTING

A breakdown of the Prescriptive Equipment Program finances is presented in Table 2-32.

**Table 2-32: Summary of Prescriptive Equipment Program Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs (Sum of rows 2 through 4) | $95,123 | $146,969 |
| 2 | EDC Incentives to Participants | $15,341 | $35,351 |
| 3 | EDC Incentives to Trade Allies | | 0 |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $79,782 | $111,618 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6 through 10 ) | $6,373 | $14,105 |
| 6 | Design & Development | $0 | $0 |
| 7 | Administration, Management, and Technical Assistance[1] | $6,373 | $14,105 |
| 8 | Marketing[2] | $0 | $0 |
| 9 | EDC Evaluation Costs | $0 | $0 |
| 10 | SWE Audit Costs | $0 | $0 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | $53 | $45 |
| | | | |
| 12 | Total TRC Costs[3] (Sum of rows 1, 5 and 11) | $101,548 | $161,119 |
| 13 | Total NPV Lifetime Energy Benefits | $111,324 | $222,649 |
| 14 | Total NPV Lifetime Capacity Benefits | $9,431 | $19,449 |
| 15 | Total NPV O&M Saving Benefits | ($0) | ($0) |
| 16 | Total NPV TRC Benefits[4] | $120,755 | $242,098 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | 1.19 | 1.50 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.
[2] Includes the marketing CSP and marketing costs by program CSPs.
[3] Total TRC Costs includes Total EDC Costs and Participant Costs.
[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.
[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.

# ADDENDUM A. PARTICIPANT SURVEY ATTRITION AND FINAL DISPOSITION

## Contact Instructions

PPL Electric Utilities provided survey contact instructions for conducting surveys. Customers cannot be contacted for a survey if they completed a PPL Electric Utilities or Cadmus survey in the past year They cannot be contacted for a survey if they have opted out of a survey or have asked not to be contacted again. Telephone survey calls cannot take place on Sundays or national holidays.

## Sample Cleaning and Attrition for Standard Lighting Participants

Cadmus coordinated with PPL Electric Utilities' contractor to screen the sample and remove customer records called in the past three months (whether for a Cadmus survey or a PPL Electric Utilities survey) and those who requested not to be contacted again. Cadmus removed records with incomplete information. Cadmus excluded from this population any participants of the Custom Incentive and the Continuous Energy Improvement programs to reserve them for inclusion in the limited sample pools for these program-specific surveys.

In some instances, the same customer completed multiple projects. This required that Cadmus generate a final survey sample of unique decision-makers to ensure that no customer was contacted more than once for the same survey. The final survey sample contained all unique decision-makers from the participant group.

This cleaning and survey sample preparation process reduced the available sample. Cadmus sent e-mail invitations to the remaining contacts with e-mail addresses. All respondents with e-mail addresses received an initial survey invitation and two reminder e-mail invitations. If the contact did not complete an online survey, participants were contacted by telephone. Cadmus attempted to reach respondents up to five times over several days, at different times of the day, and scheduled callbacks whenever possible. Table 2-33 lists total numbers of records submitted to the survey subcontractor and the outcome (final disposition) of each record.

**Table 2-33: Prescriptive Equipment Online Sample Attrition Table**

| Description of Call Outcomes | Number of Records | |
|---|---|---|
| | Lighting | Equipment |
| **E-Mail** | | |
| **Population (number of rebates)** [1] | **1,309** | **119** |
| Removed incomplete or e-mail address, inactive customer, completed survey in past 3 months, on "opt out" list, selected for a different survey, duplicate contact | **588** | **80** |
| **Survey Sample Frame (sent e-mail invitations)** | **721** | **39** |
| **Records Attempted** | **721** | **39** |
| Did not respond | 626 | 28 |
| Opt out or refused to finish survey | 63 | 8 |
| **Completed Surveys** | **32** | **3** |
| [1] Number of rebates available in EEMIS at the time of the final survey effort. | | |

| Description of Call Outcomes | Number of Records | |
|---|---|---|
| | Lighting | Equipment |
| **Telephone** | | |
| **Population (number of rebates) [1]** | **1,309** | **119** |
| Removed incomplete or bad phone number, inactive customer, completed survey in past 3 months, on "do not call" list, opted out of survey, selected for a different survey, duplicate contact | **683** | **91** |
| **Survey Sample Frame (sent to subcontractor for telephone survey calls)** | **626** | **28** |
| **Not attempted** | **296** | **0** |
| **Records Attempted** | **330** | **28** |
| Non-working number | 14 | 0 |
| Wrong number, business | 13 | 0 |
| Language barrier | 0 | 0 |
| PPL Electric Utilities or market research employee | 0 | 0 |
| Cannot confirm equipment/not aware of participation | 2 | 1 |
| Refusal | 74 | 0 |
| No answer/answering machine/phone busy | 96 | 19 |
| Non-specific or specific callback scheduled | 88 | 0 |
| Partial complete | 7 | 0 |
| **Completed survey** | **36** | **8** |

[1] Number of rebates available in EEMIS at the time of the final survey effort.

# ADDENDUM B. NET SAVINGS COMMON APPROACH

Cadmus used self-report surveys to assess net savings for the Prescriptive Equipment Program, following the Evaluation Frameworks recommended common method for assessing freeridership. The SWE team reviewed and approved the survey prior to fielding.[13]

The assessment includes two components of freeridership - *intention* to implement an energy-efficient project without a rebate and *influence* of the program in the decision to implement the energy-efficient project. When scored, each component has a value ranging from zero to 50 and a combined total freeridership score ranging from zero to 100.

## Intention

*Intention* was assessed through several brief questions to determine how the project likely would have differed if the respondent had not received the program assistance. If the customer received more than one rebate, these questions focused on the project with the largest energy savings.

### *Intention Survey Questions*

A1. Please describe why your company completed this project. Was it … [RECORD ALL THAT APPLY]
*To expand the facility; Replace old or nonworking equipment; Improve energy efficiency; Increase the comfort level of the building; To facilitate a change in production levels; Other reason [SPECIFY]; Don't know; Prefer not to answer*

A2. When you first learned about the Prescriptive Equipment rebate program, was the entire cost of the purchase and installation of the project included in your company's capital budget for this project?
*Yes; No; Not applicable; Don't know; Prefer not to answer*

A3. Had your organization ALREADY planned and designed your project BEFORE your organization heard about the PPL Electric Utilities rebates?
*Yes; No; Not applicable; Don't know; Prefer not to answer*

A4. What would have likely happened if you had not received the rebate from PPL Electric Utilities?
*Canceled or postponed the project at least one year; Reduced the size, scope, or efficiency; Done the exact same project (no change) on the same schedule; Not applicable; Don't know; Prefer not to answer*

[ASK IF A4= 2]

A5. By how much would you have reduced the size, scope, or efficiency? Would you say a…[READ LIST]
*Small amount or reduced by less than 20%; Moderate amount or reduced by 20% to 50%; Large amount or reduced by over 50%; Don't know; Prefer not to answer*

[ASK IF A4= 2]

13 Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase II Energy Efficiency and Conservation Programs.* Prepared by GDS Associates, Inc., and Nexant. June 1, 2014.

A6. Please describe what your company would have reduced about the size, scope, or efficiency of the project.
*[RECORD ANSWER]; (Don't know); (Refused)*

**[ASK IF LEDFLAG=LED]**

A7. If you had not received the rebate from PPL Electric Utilities for the LED lights, which of the following do you believe would have most likely happened? [SELECT ONE RESPONSE]
*Put off replacing the lights with LEDs for at least one year or cancelled it altogether; Replaced fewer lights with LEDs; Installed different lights [ASK 0] (What kind? [SPECIFY]); Installed the same number and type of LED lights anyway; Done something else [ASK 0] (What would you have done? [SPECIFY]); Did not receive LED lights; Don't know; Prefer not to answer*

## Influence

*Influence* is assessed by asking about how much influence—from 1 (no influence) to 5 (extreme influence)—various program elements had on the decision to do the project the way it was done. The items selected for rating were specific components of the Prescriptive Equipment Program.

### *Influence Survey Questions*

A8. Please rate each item on how much influence it had on the decision to complete the project the way it was completed. Please use a scale from 1, meaning no influence, to 5, meaning the item was extremely influential in your decisions. If a statement is not applicable, indicate that as well.
[RANDOMIZE LIST]

| Item | No influence | | | | Extremely influential | Don't know | Not applicable | Prefer not to answer |
|---|---|---|---|---|---|---|---|---|
| **INFLUENCE SCORE = Value in parentheses, underneath each rating is the influence score. Respondents' score comes from max Rating of responses highlighted in green below.** | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 98 | 96 | 99 |
| a. PPL Electric Utilities staff such as your Key Account Manager or E-power Solutions | | | | | | | | |
| b. PPL Electric Utilities rebates for this project | | | | | | | | |
| c. PPL Electric Utilities marketing | | | | | | | | |
| d. PPL Electric Utilities information about energy efficiency | | | | | | | | |
| e. Your company's financial policy for energy efficiency projects (IRR, ROI, etc.) | | | | | | | | |
| f. [ASK IF PARTICIPATED IN THE PAST] Past participation in a PPL Electric Utilities program | | | | | | | | |
| g. The contractor, vendor, or consultant who helped design your project | | | | | | | | |
| h. Your company's energy efficiency policies | | | | | | | | |

A9. Was there anything else that was highly influential in your decision to complete the project in the way that you did?
*Yes [SPECIFY]; No; Prefer not to answer*

***[ASK IF A8G=4 OR 5]***

A10. How did the contractor, vendor, or consultant influence your decision to conduct the project as it was completed?
*[RECORD ANSWER]; Prefer not to answer*

Thinking about the [PROJECT DESCRIPTION or V_PROJECTDESCRIPTION] project that was completed…

A11. How likely is it that your business would have paid the full cost to install the same quantity and efficiency of that equipment at the same time you conducted this project? Would you say… [READ LIST]
*Very likely; Somewhat likely; Not too likely; Not at all likely; Don't know; Prefer not to answer*

# 3 RESIDENTIAL RETAIL PROGRAM

The Residential Retail Program consists of two components, an upstream lighting component and a downstream rebated-equipment component. Both components are managed by one ICSP, Ecova.

The upstream lighting component offers incentives to manufacturers to discount the price of energy-efficient screw-in LEDs sold in retail stores. The program also distributes information about energy-efficient lighting in brochures, online, and at participating retailers. The ICSP works directly with manufacturers and retail store channels to coordinate and track the sale of discounted bulbs.

The ICSP also makes CFL recycling bins and recycling education materials available at participating retailers throughout the PPL Electric Utilities territory as well as in various municipal and community locations. PPL Electric Utilities posts these CFL-recycling locations on its website.

In PY7, the rebated equipment component provides rebates directly to customers for energy-efficient refrigerators and heat pump water heaters. This component also includes efficient fossil-fuel water heaters eligible for rebates under the fuel-switching pilot (see *Appendix K: Fuel-Switching Pilot Analysis: Electricity to Fossil Fuels*). The ICSP provides education and promotional materials to participating retailers and maintains a call and rebate-processing center.

The objectives of the Residential Retail Program are these:[14]

- Provide a mechanism for customers to easily obtain discounted ENERGY STAR-qualified energy-efficient light bulbs (primarily CFLs in PY5 and only LEDs in PY6 and PY7) and efficient equipment sold in retail stores
- Achieve widespread visibility through independent and regional retailers that carry the eligible ENERGY STAR products
- Develop and execute strategies aimed at transforming the market for ENERGY STAR-qualified LED bulbs and equipment
- Provide customers with the opportunity to recycle CFLs through retailers and municipalities and educate customers about proper recycling
- Educate customers on new technologies for light bulbs, such as LEDs, and the impact the Energy Independence and Security Act (EISA) will have on sales of energy-efficient light bulbs
- Engage retailers by educating and training retail sales associates about the energy-efficient equipment
- Provide a one-stop call and rebate processing center
- Promote other PPL Electric Utilities energy efficiency programs
- Obtain annual savings of approximately 186,000 MWh/yr from the lighting component of the program and 5,800 MWh/yr from the rebated equipment component

A summary of program metrics can be found in Table 3-1.

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14 Program objectives are stipulated in PPL Electric Utilities' revised EE&C Plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, p. 47.

**Table 3-1: Residential Retail Program Summary**

| Program | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Net-to-Gross Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) [1] | Program Acquisition Cost ($/Annual kWh) [1], [2] | Cost of Conserved Energy (TRC $/kWh) [3] | Phase II Participants [4] |
|---|---|---|---|---|---|---|---|---|---|
| Residential Retail- Equipment | 7,508 | 7,784 | 7,754 | 0.62 | 3.75 | $25,960 | $3.35 | $0.033 | 16,102 |
| Residential Retail- Upstream Lighting | 196,294 | 199,782 | 198,264 | 0.69 | | | | | 608,175 |
| **Total** | **203,802** | **207,565** | **206,018** | **0.69** | **3.75** | **$25,960** | **$0.13** | **$0.033** | **624,277** |

[1] Expenditures are tracked at the program level, not by component.
[2] Total EDC costs divided by first year kWh savings.
[3] Total TRC costs divided by levelized lifetime kWh savings.
[4] Participant estimates are detailed in Section 3.1.1.

## 3.1 PROGRAM UPDATES

At the start of PY7, PPL Electric Utilities introduced a tiered rebate for heat pump water heaters. In addition to the $300 rebate for ENERGY STAR-certified models with an energy factor greater than 2.3, customers could receive an additional $100, totaling $400, for models with an energy factor of 2.75 or higher.

### 3.1.1 Definition of Participant

Residential Retail Program participants for the rebated equipment component are defined by a unique job, or rebate application. In PY7, the program reported 4,417 equipment-rebate participants.

The upstream lighting component had an estimated 221,366 participants. Of these, an estimated 173,366 purchased 1,317,223 discounted bulbs. Additionally, 48,000 participants were known to have received free bulbs. Of these, 45,000 bulbs were given away, one per customer, to participants in the Low-Income Energy-Efficiency Behavior & Education Program and an additional 3,000 were given away to low-income customers during a holiday dinner event.

The ICSP reported jobs as weekly bulb sales, by product. Cadmus estimated the number of participants by dividing the total number of bulbs sold or distributed in each year by a bulbs-per-participant estimate derived from the general population surveys conducted in that program year.

Table 3-2 shows these estimates, by year and sector.

**Table 3-2: Phase II Upstream Lighting Participant Estimates, by Year and Sector**

| Program Year | Sector | Bulbs | Participants | Bulbs per Participant |
|---|---|---|---|---|
| PY5 | Residential | 1,679,161 | 208,591 | 8.05 |
| | Small C&I | 212,701 | 10,582 | 20.10 |
| PY6 | Residential | 969,730 | 157,169 | 6.17 |
| | Small C&I | 127,695 | 10,467 | 12.20 |
| PY7 | Low-Income | 48,000 | 48,000 | 1.00 |
| | Residential | 1,211,953 | 160,311 | 7.56 |
| | Small C&I | 159,270 | 13,055 | 12.20 |

## 3.2 IMPACT EVALUATION GROSS SAVINGS

### 3.2.1 Reported Gross Savings

In Phase II, the Residential Retail Program reported energy savings of 203,802 MWh/yr and demand reduction of 25.49 MW, as shown in Table 3-3. The savings for the small commercial and industrial (C&I) sector included adjustments to account for cross-sector sales in the upstream lighting portion of the program, as described in *Appendix D: Residential Lighting Upstream Program Cross-Sector Sales*.

**Table 3-3: Phase II Residential Retail Reported Results by Customer Sector**

| Sector | Phase II Participants | Phase II Reported Gross Energy Savings (MWh/yr) | Phase II Reported Gross Demand Reduction (MW) | Incentives Paid ($1,000) |
|---|---|---|---|---|
| Residential | 541,899 | 146,828 | 11.67 | $14,411 |
| Low-Income | 48,000 | 1,467 | 0.16 | - |
| Small C&I | 34,197 | 55,487 | 13.67 | $1,750 |
| Large C&I | 1 | 0 | 0.00 | $0 |
| Government/Nonprofit/Education | 180 | 20 | 0.00 | $8 |
| **Phase II Total [1]** | **624,277** | **203,802** | **25.49** | **$16,169** |
| [1] Total may not equal sum of column due to rounding. | | | | |

Table 3-4 shows the Phase II Residential Retail Program results by customer sector and component.

**Table 3-4: Phase II Residential Retail Reported Results by Customer Sector & Component**

| Sector | Phase II Participants | Phase II Reported Gross Impact (MWh/yr) | Phase II Reported Gross Demand Reduction (MW) | Incentives Paid ($1,000) |
|---|---|---|---|---|
| Residential – Equipment | 15,828 | 7,448 | 0.69 | $14,411 |
| Residential – Upstream Lighting | 526,071 | 139,380 | 10.98 | $0 |
| Government/Nonprofit/Education – Equipment | 180 | 20 | 0.00 | $8 |
| Large C&I – Equipment | 1 | 0 | 0.00 | $0 |
| Low-Income – Upstream Lighting | 48,000 | 1,467 | 0.16 | $0 |
| Low-Income – Equipment | 0 | - | - | $0 |
| Small C&I – Equipment | 93 | 40 | 0.00 | $1,750 |
| Small C&I – Upstream Lighting | 34,104 | 55,447 | 13.66 | $0 |
| **Phase II Total** | **624,277** | **203,802** | **25.49** | **$16,169** |

### 3.2.2 EM&V Sampling Approach

Cadmus used methods specific to each program component to review and adjust savings estimates. For the upstream lighting component, it conducted an audit of lighting manufacturer invoices and reviewed all database records. It used the distribution of discounted bulbs, by manufacturer and retailer, to develop a strategic sample of manufacturer lighting invoices, including a diversity of manufacturer and store invoices in the sample.

Cadmus verified the rebated equipment via desk audits of a simple random sample of rebate forms. It also used the ENERGY STAR-qualified and Consortium for Energy Efficiency (CEE)-qualified product lists to look up model-specific inputs and make adjustments to savings estimates based on either the 2014 or the 2015 Pennsylvania TRM,[15] depending on the year in which the equipment was installed. Cadmus prorated the

15 Pennsylvania Public Utility. *2014 Technical Reference Manual.* June 2014. Available online: http://www.puc.pa.gov/pcdocs/1300345.docx

Pennsylvania Public Utility. *Technical Reference Manual.* June 2015. Available online: http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx sample of 72 rebated units between refrigerators and heat pump water heaters, based on reported energy savings, and reviewed a census of the 67 fuel-switching pilot equipment.

The PY7 sampling plan for refrigerators and heat pump water heaters was designed to meet the target of 70 records, selected from Q1 to Q3 data. Cadmus reviewed all fuel-switching pilot products.

The EM&V sampling strategy is summarized in Table 3-5.

**Table 3-5: PY7 Residential Retail Sampling Strategy**

| Stratum | Population Size | Target Levels of Confidence & Precision | Target Sample Size | Achieved Sample Size | Evaluation Activity |
|---|---|---|---|---|---|
| Upstream Lighting Manufacturer Invoice Audit | 466 | 90/10 | 70 | 81 | Impact; strategic sample |
| Rebated Equipment | 4,417 | 90/10 | 70 | 139 | Impact; random sample, records review |
| Database Review (Lighting and Equipment) | 112,371 | N/A | N/A | N/A | Impact; census, QAQC and *ex ante* adjustments |
| **Program Total** | **N/A** | **90/10** | **140** | **220** | **Multiple** |

## 3.2.3 *Ex Ante* Savings Methodology and Findings

Cadmus adjusted the *ex ante* reported savings from EEMIS to align with assumptions specified in the 2014 or 2015 Pennsylvania TRM. These TRM *ex ante* adjustments are made to the population, prior to any *ex post* evaluation activity. Adjustments modified all records and savings reported in EEMIS if the reported *ex ante* savings included placeholder inputs. These could include, for example, planning assumptions, the TRM assumptions, and specifications of the actual equipment rebated to participants. This resulted in the adjusted *ex ante* savings used in the equation to determine the program's realization rate.

### 3.2.3.1 *Ex Ante* Savings Findings: Rebated Equipment

*Refrigerators*

For refrigerators, Cadmus looked up model number, volume, and estimated annual energy consumption on lists retrieved from the ENERGY STAR and CEE websites. For models installed during PY7, Cadmus used only the current ENERGY STAR- or CEE-qualified product lists to determine eligibility for savings. For the very small number (less than 0.5% of records) of models for which these data were not available, it checked an older list if the record was installed in PY6 and used the most conservative 2014 TRM default savings assumption. Cadmus could not confirm eligibility for two records and therefore accorded them *ex ante* adjusted savings of zero.

Cadmus used the TRM algorithms,[16] by configuration and model-specific volumes, to compute the baseline usage according to federal standard maximums. The federal efficiency standards for refrigerators changed on September 15, 2014. Because ENERGY STAR and CEE specifications are based upon the percentage of efficiency over the federal standard, this change affected models that qualified for all designation tiers. The energy-savings assumptions based on these new standards took effect under the 2015 Pennsylvania TRM. Therefore, using the year-specific TRM algorithms to estimate baseline

[16] Table 2-53, column 2, in the 2014 Pennsylvania Technical Reference Manual (TRM) and Table 2-69 in the 2015 TRM. Pennsylvania Public Utility Commission. *2014 Pennsylvania Technical Reference Manual.* June 2014. And Pennsylvania Public Utility Commission. *Technical Reference Manual*. June 2015.

consumption was appropriate. Cadmus subtracted each unit's annual energy consumption from the calculated baseline to compute *ex ante* adjusted energy savings, with two exceptions.

In the first exception, the 2014 TRM baseline algorithm for bottom-mounted freezers without door ice often produced an annual consumption estimate that was less than the annual consumption shown on the ENERGY STAR list. For the 174 records where this occurred, Cadmus used the default savings from the 2014 TRM. In the second exception, the 2014 TRM did not provide a baseline algorithm for refrigerators with bottom-mounted freezers; for the 273 records with this configuration, Cadmus used the default savings from the 2014 TRM.

### *Heat Pump Water Heaters*

For heat pump water heaters, Cadmus verified the energy factor and tank size associated with the model number (according to the ENERGY STAR-qualified product list) and confirmed that all records reported in PY7 were for heat pump water heaters with an energy factor greater than 2.3.

Savings for heat pump water heaters with installation dates in PY7 were based on the 2015 TRM algorithm, shown below, and dependent on energy factor, tank size, and installation location ($F_{derate}$).[17] Because Cadmus did not have data regarding heating fuel type and the existence of electric cooling, it excluded the interactive effects from the savings calculations, according to the TRM.

$$\Delta\text{kWh} = \frac{\left(\frac{1}{EF_{base}} - \frac{1}{(EF_{ee} \times F_{derate})}\right) \times HW \times 365\frac{days}{yr} \times 8.3\frac{lbs}{gal} \times 1\frac{Btu}{lbs\cdot°F} \times (T_{hot} - T_{cold})}{3412\frac{Btu}{kWh}} + \Delta kWh/yr_{ie,cool} + \Delta kWh/yr_{ie,heat}$$

$$\Delta kW_{peak} = \Delta kWh \text{ X } 0.00008047$$

Approximately 27% of the records reported in PY7 were installed in PY6. Savings for units with PY6 installation dates were based on a similar algorithm from the 2014 TRM; however, the $F_{derate}$ factor was fixed and therefore was not based on installation location.

### *Fuel-Switching Water Heaters*

For fuel-switching water heaters, Cadmus used the default savings in the 2014 or 2015 TRM, based on the program year in which the unit was installed, but verified the eligibility by confirming the models were ENERGY STAR-qualified at the time of installation.[18] Cadmus made on *ex ante* adjustment for one unit that was not ENERGY STAR-qualified.

### 3.2.3.2 *Ex Ante* Savings Findings: Upstream Lighting

The EEMIS records for the upstream lighting component of the Residential Retail Program contained input parameters from the ICSP, which PPL Electric Utilities used to compute energy and demand savings. Cadmus reviewed the EEMIS extract to ensure consistency and reasonability of data inputs by, for example, checking wattage and lumens across multiple records for the same product for the census of records and comparing reported wattages to text descriptions of each bulb type. It also looked up

17 Pennsylvania Public Utility Commission. *Technical Reference Manual*. June 2015. Page 45, Table 2-47.

18 The ENERGY STAR specification for water heaters changed in April 2015, based on changes in the federal appliance standard for water heaters.

baselines in the current TRM tables (e.g., baseline wattages by lumen range and bulb type) and calculated savings based on delta watts (baseline minus LED watts), the in-service rate, hours of use, and coincidence factor assumptions specified in the TRM.

A small number of CFLs, sold in PY5, were reported in PY7 Q1 when PPL Electric Utilities discovered a previously unprocessed invoice. Cadmus assigned baseline wattages to these CFLs using the 2013 Pennsylvania TRM assumptions for CFLs for hours of use, in-service rate, and coincidence factor.[19]

For all other bulbs reported in PY7, Cadmus used baselines from the 2015 Pennsylvania TRM.[20] To categorize bulbs, it used the bulb type reported in EEMIS (with the exception of a very few adjustments based on its records review). For reflector lamps, Cadmus used the baseline wattage reported in EEMIS (the manufacturer-rated equivalent wattage), rather than the default table, according to the instructions in the 2015 Pennsylvania TRM.

After applying baseline wattages, Cadmus used the wattage field in the EEMIS extract to compute each record's evaluated wattage delta for use in the TRM savings algorithm specific to the program year for that record.

Cadmus computed adjusted savings by applying to each record the appropriate year and sector hours of use, coincidence factor, in-service rate, and any interactive effect assumptions, as shown in Table 3-6.

**Table 3-6. PY7 Savings Algorithm Assumptions, by TRM Year**

| TRM Year | Sector | Quantity | Hours of Use | In-Service Rate | Coincidence Factor | Interactive Effect (kWh/KW) |
|---|---|---|---|---|---|---|
| 2013 | Residential | 6,024 | 2.80 | 84% | .05 | N/A |
| | Small C&I | 822 | 7.81 | 79% | .61 | |
| 2014/2015 | Residential | 1,200,652 | 2.80 | 97% | .09 | -6% |
| | Small C&I | 163,725 | 8.79 | 89% | .62 | 12% |
| | Low-Income | 48,000 | 2.80 | 94% | .09 | -6% |
| **Total** | | **1,419,223** | | | | |

The small C&I sector's hours of use and coincidence factor assumptions were weighted values, based on mapping PPL Electric Utilities' small commercial customer records to the building types provided in the TRM protocol. The small C&I sector's in-service rate was based on the PY6 small commercial customer survey.

19 Pennsylvania Public Utility Commission. *Technical Reference Manual*. June 2013. Table 2-69: "Baseline Wattage by Lumen Output" (for general-service bulbs) and Table 2-81: "Reflector Lamps." Available online: http://www.puc.pa.gov/pcdocs/1208574.docx

20 The baseline assumptions in Table 2-2: "Baseline Wattage by Lumen Output for General Service Lamps (GSL)" for A-Line bulbs and Table 2-3: "Baseline Wattage by Lumen Output for Specialty Lamps" for candelabra and globe bulbs are the same as in the equivalent tables in the 2014 TRM.

The low-income in-service rate of 94% for the 48,000 giveaway bulbs was based on data collected in the Low-Income Behavior & Education Program participant survey and the same future years' trajectory described in the Uniform Methods Project's Residential Lighting Evaluation Protocol.[21]

### 3.2.4 *Ex Post* Savings Methodology and Findings

#### 3.2.4.1 *Ex* Post Savings Findings: Rebated Equipment

Cadmus verified rebated equipment by randomly sampling records and reviewing the associated rebate forms and invoice documentation obtained from the ICSP. It did not find any errors in the sample of rebate forms for refrigerators that would change the *ex ante* adjusted savings or any incorrect quantities in EEMIS. Cadmus made one *ex post* adjustment to a heat pump water heater record found in the sample because its location was incorrectly assigned, but this adjustment was not a large enough to affect the PY7 realization rate.

For fuel-switching pilot equipment, eligibility for electricity savings was based on conversion from a standard electric water heater. Cadmus reviewed the rebate forms to ensure that the customer indicated replacing an electric water heater. Of the 67 rebate forms reviewed, it found two where customers indicated they had not replaced electric equipment and one where the brand/model information was inconsistent with the information in EEMIS (the actual information was for a model that was not ENERGY STAR-compliant). Cadmus made *ex post* adjustments to these records, according them zero savings.

#### 3.2.4.2 *Ex Post* Savings Findings: Upstream Lighting

Cadmus reviewed quarterly reports and monthly invoice summaries prepared by the ICSP and compared the quantities, by bulb type, to those reported in EEMIS. Cadmus also reviewed the per-bulb retail prices and incentive levels for reasonability in preparation for its econometric study.

The ICSP's monthly invoice summaries were Excel spreadsheets showing the manufacturer invoice dates, quantities, and buy-down amounts of bulbs for which the program provided incentives. According to the ICSP, the manufacturers provided most of these data electronically. However, the bulbs-per-pack was an input field that the ICSP used to translate the number of units shipped into the total number of bulbs sold.

Because pack size discrepancies that resulted in incorrect quantities could have a significant impact, despite being present in only a small number of records, Cadmus audited a strategic sample of upstream lighting manufacturer invoices rather than a random sample to ensure that total bulb quantities were correctly captured and reported in EEMIS. This audit consisted of checking bulb models (by model number or bulb type, depending on the level of detail provided in the invoice), packs, units, quantities, and total incentive amounts between the manufacturer invoices and the ICSP's invoice summaries. Cadmus also checked bulb wattages, where available, and followed up on any discrepancies larger than 1 watt (rounding of exact wattages in bulb descriptions; for example, it is common for a 9.6-watt bulb to be shown as 9- or 10-watt bulb).

Cadmus verified, through Internet research, the pack sizes for 98% of bulbs for stock keeping units (SKUs) treated as multi-packs. It could confirm the pack size for the overwhelming majority of bulbs shown as multi-packs and the strategic sample uncovered no data discrepancies of a different nature that would affect total quantities or savings assumptions.

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[21] Dimetrosky, Scott, K. Parkinson, and N. Lieb. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* "Chapter 21: Residential Lighting Evaluation Protocol." November 2014. Available online: http://energy.gov/sites/prod/files/2015/02/f19/UMPChapter21-residential-lighting-evaluation-protocol.pdf

The review and adjustments were considered comprehensive, and the total *ex post* verified savings for PY7 was equal to the total *ex ante* adjusted savings.

### 3.2.5 Summary of Evaluation Results

The evaluation results for both program components, by measure, are shown in Table 3-7 and Table 3-8.

**Table 3-7: PY7 Residential Retail Summary of Evaluation Results for Energy[1]**

| Stratum | PYTD Reported Gross Energy Savings (MWh/yr) | PYTD Adjusted *Ex Ante* Energy Savings (MWh/yr) | Energy Realization Rate (%) | PYTD Verified Gross Energy Savings (MWh/yr) [2] | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Fuel-Switching Water Heaters | 212 | 209 | 95% | 200 | 0.2196 | 0.00% |
| Heat Pump Water Heaters | 2,497 | 2,608 | 100% | 2,615 | 0.0203 | 0.38% |
| Refrigerators | 215 | 238 | 100% | 238 | N/A | 0.00% |
| Upstream Lighting | 59,086 | 61,187 | 100% | 61,187 | 0.7367 | 12.00% |
| **Program Total [3]** | **62,011** | **64,243** | **100%** | **64,240** | **N/A** | **11.47%** |

[1] Values in this table refer to savings at the point of consumption. (Savings targets for MWh refer to values at the point of consumption.) Due to line losses, savings at the point of generation are systematically larger.
[2] Adjusted *ex ante* multiplied by the realization rate will not equal verified gross energy savings due to rounding
[3] Total may not equal sum of column due to rounding.

**Table 3-8: PY7 Residential Retail Summary of Evaluation Results for Demand**

| Stratum | PYTD Reported Gross Demand Savings [1] (MW) | PYTD Adjusted *Ex Ante* Demand Savings [2] (MW) | Demand Realization Rate (%) | PYTD Verified Gross Demand Savings [2] (MW) | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Fuel-Switching Water Heaters | 0.017 | 0.018 | 96% | 0.018 | 0.2182 | 0.00% |
| Heat Pump Water Heaters | 0.202 | 0.229 | 100% | 0.230 | 0.0201 | 0.38% |
| Refrigerators | 0.024 | 0.029 | 100% | 0.029 | N/A | 0.00% |
| Upstream Lighting | 8.559 | 9.597 | 100% | 9.597 | 0.7367 | 12.00% |
| **Program Total [3]** | **8.803** | **9.874** | **100%** | **9.874** | **N/A** | **11.70%** |

[1] Reported gross demand reductions do not include the gross-up to reflect T&D losses.
[2] *Ex ante* and verified gross demand reductions include T&D losses.
[3] Total may not equal sum of column due to rounding.

## 3.3 IMPACT EVALUATION NET SAVINGS

The methods used to determine net savings for downstream programs are provided in the Evaluation Framework,[22] which discuss the common methods to determine freeridership and spillover in downstream programs. Freeridership is a measure of the savings that participants would have achieved on their own in the absence of the program; these savings are subtracted from verified gross savings. Participant spillover, on the other hand, credits additional savings that participants achieved on their own,

[22] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase II Energy Efficiency and Conservation Programs.* Prepared by GDS Associates, Inc., and Nexant. June 1, 2014.

where their experience with the program was highly influential in their decision to install energy-efficient equipment without the incentive of rebates. Participant spillover adds to gross savings.

Net savings are determined only for future program planning purposes. Energy savings and demand reduction compliance targets are met using verified gross savings. Table 3-9 shows the freeridership, spillover and NTG ratios by program component.

**Table 3-9: PY7 Residential Retail Program Summary of Evaluation Results for Net-to-Gross Research**

| Target Group or Stratum (if appropriate) | Freeridership | Estimated Participant Spillover | NTG Ratio | Observed Coefficient of Variation or Proportion | Relative Precision |
|---|---|---|---|---|---|
| Upstream Lighting | 39% | N/A | 0.61 | 0.04 | 11% |
| Rebated Equipment | 41% | 6% | 0.64 | 0.14 | 24% |
| **Program Total** | | N/A | | | |

## 3.3.1 Net-to-Gross Ratio Methodology: Rebated Equipment

Cadmus had not planned to conduct an analysis to determine net savings for the equipment component of the Residential Retail Program in PY7; however, because the rebate structure for heat pump water heaters changed in PY7, Cadmus included questions in a participant survey to reassess freeridership and spillover for heat pump water heaters. In addition, because there was an increase in the number of fuel-switching water heaters reported in PY7, Cadmus incorporated answers to freeridership and spillover questions in the fuel-switching pilot survey into the NTG ratio for PY7.

The overall NTG ratio was determined using a savings-weighted average of the NTG ratios for heat pump water heaters and fuel-switching water heaters in PY7 and using the NTG ratio for refrigerators from PY6.

For the rebated equipment component of the Residential Retail Program, Cadmus used data collected from self-report surveys with participating customers (as described above) to determine freeridership. *Addendum C. Net Savings Downstream Rebate Common Approach* provides additional detail about the net savings methodology and survey questions used for this analysis.

## 3.3.2 Net-to-Gross Ratio Sampling: Rebated Equipment

Table 3-10 lists the sampling strategy for the rebated equipment participant survey conducted in PY7.

**Table 3-10: PY7 Residential Retail Sampling Strategy NTG Research—Rebated Equipment**

| Stratum | Stratum Boundaries | Population Size | Assumed Cv or Proportion in Sample Design | Assumed Levels of Confidence & Precision | Target Sample size | Achieved Sample Size | Percent of Sample Frame Contacted to Achieve Sample[1] |
|---|---|---|---|---|---|---|---|
| Residential Retail HPWH Participants | HPWH rebates reported in PY7 | 1,235 | .5 | 90/10 | 70 | 70 | 36% |
| Residential Retail Fuel-Switching Participants | Fossil fuel water heater rebates reported in PY7 | 67 | N/A | N/A | 49[2] | 14 | 100% |

[1] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means of all the sample frame how many were called to get the completes.
[2] Cadmus attempted to contact as many fuel-switching participants as possible, using the data available as of June 2016, when the survey commenced, The sample frame excluded customers who were selected for other program surveys and those who requested not to be contacted.

### 3.3.3 Net-to-Gross Ratio Findings: Rebated Equipment

#### 3.3.3.1 Freeridership Findings

The freeridership and spillover ratio estimates for the rebated equipment component of the Residential Retail Program, estimated in accordance with the Evaluation Framework's NTG guidelines,[23] are shown in Table 3-11. In PY7, primary research was conducted only for the efficient equipment heat pump water heater and fuel-switching participants. Cadmus applied NTG ratio developed in PY6 for the rebated refrigerator stratum to arrive at a NTG ratio at the program-level of 64%, weighted by verified energy savings, for PY7.

**Table 3-11: PY7 Residential Retail Program Evaluation Results for NTG Research—Rebated Equipment**

| Target Group or Stratum (if appropriate) | Estimated Freeridership [1] | Estimated Participant Spillover | NTG Ratio | Observed Coefficient of Variation or Proportion | Relative Precision at 90% C.L. |
|---|---|---|---|---|---|
| Residential Retail Heat Pump Water Heater Participants | 37% | 6% | 0.69 | 0.40 | 7% |
| Residential Retail Fuel-Switching Participants | 66% | 3% | 0.37 | 0.21 | 39% |
| Residential Retail Refrigerator Participants | 65% | 3% | 0.38 | 0.10 | 17% |
| **Program Rebate Component Total[2]** | **41%** | **6%** | **0.64** | **0.14** | **24%** |

[1] These estimates were weighted by the survey sample-verified program kWh/yr savings. This method ensures that respondents who achieved higher energy savings through the program measures are given a greater influence on the measure-level freeridership estimate than those respondents who achieved lower energy savings.
2] The measure level estimates were weighted by the measure's *ex post* kWh/yr program population savings to arrive at the final rebated equipment freeridership estimate of 64%.

Although the survey sample sizes to compute freeridership estimates were not designed to produce statistically valid results at the measure level, Cadmus noted that the updated PY7 NTG ratio for heat pump water heaters did not change significantly from PY6, as shown in Table 3-12. For respondents who purchased heat pump water heaters, the estimated freeridership was 39% in PY6 (n=75) and 37% in PY7 (n=70).[24] Likewise, when examining the freeridership for heat pump water heaters by rebate level in PY7, the estimated freeridership of 38% for participants who received a $400 rebate (n=39) was not statistically significantly different than the 36% freeridership for those who received a $300 rebate (n=31; $\alpha = .05$).[25]

**Table 3-12: PY7 Residential Retail Program Heat Pump Water Heater NTG by Rebate Amount for PY7 and PY6[1]**

| Program Year | $300 Rebate | | $400 Rebate | | Overall Freeridership |
|---|---|---|---|---|---|
| | n | FR | n | FR | |
| PY7 | 31 | 36% | 39 | 38% | 37% |
| PY6 | 75 | 39% | - | - | 39% |

[1]These freeridership estimates are weighted by the survey sample-verified program kWh/yr savings. PPL Electric introduced rebates for $400 in PY7.

23 Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase II Energy Efficiency and Conservation Programs.* Prepared by GDS Associates, Inc., and Nexant. June 1, 2014.

24 This difference is not statistically significant at 90% confidence.

25 This difference is not statistically significant at 90% confidence.

#### 3.3.3.2 Spillover Findings

Fourteen PY7 heat pump water heater respondents and three PY7 fuel-switching respondents reported installing other energy-efficient measures since participating in the program where their participation was influential on their decision to purchase the items and where they did not receive a program rebate. Measures mentioned by respondents that qualified for attribution to program spillover are listed in Table 3-13. The estimated savings for these measures in conjunction with the SWE common method for participant spillover estimation resulted in the 6% spillover estimate for the heat pump water heater program stratum and 3% for the fuel-switching program stratum. *Addendum C. Net Savings Downstream Rebate Common Approach* provides additional detail about the spillover calculations.

**Table 3-13: PY7 Residential Retail Program Heat Pump Water Heater and Fuel-Switching Participant Spillover Measures**

| Program Stratum | Spillover Measure | Mentions by Respondents |
|---|---|---|
| Residential Retail Heat Pump Water Heater Participants | Clothes Washer | 2 |
| | Clothes Dryer | 1 |
| | Insulation | 6 |
| | Heat Pump | 1 |
| | Refrigerator | 6 |
| | Windows | 2 |
| Residential Retail Fuel-Switching Participants | Clothes Washer | 1 |
| | Clothes Dryer | 1 |
| | Insulation | 1 |
| | Heat Pump | 1 |
| | Water Heater | 1 |

### 3.3.4 Net-to-Gross Ratio Methodology: Upstream Lighting

The NTG Working Group, in ongoing meetings led by the SWE and attended by the EDCs and their EM&V CSPs, discussed a number of approaches to determine net savings and the market effects of upstream lighting programs. However, developing a method and NTG protocols that could be used consistently across the EDCs is complicated for several reasons, such as:

- The difficulty in identifying purchasers of bulbs discounted in the upstream program—whether by store intercept studies or general population surveys
- The lack of sales data in the market as a whole (particularly nonparticipating retail stores and non-program lamps) and the proprietary nature of these data
- The difficulty of collecting all program data to confidently estimate price response and sales lift attributable to the program

During the March 2015 meeting, the SWE and EDCs agreed that no single analysis method could fully demonstrate the net effects of an upstream lighting program and that multiple methods and perspectives were needed to tell a more robust story about its effect on the market. For PPL Electric Utilities, this would include its contribution to the market's transition from CFLs to LEDs. The NTG Working Group discussions ultimately led the SWE to develop a list of market progress indicators (MPIs) the EDCs could (voluntarily) track, in addition to other planned evaluation activities and analyses for assessing upstream lighting programs.

During Phase II, Cadmus conducted several analyses that were designed to assess the market effects of the Residential Retail Program's upstream lighting component by collecting several of the market progress indicators suggested by the SWE. These market progress indicators are indicators of market transformation assessing changes in retailer practices, consumer awareness and acceptance of LEDs, and any existing barriers to adoption.

The PY7 analyses and results are discussed in detail in this chapter (Section 3.5 Process Evaluation for Upstream Lighting). Where data are available, Cadmus makes comparisons to prior program years. Evaluation activities in PY7 included these:

- Demand elasticity modelling to estimate freeridership (all years, discussed below and in *Appendix F: Demand Elasticity Study*)
- General residential population surveys (all years)
- Low-Income Energy-Efficiency Behavior & Education Program survey (lighting questions in PY7)

### 3.3.4.1 Demand Elasticity Model Estimates of Freeridership

To estimate freeridership for the Residential Retail Program's upstream lighting component, Cadmus conducted demand elasticity modeling using bulb sales information (provided by the ICSP) in each year of Phase II. Lighting products that incur price changes and promotion over the program period provide valuable information regarding the correlation between sales volume and prices. Using price elasticity to estimate freeridership is the same principle applied in the willingness-to-pay analyses using self-report survey responses as in Phase I. However, rather than relying on self-report data, elasticities are based on actual observed changes in purchasing behavior in response to program activity.

All available data were used for this analysis in PY7. Overall, the model relied on products with price variation that accounted for 78% of total lamp sales in PY7.[26] The sampling strategy is shown in Table 3-14 and the results of the NTG research is shown in Table 3-15.

**Table 3-14: PY7 Residential Retail Sampling Strategy NTG Research—Upstream Lighting**

| Stratum | Stratum Boundaries | Population Size | Assumed Cv or Proportion in Sample Design | Assumed Levels of Confidence & Precision | Target Sample Size | Achieved Sample Size | Percent of Sample Frame Contacted to Achieve Sample[1] |
|---|---|---|---|---|---|---|---|
| Residential Retail Upstream Lighting Program Component | All available data | All records | N/A | N/A | N/A | N/A | N/A |
| [1] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means of all the sample frame how many were called to get the completes. | | | | | | | |

**Table 3-15: PY7 Residential Retail Summary of Evaluation Results for NTG Research—Upstream Lighting**

| Target Group or Stratum (if appropriate) | Freeridership Estimated from Demand Elasticity Model | Estimated Participant and Nonparticipant Spillover | NTG Ratio Estimated from Demand Elasticity Model | Observed Cv or Proportion | Relative Precision at 90% C.L. |
|---|---|---|---|---|---|
| Upstream Lighting Component | 39% | Not determined | 61% | 0.04 | 11% |
| **Program Total** | 39% | -- | 61% | 0.04 | 11% |

[26] Products with no price variation provide no information to quantify the relationship between sales and price and are therefore not included. The representativeness of sales with price variation improved from PY6 where the sales with variation represented 61% of total program sales.

The estimated freeridership from the demand elasticity model was 39% for the upstream lighting component as a whole, down from 48% in PY6.

The results of the elasticity model suggest that freeridership varies by retail channel, with do-it-yourself (DIY) store (e.g., Home Depot) shoppers being most price sensitive and mass market (e.g., Target) and club stores (e.g., Costco) are less price sensitive, at least for A-line bulbs. The model estimated freeridership is roughly 54% for mass market stores, 44% for club stores, and roughly 28% for DIY stores. The differences may be due to differences in customer demographics, customer expectations as prices of LEDs continue to decline, or retailer activities unrelated to the program. Club stores in particular had large increases in sales of reflector bulbs in the fall of 2015 that did not correspond with any program activity. (See *Appendix F: Demand Elasticity Study* for a discussion of methodology and findings.)

Additionally, DIY stores had special product promotions in the fall of 2015 that led to a substantial lift in sales. In October of 2015 one DIY retailer featured an A-line product in a special promotion and A-line bulb sales increased by 94% after controlling for price. The same retailer featured reflector bulbs the following month and reflector bulb sales increased by 25%.

The NTG estimate in Table 3-15 reflects only one analysis, the demand elasticity model. This estimate determined from the elasticity model is more accurately a net-of-freeridership estimate as the model does not account for spillover or market effects. Therefore, the estimate is likely the floor, or lower limit, of the NTG ratio for the program as there are additional effects of the program that are influencing the efficient lighting market more broadly.

#### 3.3.4.2 Upstream Lighting Market Effects

The demand elasticity model is one measure of the market impact of the upstream lighting component of the program. Cadmus collected data through its general residential population surveys to characterize consumers' purchasing patterns, attitudes, demographic differences and price sensitivity to inform a broader understanding of how the program fits into, and affects, the market for LEDs. For a discussion about willingness to pay, see Section 3.5.7.6, Willingness to Pay. For a discussion about market progress indicators, see Section 3.5.7, Market Progress Indicators and LED Purchasing Patterns. Data collected about various market progress indicators point to the influence on the market of PPL Electric Utilities' upstream lighting program. However, Cadmus did not quantify the market effects. Therefore, the NTG ratio includes only freeridership. Should market effects be quantified and included in the NTG equation, Cadmus is confident the NTG ratio would be higher than 59%.

## 3.4 PROCESS EVALUATION FOR REBATED EQUIPMENT

### 3.4.1 Research Objectives

The purpose of the process evaluation for rebated equipment was to assess and provide recommendations for improving the program's effectiveness in achieving its objectives:

- Achieve widespread visibility through independent and regional retailers that carry the eligible ENERGY STAR products
- Engage retailers by educating and training sales associates about the program-rebated energy-efficient equipment
- Provide a one-stop call and rebate processing center that would also promote other PPL Electric Utilities energy efficiency programs

Cadmus designed the process evaluation activities to assess these:

- Effectiveness encouraging customers to install energy-efficient products
- Customer satisfaction

- Opportunities and barriers to promoting participation
- Possible program enhancements

### 3.4.2 Evaluation Activities

For the equipment component of the Residential Retail Program, the PY7 process evaluation activities are listed here and discussed in the next section. These activities were consistent with those outlined in Cadmus' evaluation plan except additional surveys were completed with heat pump water heater participants to update net savings analysis. This increased the number of completed surveys from 124 in the plan to 132 for PY7.

- Program staff and implementer interviews (n=2)[27]
- Participant surveys (n=132)

The participant survey was part of a portfolio-level analysis, collecting data about program satisfaction, satisfaction with PPL Electric Utilities, freeridership, fuel-switching, and demographics across a number of Act 129 programs. In addition, Cadmus used this survey to update the net savings analysis for heat pump water heaters because its incentive structure was modified in PY7.

The sampling strategy for the Residential Retail Program process evaluation is presented in Table 3-16.

### 3.4.3 Methodology

#### 3.4.3.1 Program Staff and Implementer Interviews

Cadmus interviewed Residential Retail Program managers from PPL Electric Utilities and the ICSP to gain an understanding of the program process for the current year and to discuss their perspectives about processes that are working well and areas experiencing challenges.

#### 3.4.3.2 Participant Survey

In PY7, Cadmus conducted a survey that targeted customers who had participated in one of these general residential rebate programs—Appliance Recycling, Residential Home Comfort (equipment, weatherization, and audit), and Residential Retail (refrigerator and heat pump water heaters only). A total of 480 surveys were conducted for all three programs, with 132 surveys completed for participants of the Residential Retail Program (receiving refrigerator and heat pump water heater rebates). Table 3-16 shows the PY7 sampling strategy.

The survey collected data for several purposes. The primary purpose of this cross-program survey was to obtain a preliminary estimate of low-income participation in programs that were not specifically targeting this sector (i.e., programs that did not require income verification). In addition, Cadmus used this survey to update the net savings analysis for heat pump water heaters because its incentive structure was modified in PY7. The surveys also included questions to assess possible fuel-switching behavior, program satisfaction, satisfaction with PPL Electric Utilities, and basic demographic data.

The sample frame excluded any customers who had participated in surveys within the last three months or requested not to be contacted. From this sample frame, Cadmus selected a random sample (probability sampling) and stratified by program.

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27 Interviews for equipment and lighting were completed with the same PPL Electric Utilities program manager and ICSP.

**Table 3-16: PY7 Residential Retail Equipment Process Evaluation Sampling Strategy**

| Stratum | Stratum Boundaries | Population Size | Assumed Proportion or Cv in Sample Design | Assumed Levels of Confidence & Precision | Target Sample Size | Number of Records Selected for Sample Frame | Achieved Sample Size | Percentage of Sample Frame Contacted to Achieve Sample[1] | Used for Evaluation Activities (Impact, Process, NTG) |
|---|---|---|---|---|---|---|---|---|---|
| PPL Electric Utilities Program and CSP Staff | Staff | 2 | N/A | N/A | 2 | 2 | 2 | 100% | Process, Program Staff Interview |
| Refrigerator Participants | Residential Retail Participants [2] | 3115 | 0.5 | 90/10 | 62 | 1240 | 62 | 34% | Process, estimate low-income participation, stratified random sample |
| Heat Pump Water Heater Participants | Residential Retail Participants [2] | 1235 | 0.5 | 90/10 | 70 | 1041 | 70 | 36% | Process, estimate low-income participation, update NTG, stratified random sample |

[1] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means the percentage of the sample frame called to complete interviews.
[2] Cross-program survey included participants of the Residential Retail, Residential Home Comfort, and Appliance Recycling programs. Cadmus completed 480 cross-program surveys but the results in this table and report reflect only those records and surveys completed for the Residential Retail Program (132 surveys).

Potential sources of bias in the surveys include nonresponse, recall, and social desirability biases. These sources of bias were mitigated by applying random sampling whenever possible and using survey design and survey data collection best practices. Surveys were designed to include questions that were not leading or ambiguous, were not double-barreled, and provided clear interviewing and programming instructions so that they could be implemented consistently across interviewers and surveys. Cadmus also attempted to reach respondents four times over several days at different times of the day and scheduled callbacks whenever possible. Cadmus fielded the phone surveys during July of 2016.

### 3.4.4 Achievements Against Plan

Table 3-17 contains the Residential Retail Program's planned energy savings and incentives and the progress on these. PPL Electric Utilities' EE&C plan did not separate the annual plan for the upstream lighting component from the equipment component; therefore, the table provides planned and achieved savings for the program as a whole.

The Residential Retail Program achieved 107% of its planned Phase II MWh/yr savings, based on verified gross savings. It achieved 75% of the planned MW, based on verified gross savings. Although there is no Phase II compliance target for MW, Cadmus notes that the discrepancy between the achieved percentage of planned MWh/yr and achieved percentage of planned MW is because planned MW savings were based on end-use load profiles, not on the coincidence factors deemed in the Pennsylvania TRM (2013-2015).

**Table 3-17: Residential Retail Program Savings[1]**

| | PY5 Verified | PY6 Verified | PY7 Only | | | Phase II: PY5–PY7 | | |
|---|---|---|---|---|---|---|---|---|
| | | | Planned | Verified | Percentage of Planned | Planned | Verified | Percentage of Planned |
| MWh/yr | 90,314 | 51,463 | 50,044 | 64,240 | 128% | 191,861 | 206,018 | 107% |
| MW[2] | 8.92 | 7.76 | 9.25 | 9.87 | 107% | 35.45 | 26.55 | 75% |
| Participants | 227,378 Estimated | 171,116 Estimated | N/A | 225,783 | N/A | N/A | 624,277 | N/A |

[1] Planned savings are based on PPL Electric's revised EE&C plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, Table E6, p.56.
[2] Planned and verified MW savings include line losses.

### 3.4.5 Program Delivery

The ICSP managed rebate application processing and provided promotional materials to participating retailers. However, participants could purchase eligible equipment from any retailer, not just participating retailers. Based on interviews with program staff, interviews with participants and reviews of database records, Cadmus determined during PY7 the Residential Retail Program was delivered effectively and efficiently, and the ICSP met its program goals and forecast sales. Previously identified issues with rebate processing were addressed when the ICSP took the processing back under its management in late 2015.

For example, Cadmus reviewed the EEMIS tracking dates (rebate received versus invoice date, which registers the date a rebate check is produced) and confirmed that the average number of weeks to process a rebate was less than three weeks for applications received during PY7, well under the six-week maximum established between PPL Electric Utilities and the ICSP.

However, some participants continued to express disappointment with lower refrigerator rebates than they had expected ($25 instead of the higher-tier rebate of $100). Program staff said customers and retailers were confused because of changes in ENERGY STAR qualification criteria resulting from changes in the federal standard for refrigerators, interpretations made by ENERGY STAR regarding the efficiency of various models, and the inventory of older models. The ICSP said it had engaged in discussions with

ENERGY STAR about the equipment model qualification process and options for managing dynamic lists in the future and will be working to implement a more user-friendly qualified model list in Phase III.

#### 3.4.5.1 Key Performance Indicators

Aside from planned savings, PPL Electric Utilities and the ICSP did not track or have specific non-energy savings goals or metrics. Program staff reported that one of the internal metrics it monitored involved engaging an ample distribution of upstream lighting retailers, by geography and retail channels. In PY7, as the program came close to meeting its planned savings, PPL Electric Utilities and the ICSP intentionally tapered off promotional activities for upstream lighting at big box stores, while maintaining a presence at smaller, independently owned retailers. (The ICSP visits participating retailer locations and provides training and promotional materials, but actual incentive levels varied only for the lighting component of the program.)

### 3.4.6 Participant Profile

Of the equipment rebates reported in PY7, 2710 were for ENERGY STAR refrigerators, 405 were for ENERGY STAR Most Efficient or CEE Tier 3 refrigerators, 1235 were for heat pump water heaters, and 67 were for fuel-switching (fossil fuel) water heaters.

Ninety-four percent of heat pump water heater survey respondents (n=70) and 84% of refrigerator respondents (n=62) lived in a detached, single-family home. Only 4% of heat pump water heater respondents said they lived in an attached or row house, compared to 10% of refrigerator respondents. These percentages are not statistically different from those observed in PY6.

### 3.4.7 Satisfaction

#### 3.4.7.1 Program Satisfaction

Overall satisfaction with the rebated equipment component was higher in PY7 (n=132), with 79% of all survey respondents (n=132) saying they were *very satisfied*, compared to 69% in PY6 (n=216; $\alpha$= .05, accounting for finite population correction). Only 15% said they were *somewhat satisfied* with their overall experience, compared to 25% in PY6. Respondents who received a rebate for a heat pump water heater were more likely to say they were *very satisfied* with the program overall (86%; n=70) than those who received a rebate for a refrigerator (71%; n=62; $\alpha$= .05, accounting for finite population correction).

When asked what PPL Electric Utilities could do to improve their experience, 45% of survey respondents who said they were less than *very satisfied* (n=22*)* suggested a simpler rebate structure or process, often citing differences in the amount received compared to the amount they expected (of these 10 respondents, eight received refrigerator rebates). Three respondents (n=22) suggested faster rebates, and two expressed dissatisfaction with the absence of rebates for recycling old equipment.

#### 3.4.7.2 Satisfaction with PPL Electric Utilities

Overall satisfaction with PPL Electric Utilities as a provider of electric service was high. Seventy-six percent of respondents (n=132) rated their satisfaction as 8 or higher (on a scale of 1 through 10), which is statistically higher than in PY6 (85%; n=216) but not statistically different from the 81% (n=150) in PY5. Five percent rated PPL Electric Utilities as 7, and 10% gave a rating of 6 or lower.

Thirty-two percent of respondents (n=132) said their opinion of PPL Electric Utilities had improved at least *somewhat* after participating in the program (21% said *improved somewhat* and 11% said *improved significantly)*. Respondents who received a rebate for a heat pump water heater (n=70) were more likely to report an improved opinion of PPL Electric Utilities (40% said their opinion had improved at least *somewhat*) than those who received a rebate for a refrigerator, of whom only 22% (n=62) said their opinion had improved (α=.05, accounting for finite population correction).

## 3.4.8 Marketing and Outreach

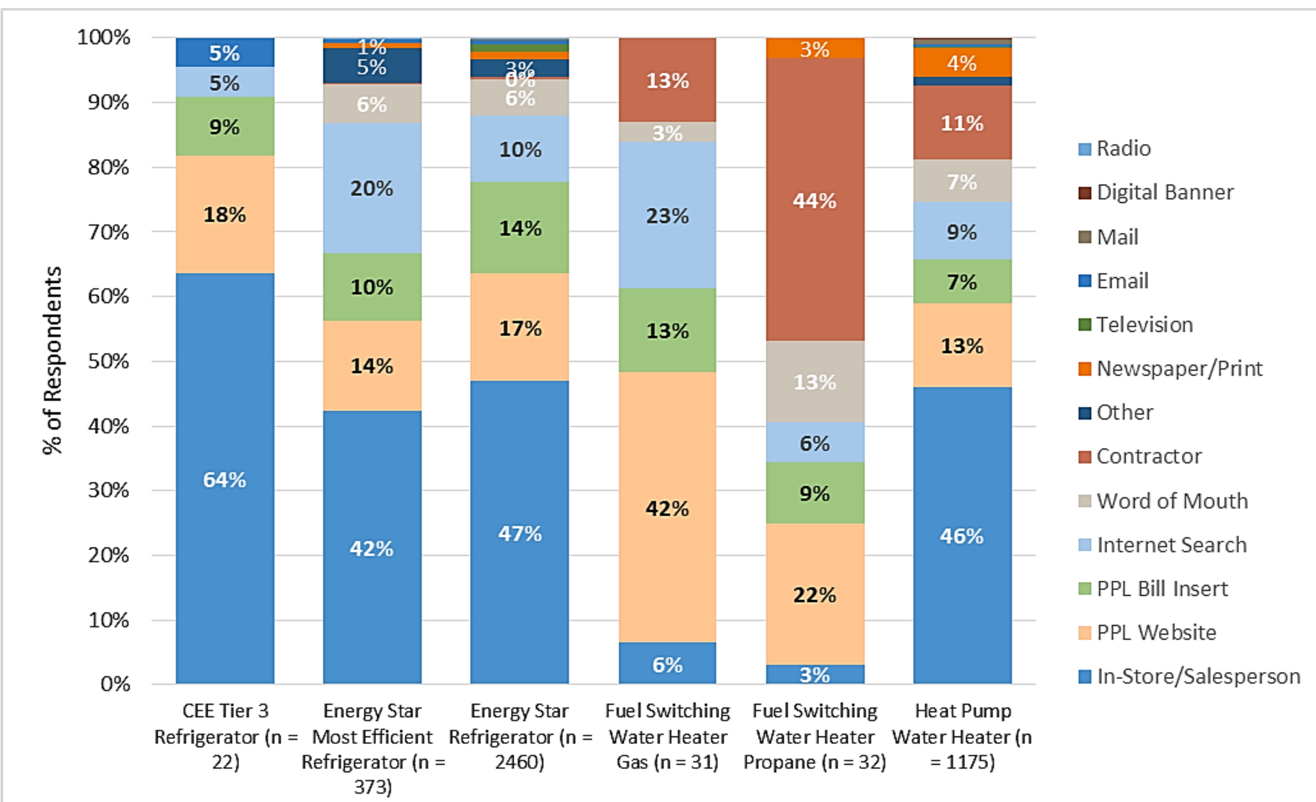
### 3.4.8.1 PPL Electric Utilities and ICSP Marketing

With approval from PPL Electric Utilities, the ICSP plans, creates, and implements marketing activities and materials that are specific for the equipment component of the Residential Retail Program. Marketing materials include posters to display at participating retailers and "ribbons" on refrigerators to indicate which models are eligible for incentives and to describe the incentive levels.

### 3.4.8.2 Program Awareness

According to data collected on rebate forms and reported in EEMIS, 42% of participants (n=4,094) learned about the Residential Retail Program through a retailer. The fuel-switching participants most commonly learned about the program from PPL Electric Utilities' website or a contractor.[28] Only 11% of heat pump water heater participants (n=1,175) said they heard about the rebate from a contractor, which suggests there may be room for additional outreach to these market actors. These findings are shown in Figure 3-1 and are similar to the findings in PY6.

**Figure 3-1: How Participants Learned About the Residential Retail Equipment Program**




Source: EEMIS/Rebate forms

28 The sample sizes for the fuel-switching measures are small so variation is to be expected.

## 3.5 PROCESS EVALUATION FOR UPSTREAM LIGHTING

### 3.5.1 Research Objectives

The purpose of the process evaluation for upstream lighting is to assess and provide recommendations for improving, the program's effectiveness in achieving its objectives, which are these:

- Provide a mechanism for customers to easily obtain discounted ENERGY STAR-qualified energy-efficient LEDs and efficient equipment sold in retail stores
- Achieve widespread visibility through independent and regional retailers that carry eligible ENERGY STAR products
- Develop and execute strategies aimed at transforming the market for ENERGY STAR-qualified LED bulbs and equipment
- Educate customer on proper disposal of CFLs and give them opportunities to do so
- Educate customers on new lighting technologies, such as LEDs

Cadmus designed the process evaluation activities to effectively assess these:

- Awareness of energy-efficient light bulbs
- Level of environmentally sound CFL disposal behavior
- Purchases of energy-efficient lighting
- Customer satisfaction and decision-making
- Opportunities and barriers
- Possible program enhancements

### 3.5.2 Evaluation Activities

The PY7 process evaluation activities for the upstream lighting component of the Residential Retail Program are listed here, summarized in Table 3-18, and discussed in Section 3.5.3 Methodology.

- General residential population surveys (n=337/70 LED purchasers from participating retailers)
- Program staff and implementer interviews (n=2)[29]
- Low-Income Energy-Efficiency Behavior & Education Program surveys (included questions about LEDs) (n=301)

These activities were consistent with those outlined in Cadmus' evaluation plan with two exceptions: the sample size for the general residential population survey required 337 completes to achieve the sub-target of 70 LED purchasers from participating retailers, and the Low-Income Energy-Efficiency Behavior & Education Program surveys were used to compute an in-service rate for the giveaway bulbs and to enhance the analysis of market progress indicators.

### 3.5.3 Methodology

Cadmus' methodology for the PY7 process evaluation included interviews to gather high-level perspectives from program staff about the Residential Retail Program and general population surveys with the residential population. The general population surveys included questions designed to identify likely participants (bulb purchasers) and nonparticipants (customers who had not recently purchased an LED from a participating retailer). The Low-Income Energy-Efficiency Behavior & Education Program surveys included questions about LED awareness, bulb purchases, and installation of the LED bulbs mailed to a select group of participants.

29 Interviews for equipment and lighting were completed with the same PPL Electric Utilities program manager and ICSP.

**Table 3-18: PY7 Residential Retail Lighting Process Evaluation Sampling Strategy**

| Stratum | Stratum Boundaries | Population Size | Assumed Proportion or Cv in Sample Design | Assumed Levels of Confidence & Precision | Target Sample Size | Number of Records Selected for Sample Frame | Achieved Sample Size | Percentage of Sample Frame Contacted[1] | Evaluation Activities |
|---|---|---|---|---|---|---|---|---|---|
| PPL Electric Program and CSP Staff | Staff | 2 | N/A | N/A | 2 | 2 | 2 | 100% | Process, Program Staff Interview, Census |
| Residential | General Population | 1,200,000 | 0.5 | 90/10 | 300 total / 70 LED purchasers | 16,831 | 337 / 70 | 42% | Process, impact, general population survey, probability sample, simple random sample |
| Low-Income Behavior & Education Program Participants | Both treatment and control groups | 123,232 | 0.5 | 90/10 | 300 | 9,984 | 301 | 5,350 | Impact, market progress indicators, stratified random sample |

[1] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means the percentage of the sample frame called to complete interviews.

Cadmus thoroughly reviewed data sources and supporting documentation through a database review and an audit of lighting manufacturer invoices to ensure data were accurate and to identify possible improvements in the data handling or quality assurance process.

#### 3.5.3.1 Program Staff and Implementer Interviews

Cadmus interviewed PPL Electric staff and the ICSP to gain an understanding of the program processes for the current year and to discuss their perspectives on processes that worked well or any areas where they had experienced challenges.

#### 3.5.3.2 General Residential Population Survey

The purpose of the general residential population survey was to obtain information about recent bulb purchases. A general population survey allowed Cadmus not only to identify likely program participants and the rate of participation but also to track market progress indicators and willingness to pay and to compare the perspectives and demographics of people who have purchased or used LEDs and people who have not.

The program's primary target audience was residential customers. However, because incentives were paid directly to manufacturers, the actual participants were not known. In addition, because signage indicating PPL's discounts varies by retailer, customers were not always aware they were purchasing a program-discounted bulb.

Therefore, Cadmus conducted a general population survey of all PPL Electric Utilities' residential customers. It excluded any participants who had received a rebate for a pool pump or an electronically commutated motor (ECM) fan from the Residential Home Comfort Program, a rebate for a heat pump water heater from the Residential Retail Program, or a rebate for a fuel-switching pilot program measure. These participants were reserved for inclusion in the limited sample pools for the program-specific surveys. It also excluded any customers who had completed a survey in the past year (as required by PPL Electric Utilities),[30] had been selected as part of another sample for a pending or in-process survey, or had requested not to be contacted.

From this sample frame, Cadmus selected a simple random sample (probability sampling). Potential sources of bias in the surveys include nonresponse, recall, and social desirability biases. Cadmus attempted to mitigate these sources of bias by applying random sampling whenever possible and using survey design and survey data collection best practices. Surveys were designed to include questions that were not leading or ambiguous, were not double-barreled, and provided clear interviewing and programming instructions so that they could be implemented consistently across interviewers and surveys. Cadmus also attempted to reach respondents five times over several days at different times of the day and scheduled callbacks whenever possible.

### 3.5.4 Achievements Against Plan

Table 3-19 contains the Residential Retail Program's planned energy savings and the progress on these. PPL Electric Utilities' EE&C plan did not separate the annual plan for the upstream lighting component from the equipment component; therefore, the table provides planned and achieved savings for the program as a whole.

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30 This policy changed following the conclusion of this survey. As of April 2016, customers could not be contacted for a survey until three months had passed since they completed their last survey (with PPL Electric Utilities or Cadmus).

**Table 3-19: Residential Retail Program Savings[1]**

| | PY5 Verified | PY6 Verified | PY7 Only | | | Phase II: PY5–PY7 | | |
|---|---|---|---|---|---|---|---|---|
| | | | Planned | Verified | Percentage of Planned | Planned | Verified | Percentage of Planned |
| MWh/yr | 90,314 | 51,463 | 50,044 | 64,240 | 128% | 191,861 | 206,018 | 107% |
| MW[2] | 8.92 | 7.76 | 9.25 | 9.87 | 107% | 35.45 | 26.55 | 75% |
| Participants | 227,378 Estimated | 171,116 Estimated | N/A | 225,783 | N/A | N/A | 624,277 | N/A |

[1] Planned savings are based on PPL Electric's revised EE&C plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, Table E6, p.56.
[2] Planned and verified MW savings include line losses.

The Residential Retail Program achieved 107% of its planned Phase II MWh/yr savings, based on verified gross savings. It achieved 75% of the planned MW, based on verified gross savings. Although there was no Phase II compliance target for MW, Cadmus notes that the discrepancy between the achieved percentage of planned MWh/yr and achieved percentage of planned MW was because the planned MW savings were based on end-use load profiles, not on the coincidence factors deemed in the Pennsylvania TRM (2013-2015).

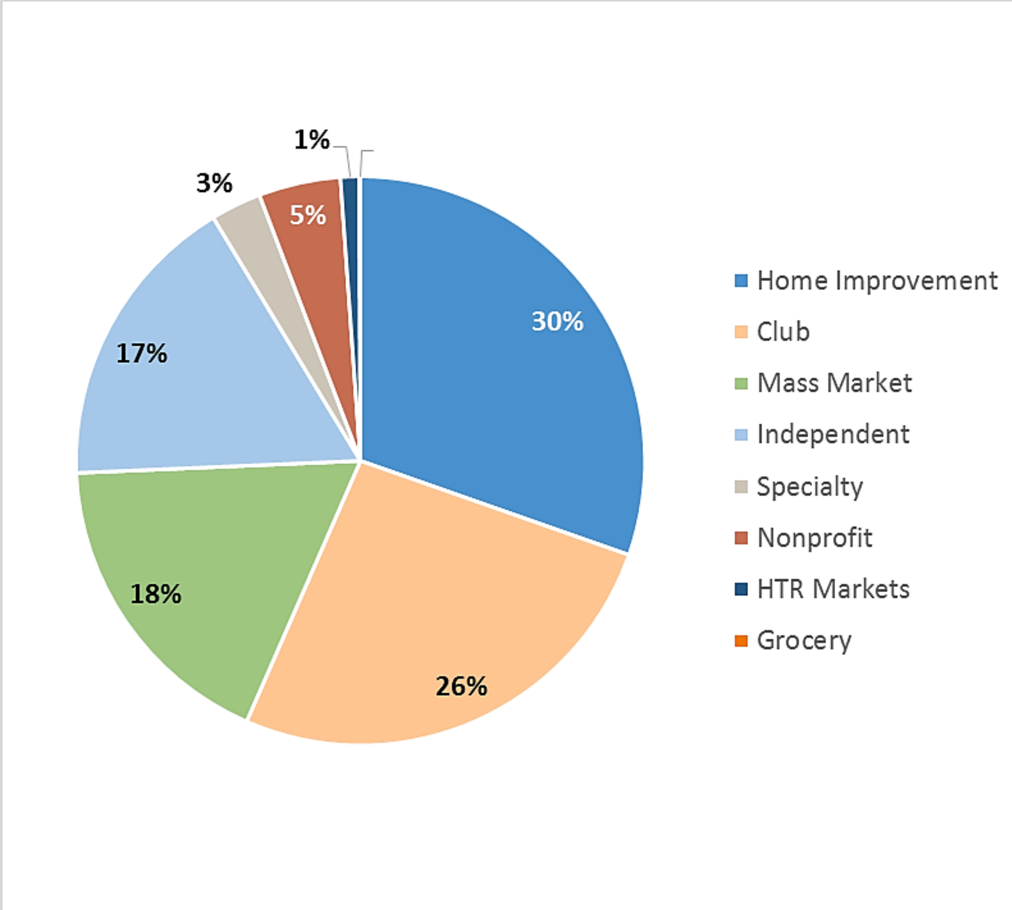
### 3.5.5 Program Delivery

Based on interviews with program staff, interviews with participants and reviews of database records, Cadmus determined, the upstream lighting component was delivered effectively and efficiently during PY7, and the ICSP was able to meet its program goals and forecast sales accurately. The quality of data received from the ICSP was very good in PY7; data across multiple sources were sufficiently detailed and consistent, and Cadmus did not uncover any material errors during the audit of lighting manufacturer invoices.

#### 3.5.5.1 Key Performance Indicators

Aside from planned savings, PPL Electric Utilities and the ICSP did not track or have specific goals or metrics unrelated to savings. Program staff reported that the objectives of the program included engaging an ample distribution of retailers, by both geography and retail channels; increasing awareness and adoption of LEDs by customers; reducing retail prices of LEDs; increasing awareness of PPL Electric's bulb subsidies; and encouraging the responsible disposal of CFLs. The PY7 distribution of bulb sales, by retail channel, is shown in Figure 3-2.

**Figure 3-2: Distribution of Bulbs Sold, by Retail Channel**




Source: PY7 EEMIS data. (n=1,371,223 bulbs; The "Home Improvement" channel includes do-it-yourself retailers such as Home Depot, "Club" includes membership chains such as Costco, and "Mass Market" includes discount retailers such as Walmart.)

#### 3.5.5.2 Program Updates

Program changes in PY7 were these:

- Mailed 45,000 LEDs to participants in the Low-Income Energy Efficiency Behavior & Education Program
- Distributed 3,000 LEDs at a low-income customer holiday dinner event
- Ramped down incentives at big box stores while maintaining promotions and independent hardware and grocery channels

### 3.5.6 Participant Profile

Using data collected in the general population residential survey (n=337), Cadmus established a profile of customers purchasing LEDs in the upstream lighting component of the Residential Retail Program. Table 3-20 shows the breakdown of respondents into recent purchasers and non-purchasers. Most of the recent purchases were from retailers participating in the Residential Retail program; 84% of the bulbs respondents reported having purchased were from participating retailers.

**Table 3-20. General Residential Population Recent LED Purchasers and Non-Purchasers**

| Customer Base | Subset of Respondents | Percentage of Respondents | | | Percentage of LEDs Purchased |
|---|---|---|---|---|---|
| Residential General Population (n=337) | Recent LED Purchasers | Recent Purchasers from Participating Retailers | 21% | 28% | 84% |
| | | From Other Retailers | 6% | | 16% |
| | Non-Recent Purchasers | | 72% | | - |

Of the residential respondents who had purchased or used LEDs (n=162), the majority (70%) lived in single-family detached residences, 10% lived in multifamily apartments, 16% lived in attached houses, and 2% live in manufactured or mobile homes. Twenty-three percent of respondents who have purchased or used LEDs (n=162) had a bachelor's degree, 28% had a two-year or technical degree, 15% had an advanced degree, and about a quarter had a high school diploma.

In terms of housing type, education level, and age, LED users were not significantly different from non-users.[31] However, in contrast to Cadmus' findings in PY6, there was a statistically significant difference in income level among general population residential respondents who had used LEDs and those who had not: 57% of LED users (n=144) earned more than $50,000 per year compared to 39% of non-users (n=155).[32] (In PY6, these proportions were 55% and 51%, respectively, which was not statistically different.)

In addition to looking at income, Cadmus determined which respondents were within 150% of the federal poverty level. In contrast to its findings based on income alone (above or below $50,000), Cadmus did not find a significant difference between LED users and non-users: 15% of LED users (n=162) were below 150% of the federal poverty level compared to 14% of non-users (n=175).

## 3.5.7 Market Progress Indicators and LED Purchasing Patterns

### 3.5.7.1 Market Progress Indicators

During the residential general population survey, Cadmus gathered data to measure these market progress indicators—awareness of LEDs, LED purchases, likelihood to purchase LEDs in the future, experience using LEDS, and willingness to pay for LEDs. This section discusses changes over time, where possible. Cadmus conducted t-tests on differences in proportion between years, with critical values (represented as the symbol α) shown in parenthesis to indicate statistically significant differences.

**Awareness of LEDs.** Seventy-nine percent of general population residents (n=337) were aware of LEDs. This proportion is unchanged from PY6. About the same number of respondents had seen LEDs for sale at retail stores (78% in PY7; n=267, compared to 71% in PY6; n=236; this is not a statistically significant difference). Most respondents (85%; n=337) were not aware that PPL Electric Utilities discounted the bulbs.

Of the Low-Income Energy-Efficiency Behavior & Education Program survey respondents who had not received a free LED from PPL Electric Utilities', 82% (n=225, out of 301 total respondents) were aware of LEDs, which is not statistically different from the awareness of the general residential population ($\alpha$=.05).

**Purchasing Likelihood and Decision-Making Factors.** Cadmus asked respondents how likely they were to install LEDs in the next 12 months and why. Similar to PY6, 76% of respondents said they were either *very*

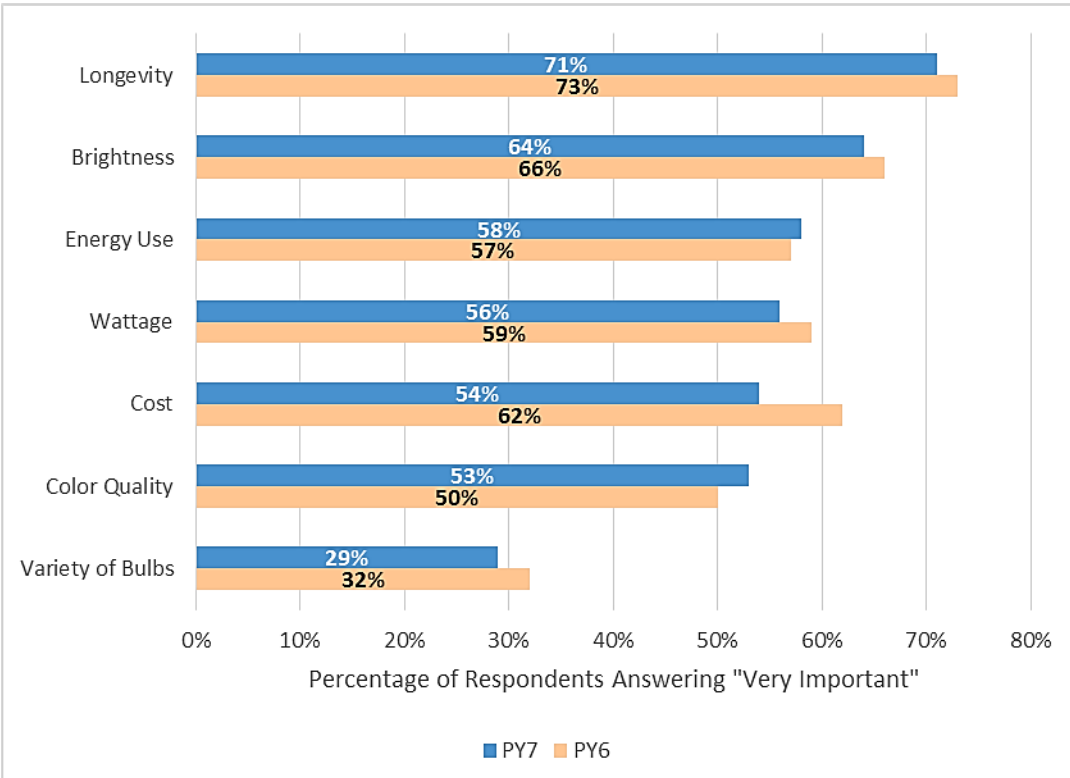
31 Differences are not significant at $\alpha$=0.10

32 Differences are significant at $\alpha$=0.025

or *somewhat likely* to install LEDs. For the responses *not too* or *not at all likely* to purchase LEDs, 27% of respondents (n=149) said they cost too much. However, the same proportion said either they already had bulbs in storage (10%) or they did not expect to have to replace any bulbs (17%).

When making a purchasing decision, bulb longevity, brightness, and energy use (in this order) were more important to respondents than cost (Figure 3-3). In PY6, the importance of most traits was similar to the importance of these traits; however, in PY7, somewhat fewer respondents (54%; n=337; α=.05) said that cost was *very important* compared to 62% in PY6 (n=301).

**Figure 3-3: Importance of Various Bulb Traits**




Source: Questions P1a-g, "Next, I'll read some factors that people consider when deciding which light bulbs to buy. For each factor, please indicate whether it is very important, somewhat important, not very important, or not at all important in your light bulb purchasing decisions." (PY6 n=301 and PY7 n=337). The difference in the percentage of respondents who said cost was very important is statistically significant.

### 3.5.7.2 LED Purchasers, by Sector

In PY7, approximately 70% of residential respondents (n=337) reported purchasing screw-in bulbs, and 28% had purchased LEDs within the last six months, a significant increase (α=.025) from the previous year. A similar proportion (not statistically different at α=.05) of the subset of low-income respondents (determined based on demographic questions to have an income less than 150% of the federal poverty level) had purchased LEDs; this was also true of participants in the Low-Income Energy-Efficiency Behavior & Education Program. Table 3-21 shows the percentages of respondents who purchased lamps, by customer base and technology type, from any source (i.e., not just from participating retailers).

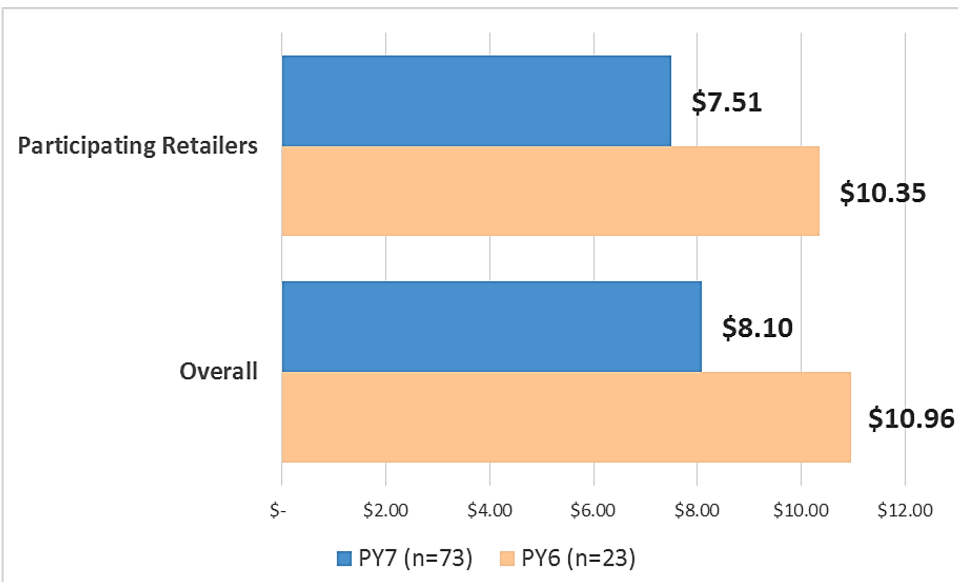
**Table 3-21: Percentage of Respondents Purchasing Bulbs in Past Six Months**

| Customer Base | N | Year | LEDs | CFLs | Incandescent or Halogens | Any Screw-In Bulb |
|---|---|---|---|---|---|---|
| Residential General Population | **337** | **PY7** | **28%** | **30%** | **24%** | **70%** |
| | 301 | PY6 | 16% | 29% | 26% | 65% |
| | 301 | PY5 | 17% | 45% | Unknown | |
| Low-Income Respondents in Residential General Population | 49 | PY7 | 20% | 24% | 22% | 57% |
| Low-Income Energy-Efficiency Behavior & Education Program Survey Respondents | 301 | PY7 | 24% | 12% | 12% | 46% |

### 3.5.7.3 LED Pricing

Cadmus asked general residential survey respondents who had recently purchased LEDs about the price they paid for the most recently purchased bulb.[33] Customers in PY7 (n=73) recalled paying lower prices than in PY6 (n=23), as shown in Figure 3-4. However, due to the small number of respondents in PY6 who purchased an LED recently and recalled the price they paid, these differences are not statistically significant.

**Figure 3-4. PY7 Average Prices Paid by Recent LED Purchasers**




Source: Question F8, "F8. Approximately, what was the price of the screw-based LED light bulb that you purchased most recently?"

PPL Electric Utilities' program bulbs, especially the most common general-service bulbs, sold for well within the range most respondents indicated they would be willing to pay for an LED (Section 3.5.7.6). The average price and incentive levels of program bulbs sold during PY7, weighted by the number of bulbs sold, are shown in Table 3-22.

33 Cadmus did not ask customers to specify what type of LED they purchased, A-line or reflector/flood, which are significantly more expensive.

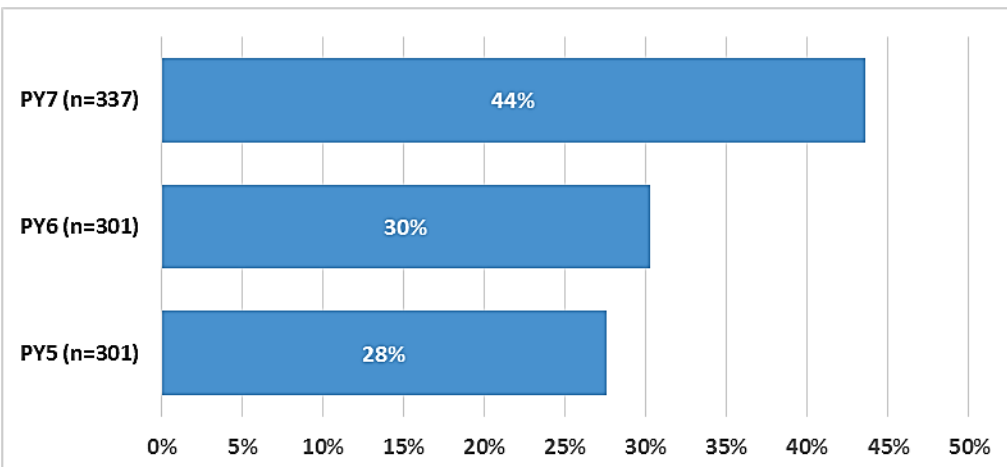
**Table 3-22: PY7 Program Bulb Pricing**

| Bulb Type | Percentage of Program Bulbs Sold | SKUs | Average Retail Price | Average Incentive | Average Promotional Price |
|---|---|---|---|---|---|
| Candelabra/Decorative | 8% | 61 | $9.58 | $3.59 | $4.54 |
| Exempt (3-Way) | 0% | 5 | $21.90 | $4.49 | $17.42 |
| Globe | 1% | 23 | $12.07 | $5.14 | $4.66 |
| GSL | 71% | 185 | $9.89 | $4.81 | $3.67 |
| Pin-Based | 1% | 4 | $16.00 | $5.00 | $2.51 |
| Reflector | 20% | 168 | $12.74 | $5.04 | $6.62 |
| Source: EEMIS data; bulbs sold during PY7 (excludes bulbs reported in but sold prior to PY7) | | | | | |

### 3.5.7.4 General Residential LED Saturation and Use

More general residential survey respondents said they were currently using LEDs, compared to PY6 and PY5 (α=.025), as shown in Figure 3-5. This is consistent with the trend Cadmus observed in residential respondents' reported purchasing behavior.

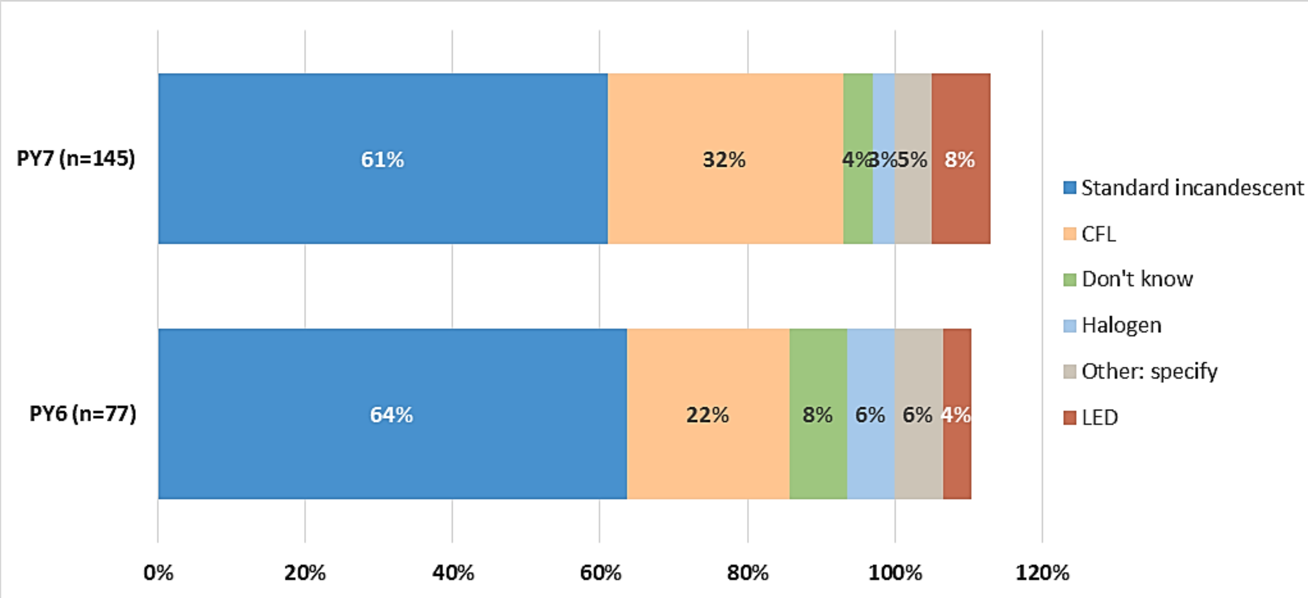
**Figure 3-5: PY7 Percentage of Respondents Using LEDs**




Source: Question E9. Are you currently using any screw-based LEDs inside or outside your home? + Question E12 "Earlier you said that you acquired screw-based LEDs in the past six months. Of these, how many are currently installed inside or outside your home?"

The majority of respondents who currently had LEDs installed (and remembered how many; n=145) said that the LEDs replaced standard incandescent bulbs (Figure 3-6), similar to in PY6. In PY7, somewhat more respondents said that the LEDs replaced CFLs (32% compared to 22% in PY6); however, this difference is not statistically significant at 90% confidence.

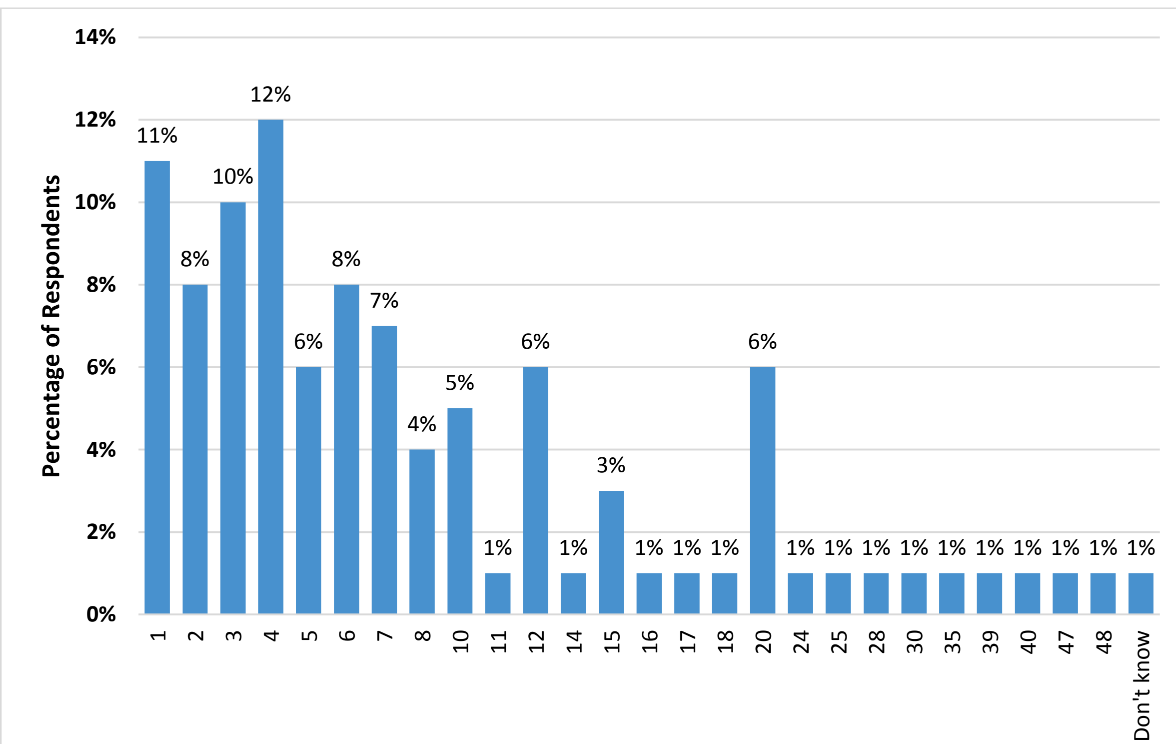
**Figure 3-6: Type of Bulbs the LEDs Replaced in PY7 and PY6**




Source: E13 (multiple response; responses may add up to over 100%). What kind of light bulbs did the LED bulbs replace?

Of the general residential respondents who had at least one LED installed (n=147), most had fewer than six installed. Figure 3-7 shows the distribution of responses regarding the number of LEDs currently installed.

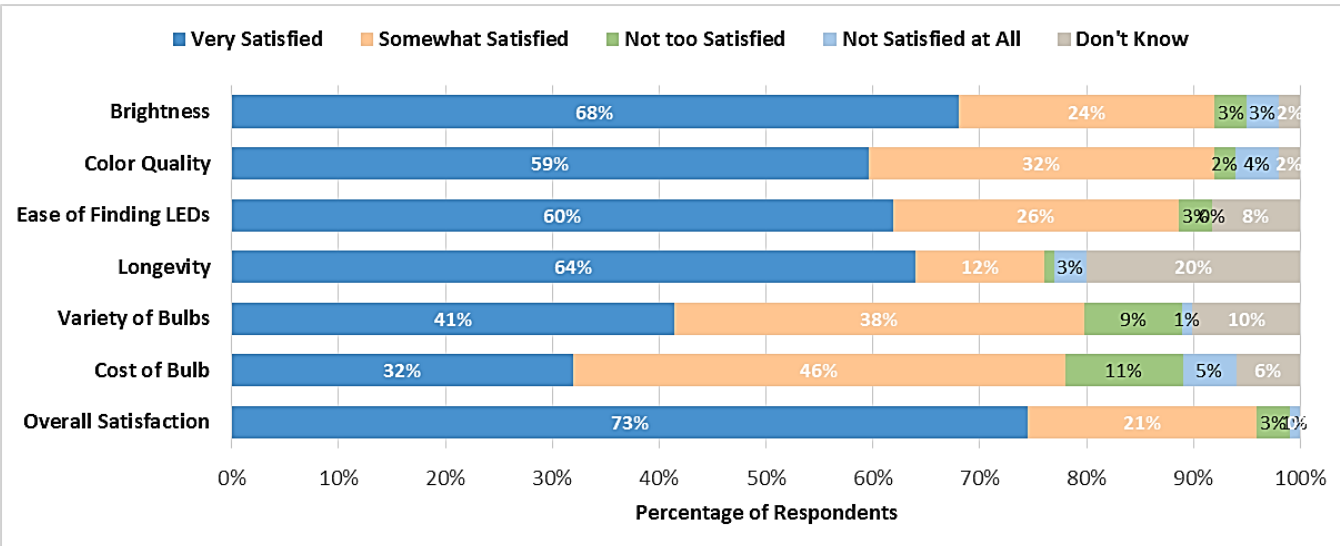
**Figure 3-7: PY7 Number of LEDs Currently Installed**




Source: General Population Residential Survey, E11. Approximately, how many screw-based LEDs are installed inside and outside your home right now? (n=147)

**User Experience with LEDs.** Figure 3-8 presents general residential respondent's satisfaction with various LED bulb traits. The majority of respondents (94%; n=158) were happy with the LED they installed (73% were *very satisfied* and 21% *somewhat satisfied*). Respondents were most satisfied with the brightness of the bulbs, followed by color quality, ease of finding LEDs to purchase, and longevity. Respondents were least satisfied with the cost of the LED. Twenty percent of respondents expressed uncertainty about longevity, presumably due to not having experienced one burning out. (In response to a separate question, 17% (n=158) said that an LED they had installed burned out before it should have.)

**Figure 3-8: General Residential Survey Respondents' Satisfaction with Various LED Traits**




Source: Questions G2,J3a-f, "How satisfied were you with the screw-based LEDs you installed in terms of…" Note that segments in the bar graph with no data label represent 3% or fewer of the responses.

### 3.5.7.5 Awareness of ENERGY STAR

In PY7, the general residential population survey included questions to ascertain whether respondents were aware that some LEDs meet ENERGY STAR certification standards for longevity, quality, and efficiency and some do not. Cadmus decided to add these questions in PY7 in response to concerns in the energy efficiency industry that the emergence of inexpensive, low-quality bulbs (commonly referred to as "value line" LEDs) could cause disruption of the market for ENERGY STAR certified bulbs.[34] ENERGY STAR revised its lamp specification, relaxing criteria for rated lifetime and omni-directionality. The ENERGY STAR 2.0 specification,[35] fully in effect in January 2017, will effectively allow less expensive bulbs to carry the ENERGY STAR label and increase the diversity of bulbs included in utility incentive programs. However, it is expected that not all "value line" LEDs will meet the requirements and that non-ENERGY STAR-certified bulbs will continue to compete with program bulbs.

Only 17% of respondents who had recently purchased LEDs (n=93) said they were *very aware* of this; 24% said they were *somewhat aware*. The majority of respondents said they were either *not too aware* (26%) or *not at all aware* (32%) that not all LEDs qualify for ENERGY STAR certification. Cadmus then asked

34 CLEAResult. *ENERGY STAR Lamps v.2.0 DRAFT 3 (+ Interim Proposal) Specification Comments.* November 23, 2015. Available online: https://www.energystar.gov/sites/default/files/CLEAResult%20Comments_0.pdf

35 ENERGY STAR. "Certified Products: Lamps Specification Version 2.0." Accessed October 2016: https://www.energystar.gov/products/spec/lamps_specification_version_2_0_pd

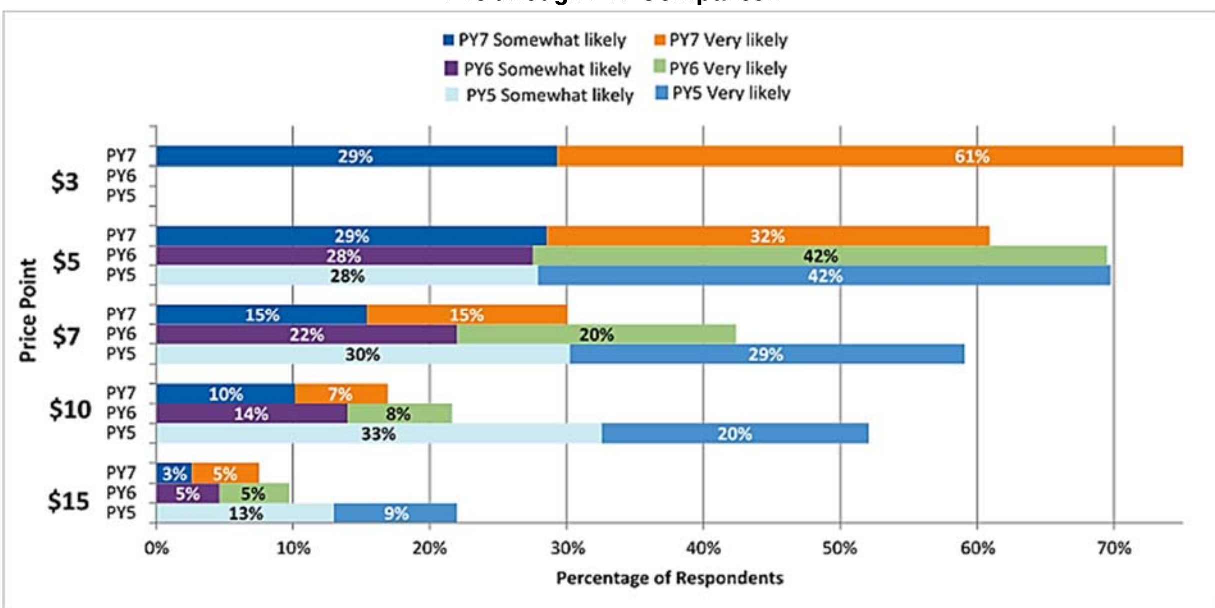
respondents (who were aware of LEDs) how important ENERGY STAR certification was in their decision to purchase a particular bulb. Most respondents (n=62) said it was either *very important* (26%) or *somewhat important (*47%) in their decision.

### 3.5.7.6 Willingness to Pay

As in PY6 and PY5, residential survey respondents indicated their price sensitivity to hypothetical price points of $5, $10, $7, and $15. In PY7, Cadmus added another price point and asked customers about willingness to pay $3. In PY7, residential customers were *very willing* to pay $3 for an LED; however, they appeared to be less likely to pay $5 or more than were respondents in prior years.

Figure 3-9 compares the percentages of PY7 through PY5 residential customers who reported they were *somewhat* or *very likely* to pay for an LED at different prices points. Willingness to pay $5 or more dropped in PY7, across all price points, but most noticeably at the $7 price point. However, the majority of customers (61%) said they would be *very willing* to pay $3 for an LED and 90% said they would be at least *somewhat* willing to pay $3 (*somewhat willing + very willing)*.

**Figure 3-9: General Residential Survey Respondents' Willingness to Pay for LEDs: PY5 through PY7 Comparison**

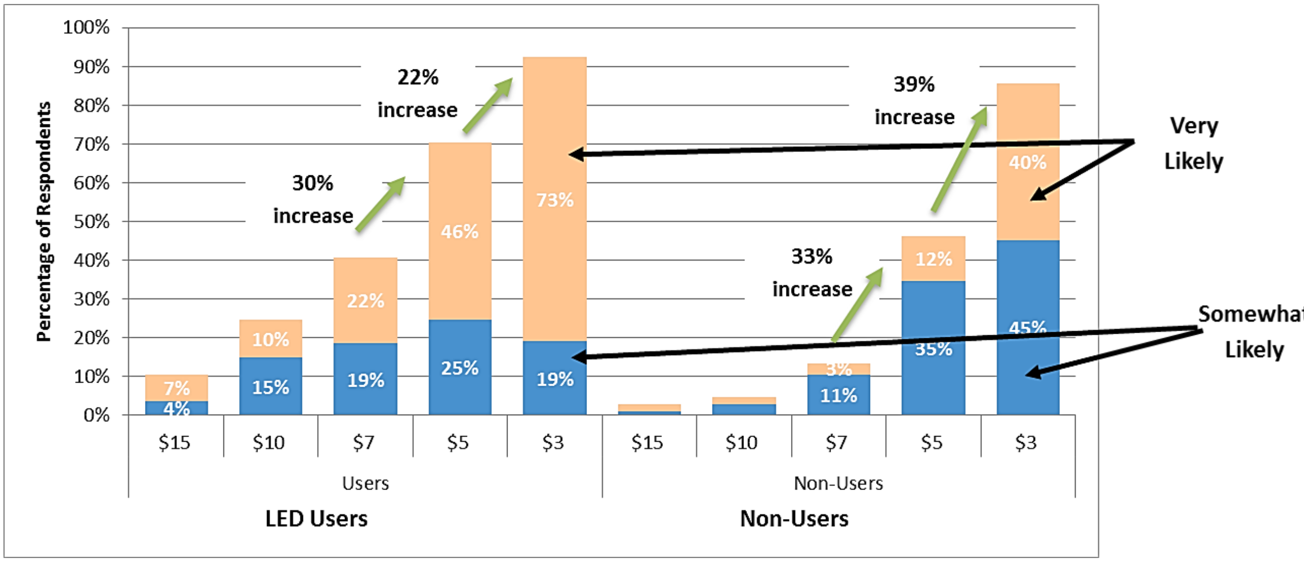



Source: PY7: Questions F11, F15, F16, F17, F18, "Suppose one of your light bulbs burns out or stops working and you need to buy a new bulb. If a typical screw-based LED cost $3, how likely would you be to purchase the LED instead of a CFL or a halogen incandescent bulb?" (n=266);
PY6: Questions F11, F15, F16, and F17, "Suppose one of your light bulbs burns out or stops working and you need to buy a new bulb. If a typical screw-based LED cost $5, how likely would you be to purchase the LED instead of a CFL?" (n=236);
PY5: Questions F15, F16 & F17, "If the LED cost $5/$8/$10 less [than $15], or $10/$7/$5,
how likely would you be to purchase the LED?" (n=215)

**Differences between LED Users and Non-Users.** Figure 3-10, similar to the previous figures, shows the percentages of PY7 respondents who were *somewhat* or *very likely* to purchase an LED at various price points but breaks the respondents into groups. "Users" were respondents who either recently purchased or had used an LED. "Non-users" were the remaining respondents who were aware of LEDs. The percentage increases indicated in Figure 3-10 represent the increase in *total likelihood* (sum of *somewhat and very likely)* as the hypothetical prices decreased.

Similar to prior years, there is a marked difference in willingness to pay between general residential respondents who had used LEDs and those who had not. In PY6, the largest jump in willingness to pay occurred in general residential non-users, between price points of $10 and $7. However, in PY7, the largest jump occurred in non-users between price points of $5 and $3, where almost 40% more customers said they would be at least *somewhat* willing to buy an LED than at the $5 price point.

**Figure 3-10: General Residential LED Users' versus Non-Users' Willingness to Pay**

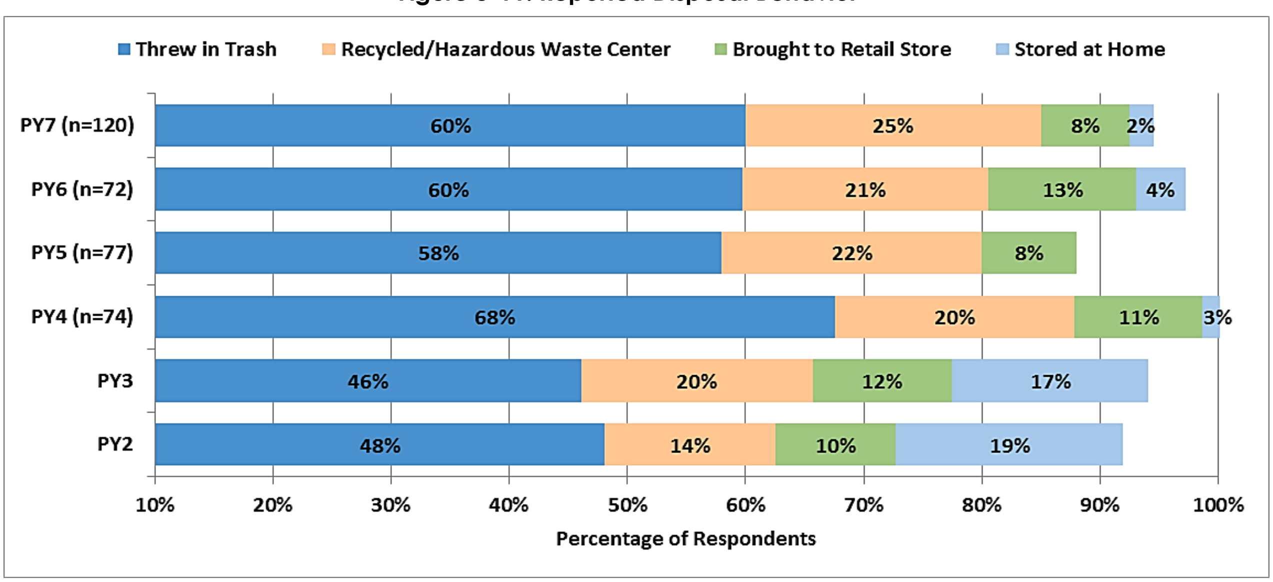



Source: Questions F11, F15, F16, F17, F18, "Suppose one of your light bulbs burns out or stops working and you need to buy a new bulb. If a typical screw-based LED cost $3, how likely would you be to purchase the LED instead of a CFL or a halogen incandescent bulb?" (n=162 users and 104 non-users)

### 3.5.7.7 CFL Disposal

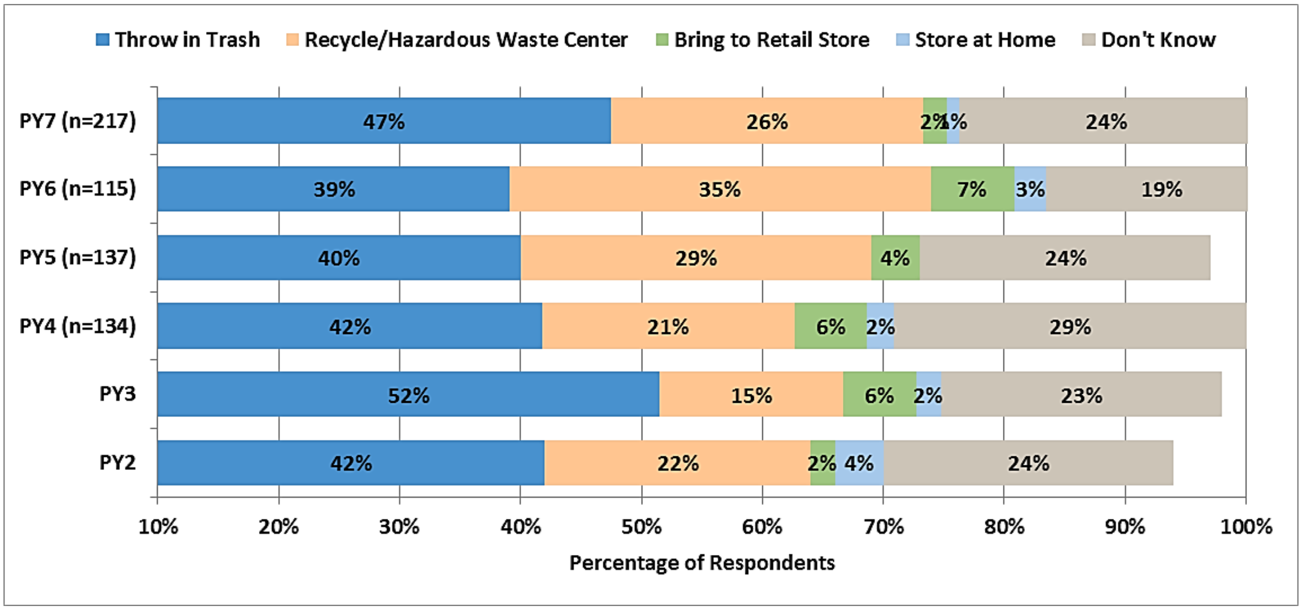
Of the 120 residential respondents who said they had disposed of CFLs in the past 12 months, 60% said they threw the CFLs in the trash. Cadmus asked those who had not, or were not sure, if, hypothetically, they were to dispose of a CFL, how they would do so. Less than half said they would throw a CFL in the trash, and more said they would dispose of CFLs by taking them to a recycling center or a retail store. Twenty-four percent said they were unsure how they would dispose of a CFL. These patterns are similar to patterns in previous years, as shown in Figure 3-11 (reported disposal behavior) and Figure 3-12 (hypothetical disposal behavior).

**Figure 3-11: Reported Disposal Behavior**



Source: (PY7) Question H2 "How did you dispose of the CFL?" (n=120; multiple response question)

**Figure 3-12: Hypothetical Disposal Behavior**




Source: (PY7) Question H3 "If you were to dispose of a CFL, how would you do so?" (n=217; multiple response question)

Only 7% of residential respondents (24; n=337) said they knew that PPL Electric Utilities provided recycle bins, and only one-third of these 24 respondents had actually seen bins in the last six months.

Similar to past years, 57% of respondents (n=337) said they had no concerns regarding CFL disposal, 19% had concerns about mercury or other environmental factors, and 11% were unsure about proper disposal.

In PY7, Cadmus included additional questions in the general residential population survey to investigate whether additional recycle bins might improve disposal behavior. Most respondents who had not or said they would not recycle CFLs (72%; n=246) said that they would be *more likely* to recycle CFLs if bins were available in more locations, such as grocery stores; 16% said they would be *somewhat more likely*. Of the remaining 28 respondents who would not be encouraged by more bins, eleven (39%) said there was nothing that would encourage them, four (14%) said curbside recycling, three (11%) suggested a cash incentive or electric bill credit, and another three (11%) said they did not know.

### 3.5.8 Satisfaction

Overall satisfaction with PPL Electric Utilities as a provider of electric service was high. Seventy-four percent of general residential customers (n=337) rated their satisfaction as 8 or higher (on a scale of 1 through 10),[36] which is similar to findings in previous years. Twelve percent rated PPL Electric as 7, and 13% gave a rating of 6 or lower.

36 Using a 1-to-10 scale where 10 means *outstanding* and 1 means *unacceptable.*

### 3.5.9 Energy Efficiency Knowledge

#### 3.5.9.1 Knowledge About Ways to Save Energy

Cadmus asked general residential respondents (n=337) to rate their current knowledge about ways to save energy in their home.[37] The majority (55%) rated themselves *somewhat knowledgeable*. Twenty-four percent of respondents said they were *very* knowledgeable, and 15% said *not too* knowledgeable. Only 4% said they were *not at all* knowledgeable.

## 3.6 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings, Cadmus presents its conclusions for PY7 and suggests that PPL Electric consider these recommendations in PY8.

**Conclusion**

PY7 rebate-processing times improved since the ICSP began processing rebates in house, and program satisfaction improved over PY6. The increase in satisfaction is mainly attributable to heat pump water heater respondents; those who received rebates for refrigerators were not more satisfied. Some customers were still confused by eligibility criteria for refrigerator rebate tiers (see Section 3.4.7.1).

**Recommendation**

Continue working with the ICSP to maintain rebate-processing times. Making eligibility criteria, especially for tiered rebates, as transparent as possible will minimize confusion or frustration among participants. Implementing an online model-number lookup mechanism for customers, including incentive levels, could effectively eliminate complaints about rebate amounts that did not meet participants' expectations.

**Recommendation**

Freeridership for refrigerators (evaluated in PY6) was high, and per-unit savings are low, especially following the change in the federal standard for refrigerators, which came into effect in September 2014. Program satisfaction and the NTG ratio are adversely impacted by refrigerators. PPL Electric could consider replacing this measure with another common household appliance that will have a larger impact in terms of both savings and customer satisfaction with the program and with PPL Electric.

**Conclusion**

General population surveys indicated an increase in the number of residential customers purchasing and using LEDs. Awareness of, and reported likelihood to purchase LEDs, had not changed since PY6. Customers still cared very much about bulb longevity, quality, and energy use. Although fewer residential customers said that cost was a very important factor in their decision regarding which light bulbs to purchase, their hypothetical willingness to pay at price points of $5 or above dropped significantly since PY6. Price sensitivity was highest among customers who had not yet used LEDs, and the largest jump in hypothetical likelihood to purchase was between price points of $5 and $3 (see Section 3.5.7.6).

**Conclusion**

The price response (demand modelling) analysis of the program's LED data indicated retailer's product merchandising, such as displays or off-shelf placement increases sales (as discussed in Section 3.3.4.1); however, there was only one retail channel for which promotional data were provided by the ICSP. The retailer for which off-shelf placements were tracked saw an average increase in sales of 30% of products featured in the merchandising displays.

[37] Cadmus did not ask Act 129 participants or small commercial customers the same questions about energy efficiency education or behavior.

**Recommendation**

This conclusion suggests another opportunity for the program. PPL Electric Utilities and the ICSP could work with retailers to use product placement as a lower-cost mechanism for generating sales lift rather than more aggressive incentives throughout the year. Additionally, PPL Electric Utilities could consider working with the ICSP to track product placement across all retailers, to the greatest degree that is practical, so that the program is credited for all activities that increase sales.

**Conclusion**

The demand elasticity modeling analysis found greater levels of freeridership in big box stores and lower levels in do-it-yourself stores. While not yet researched, this may possibly be because prices absent incentives are higher, on average, at do-it-yourself stores compared to club and mass market stores. Another potential factor could be the emergence of "value line" LEDs in various retailers. If program LEDs are competing against non-ENERGY STAR-certified bulbs that are cheaper or comparable in price to discounted program LEDs, one would expect demand to be less elastic. That is, sales would respond less to changes in prices of program bulbs as customers expect lower prices for LEDs or until incentives are sufficient so that the program bulbs are cheaper than the "value line" bulbs (see section 3.3.3.1 and *Appendix F: Demand Elasticity Study*).

**Recommendation**

PPL Electric Utilities could consider ways to organize its program to decrease freeridership by focusing on products or retailers with less competition from non-program eligible LEDs and products where demand is more elastic in response to price changes. For example, reflector bulbs had elasticities between -1.5 and -2 in all but the hard-to-reach retailers. This suggests that when prices decrease by 1% for reflector bulbs, sales increase by 1.5% to 2%. A-lamps had elasticities that were considerably lower (except at DIY retailers) that suggest for a price decrease of 1%, sales increase by 0.5% to 1%.

**Conclusion**

The demand elasticity model demonstrates that freeridership varies by retail channel, and that promotional merchandizing can have a substantial impact on sales. In addition, general population survey data indicates that customers, especially those who have not yet used LEDs, are very price sensitive (see Section 3.5.7.6). Survey data across program years suggests that customers are less willing to pay at price points above $5 than in prior years. These indicators suggest that the market for LEDs is not homogenous, thus can still benefit from intervention.

The average price of the general-service LEDs included in the program (Table 3-22) during PY7 was over $9, which is more than most customers are currently willing to pay. The average price of these bulbs net of incentives is closer to $4. The fact that 61% of general-population survey respondents (both LED users and non-users) said they would be *very likely* to purchase an LED for $3, 32% said they would be *very likely* to pay $5, and only 7% said they would be as likely to pay $10, further supports the importance of incentives in maintaining diffusion of LEDs into the general lighting market.

**Conclusion**

Hard-to-reach retailers had the least amount of sales with varying prices in PY7 with 36% of HTR sales represented in the model (see *Appendix F: Demand Elasticity Study*, Table F-2). Therefore, there is greater statistical uncertainty in the elasticity estimates for HTR retailers. Additional data with greater levels of price variation is needed before concluding that demand is less elastic at HTR retailers.

**Recommendation**

Cadmus recommends that PPL Electric Utilities work with the ICSP to identify opportunities to increase variation in program activity specifically within hard-to-reach retailers, by introducing new products with lower price points, special promotions, or pricing experiments, if possible.

**Conclusion**

Awareness of ENERGY STAR certification was relatively low (see Section 3.5.7.5). Fewer than half of customers were even *somewhat aware* that some bulbs meet the standard and some do not, yet customers who are at least somewhat aware of the certification said it was important to them. This suggests customers are not aware some LEDs may not have the high quality they have come to expect, which could open the door to competition from lower quality, competitively priced bulbs. This may erode sales of ENERGY STAR-certified program bulbs.

**Recommendation**

Although bulb quality was important, consumers were still responsive to changes in price. Given the low awareness that ENERGY STAR certification denotes quality and of the recent emergence of inexpensive value-line LEDs (not ENERGY STAR-certified), it will be important to watch market trends and purchasing patterns during Phase III. This includes monitoring the pricing of program and non-program bulbs, and consumer attitudes about quality versus price, in order to maintain satisfaction and the impact of program incentives.

**Conclusion**

CFL disposal behavior remains relatively unchanged from prior years (see Section 3.5.7.7), with over half of customers disposing of CFLs in the trash, in spite of more recycling bins in diverse locations. Most customers (72%; n=246) said they would be more likely to recycle CFLs if bins were available in more locations. Although PPL Electric Utilities has increased the quantity of bins and the diversity of locations in which they are available (adding community and municipal locations), very few customers reported having seen bins.

**Recommendation**

PPL Electric Utilities has not promoted CFLs for two years and is not planning to resume promoting them. In Phase III, PPL Electric Utilities will continue to support the existing bin program but is not planning to expand the effort to encourage consumers to recycle CFLs. Because few consumers know of the CFL recycling bins, PPL Electric Utilities could consider bundling advertising of bin locations with other promotional materials as a cost-effective method to increase awareness. Cadmus is not currently planning to continue evaluating CFL disposal behavior in Phase III.

### 3.6.1 Status of Recommendations for Program

Table 3-23 contains the status of each PY7 process recommendation made to PPL Electric Utilities.

**Table 3-23: Residential Retail Program Status Report on Process and Impact Recommendations**

| Recommendations | EDC Status of Recommendation (Implemented, Being Considered, Rejected AND Explanation of Action Taken by EDC) |
|---|---|
| **Residential Retail Program** | |
| Equipment--Consider implementing an online model-number lookup mechanism for customers, including incentive levels, to minimize confusion when tiered rebates are offered for the same type of appliance. | Being considered. |
| Equipment--Consider replacing refrigerators with another common household appliance that will have a larger impact in terms of both savings and customer satisfaction with the program and with PPL Electric Utilities. | Rejected but may be reconsidered over time. During the Phase III EE&C Plan, PPL rejected replacing refrigerators with another household appliance. No other appliances (washing machines, dishwashers, etc.) have materially higher savings or a lower program acquisition cost. Also, the purchase of a new refrigerator often leads to the recycling of an old one. |
| Upstream Lighting--Work with retailers to use product placement as a lower-cost mechanism for generating sales lift rather than more aggressive incentives throughout the year. Additionally, PPL Electric Utilities could consider working with the ICSP to track product placement across all retailers, to the greatest degree practical, so that the program is credited for all activities that increase sales. | Implemented where possible. Some retailers will not allow PPL much control over merchandising or provide PPL with product placement information/documentation. Through in-store inspections, the ICSP will try to influence and document product placement. |
| Upstream Lighting--Consider ways to organize the program to decrease freeridership by focusing on the products or retailers with less competition from non-program-eligible LEDs and products where demand is more elastic in response to price changes. | Will be considered if the NTGR is too low. Based on the PY7 evaluation, the NTGR is currently acceptable but PPL will continually look to improve the NTGR where possible within program budget constraints (i.e. ensure PPL hits its savings targets within the program's cost budget). |
| Upstream Lighting--Work with the ICSP to identify opportunities to increase variation in program activity specifically within hard-to-reach retailers, by introducing new products with lower price points, special promotions, or pricing experiments, if possible. | Implemented. |
| Upstream Lighting--Watch market trends and purchasing patterns during Phase III. This includes monitoring the pricing of program and non-program bulbs, as well as consumer attitudes about quality versus price, to maintain the impact of program incentives. | Implemented. Market effects and saturation studies are in progress as of October 2016. |
| Upstream Lighting--Consider bundling advertising of CFL recycling bin locations with other promotional materials as a cost-effective method to increase awareness. | Being considered. |

## 3.7 FINANCIAL REPORTING

A breakdown of the Residential Retail Program finances is presented in Table 3-24.

**Table 3-24: Summary of Residential Retail Program Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs [6] ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs | $12,142 | $32,109 |
| 2 | EDC Incentives to Participants | $8,559 | $14,552 |
| 3 | EDC Incentives to Trade Allies | - | - |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $3,582 | $17,557 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6, 7, 8, 9, 10 ) | $4,092 | $8,966 |
| 6 | Design & Development | $0 | $0 |
| 7 | Administration, Management, and Technical Assistance[1] | $4,092 | $8,966 |
| 8 | Marketing[2] | $0 | $0 |
| 9 | EDC Evaluation Costs | $0 | $0 |
| 10 | SWE Audit Costs | $0 | $0 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | $113 | $107 |
| | | | |
| 12 | Total TRC Costs[3] (Sum of rows 1, 5 and 11) | $16,347 | $41,183 |
| 13 | Total NPV Lifetime Energy Benefits | $45,778 | $117,287 |
| 14 | Total NPV Lifetime Capacity Benefits | $3,275 | $7,005 |
| 15 | Total NPV O&M Saving Benefits | $12,272 | $30,033 |
| 16 | Total NPV TRC Benefits[4] | $61,325 | $154,325 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | 3.75 | 3.75 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.
[2] Includes the marketing CSP and marketing costs by program CSPs.
[3] Total TRC Costs includes Total EDC Costs and Participant Costs.
[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.
[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[6] Phase II Costs in this table are discounted back to PY5, thus will not match cumulative costs reported in the PY7 Q4 quarterly report.

# ADDENDUM A. PARTICIPANT SURVEY METHODOLOGY

## Dialing Instructions

PPL Electric Utilities provided dialing instructions for conducting surveys. Customers cannot be contacted within a three months of the last time they completed a survey (with PPL Electric Utilities or Cadmus).[38] Any customer who has requested to be removed from the sample frame for any survey cannot be contacted again. Telephone survey calls cannot take place on Sundays or national holidays.

## Sample Cleaning and Attrition

Prior to the start of survey data collection, Cadmus coordinated with PPL Electric Utilities' survey subcontractor to screen the sample and remove records of any customers who completed a survey in the past three months (whether for a Cadmus survey or a PPL Electric Utilities survey) or who requested not to be contacted again. Cadmus removed records with incomplete information.

For the cross-program survey, Cadmus selected a simple random sample, stratified by program and measure category, from the remaining records and sent them to the survey subcontractor. Table 3-25 lists total number of records submitted to the survey subcontractor and the outcome (final disposition) of each record for the cross-program survey.

For the program-specific survey, Cadmus selected and sent all remaining records to the survey subcontractor. Table 3-25 lists total number of records submitted to the survey subcontractor and the outcome (final disposition) of each record for the program-specific survey. The survey subcontractor attempted to reach respondents up to four times over several days, at different times of the day, and scheduled callbacks whenever possible. The survey subcontractor called 795 records and made up to four attempts per record.

38 This policy changed in April of 2016 before this survey was completed. Prior to this, customers could not be contacted for a survey until one year passed since they completed their last survey (with PPL Electric Utilities or Cadmus).

**Table 3-25: Cross-Program Sample Attrition**

| Cross-Program: Residential Retail Participants | | |
|---|---|---|
| **Description** | **Heat Pump Water Heater Count** | **Refrigerator Count** |
| **Total Population (Number of Participants Q1-Q4) [1]** | **1,151** | **2,814** |
| Removed incomplete or bad phone number, inactive customer, completed survey in past year, on "do not call" list, selected for a different survey, duplicate contact | **110** | **272** |
| **Random Sample Selection** | **1,041** | **1,240** |
| **Sent to Survey Subcontractor** | **1,041** | **1,240** |
| **Records Not Attempted [2]** | **669** | **817** |
| **Records Attempted** | **372** | **423** |
| Nonworking number | 33 | 42 |
| Business/wrong number | 5 | 5 |
| Refusal | 60 | 101 |
| Language barrier | 0 | 3 |
| Ineligible; PPL Electric Utilities or market research employment | 3 | 5 |
| Ineligible; did not participate in program | 0 | 0 |
| No answer/answering machine/phone busy | 68 | 50 |
| Nonspecific or specific callback scheduled | 131 | 151 |
| Partially completed survey | 2 | 4 |
| **Completed Survey** | **70** | **62** |

[1] The population from which the survey samples were drawn is slightly lower than the total PY7 population shown in Table 3-16 because incremental tracking records were received after the survey was conducted.
[2] These records were not needed because the overall survey target for the cross-program survey was reached before they were attempted.

# ADDENDUM B. GENERAL POPULATION SURVEY ATTRITION AND FINAL DISPOSITION

## SURVEY METHODOLOGY

### Dialing Instructions

PPL Electric provided dialing instructions for conducting surveys. Customers cannot be contacted for a telephone survey until one year has passed since they completed their last survey (with PPL Electric or Cadmus).[39] Customers who have requested not to be contacted again are also removed from the sample frame. Telephone survey calls cannot take place on Sundays or national holidays.

Researchers called participants at different times of day and different days of the week to increase the probability of contact. Researchers attempted surveys with potential respondents up to five times each.

### Sample Cleaning and Attrition

Cadmus coordinated with PPL Electric's survey subcontractor to screen the sample and remove any records of customers who had been called in the past year (whether for a Cadmus survey or a PPL Electric survey) or requested not to be contacted again.Cadmus also removed records with incomplete information and participants reserved for another survey.

Cadmus selected a simple random sample of all remaining records and sent them to the survey subcontractor. Table 3-26 lists total number of records submitted to the survey subcontractor and the outcome (final disposition) of each record.

39 This policy changed following the conclusion of this survey. As of April 2016, customers could not be contacted for a survey until three months passed since they completed their last survey (with PPL Electric Utilities or Cadmus).

**Table 3-26: Survey Sample Attrition Table for General Population Residential Customers**

| Description | Count |
|---|---|
| **Total Population (Number of Residential Customers)** | **2,269,287** |
| **Random Sample Selection** | **52,500** |
| Removed because RHC Equipment Participant | 7 |
| Removed because Res Retail HPWH participant | 49 |
| Removed because incomplete or missing phone number | 2,717 |
| Removed because duplicate record | 1,204 |
| Removed because inactive | 21,952 |
| Removed because on do not call or opt-out list | 309 |
| Removed because completed survey in past year | 670 |
| Removed because selected for a different survey fielding at the same time | 8,761 |
| **Sent to Survey Subcontractor** | **16,831** |
| **Records Not Attempted [1]** | **11,830** |
| Nonworking | 384 |
| Business/wrong number | 151 |
| Refusal | 668 |
| Language barrier | 33 |
| Ineligible; PPL Electric Utilities or market research employment | 46 |
| No answer/answering machine/phone busy/call privacy | 2,014 |
| Nonspecific or specific callback scheduled | 1,287 |
| Partially completed survey | 81 |
| **Completed Surveys** | **337** |

[1] These records were not needed because the overall survey target was reached before they were attempted.

# ADDENDUM C. NET SAVINGS DOWNSTREAM REBATE COMMON APPROACH

Cadmus used self-report surveys to assess net savings for the Residential Retail Program equipment rebate program component, following the Evaluation Framework's recommended common method for assessing freeridership.[40] The SWE team reviewed and approved the survey prior to fielding.

The assessment includes two components of freeridership—*intention* to implement an energy-efficient project without a rebate and *influence* of the program in the decision to implement the energy-efficient project. When scored, each component has a value ranging from zero to 50 and a combined total freeridership score ranging from zero to 100.

### 3.7.1 Intention

*Intention* was assessed through several brief questions to determine how the project likely would have differed if the respondent had not received the program assistance. If the customer received more than one rebate, these questions focused on the project with the largest energy savings.

#### 3.7.1.1 Intention Survey Questions

A12. Which of the following would have happened if you had not received the [V_MEASURE**]** rebate from PPL Electric Utilities? [READ LIST AND SELECT ONE RESPONSE]
*Canceled or postponed purchase at least one year; Repaired the old [V_MEASURE]; Purchased a less expensive [V_MEASURE]; Purchased a less efficient [V_MEASURE]; Purchased the same [V_MEASURE1] without the [V_REBATE**]** rebate?; (Don't know); (Refused)*

### 3.7.2 Influence

*Influence* is assessed by asking about how much influence—from 1 (no influence) to 5 (extreme influence)—various program elements had on the decision to do the project the way it was done. The items selected for rating were specific components of the Residential Retail Program.

#### 3.7.2.1 Influence Survey Questions

A13. I'm going to read a list of items about the [PROGRAM] program. Please rate each item on how much influence it had on your decision to purchase the **[V_MEASURE].** Please use a scale from 1 to 5, 1 meaning no influence, and 5 meaning the item was extremely influential in your decision.
[RANDOMIZE STATEMENTS]

[40] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase II Energy Efficiency and Conservation Programs.* Prepared by GDS Associates, Inc., and Nexant. June 1, 2014.

| Item | No influence | | | | Extremely influential | Don't know | Not applicable |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 98 | 96 |
| A. The [V_REBATE] rebate | | | | | | | |
| B. PPL Electric Utilities' marketing | | | | | | | |
| C. PPL Electric Utilities' information about energy efficiency | | | | | | | |
| [ASK IF PROGRAM=RHC] D. Information about the program from your installer or contractor | | | | | | | |
| [ASK IF RES RETAIL HPWH] E. Information about saving energy from the salesperson | | | | | | | |
| [ASK IF RES RETAIL HPWH] F. Information about heat pump water heaters from a plumber or contractor | | | | | | | |

A14. What else, if anything, was highly influential in your decision to purchase the [V_MEASURE]?
[RECORD RESPONSE]
*Nothing; Don't know; Refused*

# 4 CUSTOM INCENTIVE PROGRAM

The Commercial and Industrial (C&I) Custom Incentive Program offers financial incentives to customers for installing extensive energy efficiency projects, retrocommissioning existing equipment, making repairs, optimizing equipment, installing equipment measures or systems not covered by the Prescriptive Equipment Program, and making operational and process improvements that result in cost-effective energy savings.

The program offers performance-based incentives for the avoided or reduced energy consumption—in kilowatt hours per year (kWh/yr)—that result from the project. Incentives are subject to an annual cap for each project ($250,000 in PY5 and $500,000 in PY6 and PY7) and for each participating customer ($500,000 per customer site per year or $1,000,000 per parent company per year). Incentives cannot exceed 50% of the total project cost, excluding internal labor costs.

To qualify, C& I customers are required to submit documentation that their proposed efficiency upgrades pass the program's cost-effectiveness threshold, and the project must be approved before equipment is purchased. PPL Electric Utilities reimburses the customer following successful implementation of a cost-effective project, and the reimbursement may vary by the type or size of the equipment, system, or improvement.

An ICSP, DNV GL Energy Services USA, Inc., manages the program and handles application intake, assesses eligibility, and calculates project energy savings and incentives.

The objectives of the Custom Incentive Program are these:[41]

- Encourage PPL Electric Utilities customers to install high-efficiency custom projects. In PY5, custom could include any projects not included in PPL Electric Utilities' Prescriptive Equipment Program. Starting in PY6, only projects that are not included in the Pennsylvania TRM are eligible.
- Encourage qualifying equipment repairs and optimization and operational or process changes that reduce electricity consumption.
- Encourage a whole-facility approach to energy efficiency.
- Increase customer awareness of the features and benefits of electric energy-efficient equipment.
- Increase the market penetration of high-efficiency equipment.
- Support emerging technologies and non-typical efficiency solutions in cost-effective applications.
- Encourage advanced energy efficiency strategies required for certification by national market transformation programs such as Leadership in Energy and Environmental Design (LEED), Architecture 2030, ENERGY STAR Buildings, or Energy Policy Act of 2005 (EPAct) tax credits.
- Promote other PPL Electric Utilities energy efficiency programs.
- Achieve approximately 96 completed projects through PY7, with a total reduction of approximately 8,500 MWh/yr (small C&I customers).
- Achieve approximately 111 completed projects through PY7, with a total reduction of approximately 34,000 MWh/yr (large C&I customers).
- Achieve approximately 26 completed projects through PY7, with a total reduction of approximately 20,000 MWh/yr (GNE customers).

41 Program objectives are stipulated on PPL Electric Utilities' revised EE&C Plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, pp.120, 137, and 155.

A summary of Phase II program metrics by sector is presented in Table 4-1.

**Table 4-1: Phase II Custom Incentive Summary by Customer Sector**

| Sector | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Net-to-Gross Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) | Program Acquisition Cost ($/Annual kWh) | Cost of Conserved Energy[1] (TRC $/kWh) | Phase II Participants |
|---|---|---|---|---|---|---|---|---|---|
| Government/Nonprofit/ Education | 8,268 | 8,268 | 8,076 | 0.58 | N/A | $1,534 | $0.19 | $0.096 | 27 |
| Large C&I | 41,356 | 41,356 | 40,994 | 0.54 | N/A | $4,018 | $0.10 | $0.051 | 71 |
| Small C&I | 7,986 | 7,986 | 7,782 | 0.53 | N/A | $1,822 | $0.23 | $0.053 | 109 |
| **Total** | **57,610** | **57,610** | **56,852** | **0.54** | **1.32** | **$7,373** | **$0.13** | **$0.057** | **207** |

[1] Total TRC Costs divided by levelized lifetime kWh savings.

## 4.1 PROGRAM UPDATES

In PY5, the Custom Incentive Program could include any projects not included in PPL Electric Utilities' Prescriptive Equipment Program. Starting in PY6, only projects that are not included in the Pennsylvania TRM are eligible.

In PY6 and PY7, preapproval was required prior to equipment purchase.

PY7 was the final year of Phase II. The ICSP reserved any incoming projects until the total reservation funds by sector met Phase II projections. At that point, it placed additional incoming projects on a wait list. These wait-listed projects underwent the same implementation and verification process as the previous projects; however, they were not paid an incentive unless and until additional funding became available. Funds became available when reserved projects were cancelled, when the verified savings of previously reserved projects were less than the originally reserved savings or project installation timelines extended past the end of Phase II (May 31, 2016).

### 4.1.1 Definition of Participant

A PY7 participant is defined as a project that received an incentive payment between June 1, 2015, and May 31, 2016. Projects for which customers submitted an application during this period but did not receive an incentive are not counted as participants in PY7. It is possible for an individual customer to have multiple participating projects. Typical custom projects may take more than one quarter to complete.

## 4.2 IMPACT EVALUATION GROSS SAVINGS

### 4.2.1 Reported Gross Savings

Table 4-2 shows the cumulative reported results for Phase II for the entire program.

### 4.2.2 Database Review

As part of the evaluation, Cadmus reviewed the project files for all large stratum projects and the sample of the small stratum projects and found project files were consistent with entries in EEMIS and included sufficient information to facilitate project evaluation. PPL Electric was alerted to any errors found in the EEMIS database if found to be inconsistent with project documentation. Cadmus conducted no separate database review.

**Table 4-2: Phase II Custom Incentive Reported Results by Customer Sector**

| Sector | Phase II Participants | Phase II Reported Gross Energy Savings (MWh/yr) | Phase II Reported Gross Demand Reduction (MW) | Incentives Paid ($1,000) |
|---|---|---|---|---|
| Government/Nonprofit/Education | 27 | 8,268 | 1.25 | $798 |
| Large C&I | 71 | 41,356 | 4.93 | $2,918 |
| Low-Income | - | - | - | - |
| Residential | - | - | - | - |
| Small C&I | 109 | 7,986 | 0.78 | $593 |
| **Phase II Total** | **207** | **57,610** | **6.96** | **$4,309** |

### 4.2.3 EM&V Sampling Approach

To evaluate savings for the Custom Incentive Program, Cadmus defined projects as large stratum and small stratum projects.

- During the application process, projects with an expected energy savings greater than 500,000 kWh/yr were assigned to the large stratum. Projects that were unusually complicated or had a high level of uncertainty in the expected energy savings could be added to the large stratum at the behest of the ICSP. All projects in the large stratum were verified.
- Projects with expected savings below 500,000 kWh/yr were assigned to the small stratum.

Table 4-3 shows the sampling parameters for PY7. The achieved precision for the program-level results are in compliance with the Evaluation Framework requirements to meet 85% confidence and 15% precision (85/15). The large stratum savings make up 84% of the reported savings for PY7, and all projects were verified with a 100% realization rate (precision is not applicable). The small stratum savings are known with less precision (29%), but in PY7 they represent only 16% of the reported savings. Therefore, the sample exceeded the requirements of 85/15 at the program level, with 4% precision at the 85% confidence level.

**Table 4-3: PY7 Custom Incentive Program Impact Evaluation Sampling Strategy**

| Stratum | Population Size[1] | Target Levels of Confidence & Precision | Target Sample Size | Achieved Sample Size | Evaluation Activity |
|---|---|---|---|---|---|
| Small | 64 | 85/15 | 10 | 10 | Impact, process, records review, site visits |
| Large | 18 | N/A[2] | 18 | 18 | Impact, process, records review, site visits |
| **Program Total** | **82** | **85/15** | **28** | **28** | **Impact, process, records review, site visits** |

[1] The population size is based on the number of jobs that contributed to reported savings in PY7. The total number of projects in PY7 is 82.
[2] This evaluation included the census of program participants in the large stratum. As a result, the savings estimate in this stratum is not subject to sampling error. The coefficient of variation (Cv) and confidence and precision do not apply to the large stratum.

**Small stratum:** At the close of Q3 in PY7, Cadmus selected a sample of 10 small stratum projects participating from Q1 through Q3, verified their savings, and determined a realization rate.

Cadmus prepared the site-specific measurement and verification plan (SSMVP) for these 10 sample projects then conducted post-installation inspections and verified their savings. (Pre-installation inspections are not possible for small stratum projects because they cannot be selected into the sample until after the equipment is installed and an incentive is paid.)

Cadmus calculated the realization rate as the ratio of *ex post* verified gross savings to *ex ante* savings then applied this realization rate for the selected sample to the entire small stratum population.

**Large stratum:** The ICSP informed Cadmus about projects likely to fall into the large stratum. Cadmus prepared the SSMVP, typically in coordination with the ICSP, and then evaluated these large stratum projects at a high level of rigor. In most cases, an inspector conducted pre-installation inspections for all large stratum projects. There are exceptions where baseline visits did not take place. These include new construction projects, for which there was no existing condition, and projects that did not enter the large stratum until after the measure was installed. Post-installation site visits also take place to gather additional data and verify measure installation.

Cadmus collected data to verify energy savings during these site visits and through other customer outreach. Unlike the small stratum, PPL Electric Utilities based the incentive payment upon the verified savings, rather than the reported savings. As such, the realization rate is 100% for these large stratum projects.

### 4.2.4 Custom Incentive Program Project Details

PPL Electric Utilities paid incentives for 82 projects—18 large stratum and 64 small stratum—in the Custom Incentive Program in PY7. All were finalized (paid) during the program year (two projects were paid within two weeks of the end of Phase II but were included in the PY7 totals).

The number of projects initiated (submitted applications from June 1, 2015, through May 31, 2016) and completed in PY7 are shown by sector in Table 4-4. Note that the number of projects initiated was likely affected by the presence of a waitlist. Also note that the projects initiated in PY7 were not necessarily completed in PY7 and the projects completed in PY7 were not necessarily initiated in PY7.

**Table 4-4: PY7 Projects by Sector**

| Sector | Projects Initiated in PY7 | Projects Completed in PY7 |
|---|---|---|
| Government/Nonprofit/Education | 8 | 14 |
| Large C&I | 8 | 21 |
| Small C&I | 15 | 47 |
| **Program Total** | **31** | **82** |

The size of projects for which incentives were paid has varied from program year to program year. Table 4-5 lists the average project size for all program years in Phase I and Phase II.

**Table 4-5: Average Project Size by Program Year**

| | Phase I | | | | Phase II | | | Average |
|---|---|---|---|---|---|---|---|---|
| | PY1 | PY2 | PY3 | PY4 | PY5 | PY6 | PY7 | |
| Average kWh/yr Saved | 55,731 | 309,722 | 931,091 | 647,902 | 96,321 | 317,311 | 360,664 | 511,092 |
| Average kW Saved | 4.16 | 35.81 | 106.48 | 70.33 | 8.19 | 35.58 | 47.09 | 58.18 |
| **Projects** | **1** | **54** | **107** | **112** | **56** | **69** | **82** | **69** |

Note that the average project size can depend highly on relatively few projects. For example, in PY3 the average project size was 50% larger than it otherwise would have been because one large project had more than 33,000,000 kWh/yr in verified savings. For PY7, the average project size increased from PY6 but was still less than the average project size throughout Phase I and Phase II. PY7 could be considered a typical program year because its average project size moved closer to the overall program average with a balance of individual project savings to number of projects.

Incentives for Custom Incentive Program are limited to either 50% of the total project cost or $500,000, whichever is less. The Phase II incentives as a percentage of verified measure costs were consistent in PY5 and PY6 but dropped in PY7, as shown in Table 4-6. This drop was for two reasons—several large strata projects had less than expected verified savings, resulting in lower incentives, and another large project's incentive was limited by program rules rather than project cost.

**Table 4-6: Project Costs Compared to Incentives**

| Program Year | Cost Capped Projects | Maximum Incentive Projects | Verified Measure Cost | Total Incentives | Incentives as Percent of Verified Measure Cost |
|---|---|---|---|---|---|
| PY5 | 13 | 0 | $1,525,727 | $336,397 | 22% |
| PY6 | 11 | 0 | $8,372,297 | $1,654,125 | 20% |
| PY7 | 15 | 1 | $25,822,264 | $2,318,156 | 9% |

### 4.2.5 Summary of Evaluation Results

As shown in Table 4-7 and Table 4-8, the realization rates for energy and demand savings were slightly lower for large strata projects (100%) than for small strata projects (101% energy, 142% demand). In PY7, the total program realization rate was 100% for energy and 107% for demand.

**Table 4-7: PY7 Custom Incentive Summary of Evaluation Results for Energy [1]**

| Stratum | PYTD Reported Gross Impact (MWh/yr) | PYTD Adjusted *Ex Ante* Energy Savings (MWh/yr) | Energy Realization Rate (%) | PYTD Verified Gross Energy Savings (MWh/yr) [2] | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Large | 24,904 | 24,904 | 100% | 24,904 | 0.0000 | 0.00% |
| Small | 4,627 | 4,627 | 101% | 4,660 | 0.6271 | 28.67% |
| **Program Total** | **29,531** | **29,531** | **100%** | **29,564** | **N/A** | **4.26%** |

[1] Values in this table refer to savings at the point of consumption. (Savings targets for MWh refer to values at the point of consumption.) Due to line losses, savings at the point of generation are systematically larger.
[2] No *ex ante* adjustments were made. Reported *ex ante* multiplied by the realization rate will not equal verified gross energy savings due to rounding

**Table 4-8: PY7 Custom Incentive Summary of Evaluation Results for Demand**

| Program | PYTD Reported Gross Demand Savings [1] (MW) | PYTD Adjusted *Ex Ante* Demand Savings [2] (MW) | Demand Realization Rate (%) | PYTD Verified Gross Demand Savings [2] (MW) | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Large | 3.219 | 3.371 | 100% | 3.371 | 0.0000 | 0.00% |
| Small | 0.642 | 0.686 | 142% | 0.970 | 0.9018 | 41.23% |
| **Program Total** | **3.861** | **4.056** | **107%** | **4.341** | **N/A** | **8.56%** |

[1] Reported Gross Demand reductions do not include T&D losses.
[2] Adjusted *Ex Ante* and Verified Gross Demand reductions include T&D losses.

### 4.2.6 Summary of Site Visits

The ICSP conducted quality assurance site visits during project scoping and calculated *ex ante* savings. Cadmus conducted site visits and inspections to verify that program-related measures were installed and operating as reported and that correct data were used to calculate *ex ante* savings.

Large stratum projects had no discrepancies between the *ex ante* reported and the *ex post* verified savings—that is, the *ex ante* reported and *ex post* verified savings were equal—because Cadmus was involved as soon as the project was identified for the large stratum.

Cadmus found a variety of discrepancies during the on-site inspections of the sample of small stratum projects; however, no sites were classified as having failed. For these, the inspections found nothing unexpected (e.g., measures were installed and were operating as reported), though the operating parameters were typically somewhat different than assumed by the ICSP.

Table 4-9 summarizes the number of site visits planned, conducted, and the type and resolution of discrepancies. Cadmus documented discrepancies for small stratum projects in project verification reports and used site-specific data to calculate the *ex post* verified gross savings.

**Table 4-9: PY7 Custom Incentive Program Summary of Site Visits**

| Program | Measure | Inspection Firm | Number of Inspections Planned | Number of Inspections Conducted | Number of Sites with Discrepancies from Reports | Resolution of Discrepancies |
|---|---|---|---|---|---|---|
| Custom | All Verified Custom Projects | Cadmus | ~46 | ~46 | Large custom sites not reported until verified. Small custom site all had discrepancies (e.g., operating parameters, equipment specifications, baseline adjustments. | Varies; typically updated with site-specific data or through M&V. |

## 4.3 IMPACT EVALUATION NET SAVINGS

The methods used to determine net savings for downstream programs are provided in the Evaluation Framework,[42] which discusses the common methods to determine freeridership and spillover in downstream programs. Freeridership is a measure of the savings that participants would have achieved on their own in the absence of the program; these savings are subtracted from verified gross savings.

42 Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase II Energy Efficiency and Conservation Programs.* Page 56. Prepared by GDS Associates, Inc., and Nexant. June 1, 2014.

Participant spillover, on the other hand, credits additional savings that participants achieved on their own, where their experience with the program was highly influential in their decision to install energy-efficient equipment without the incentive of rebates. Participant spillover adds to gross savings.

Net savings are determined only for future program planning purposes. Energy savings and demand reduction compliance targets are met using verified gross savings.

### 4.3.1 Net-to-Gross Ratio Methodology

Cadmus used information collected from self-report surveys with participating customers in the Custom Incentive Program to determine freeridership. *Addendum B. Net Savings Common Approach* provides additional detail about the net savings methodology and survey questions used for this analysis.

### 4.3.2 Net-to-Gross Ratio Sampling

Cadmus conducted a telephone survey with Custom Incentive Program participants in PY7. In many instances, multiple custom projects were initiated or completed by the same customer. This required Cadmus to generate a sample of unique decision-makers to ensure no customer contact was called more than once. Cadmus generated the final sample following these steps:

- Identify unique decision-maker phone numbers and contact information.
- Remove accounts contacted in the past three months for a PPL Electric Utilities or Cadmus survey effort.
- Remove accounts with in-progress, reserved, or cancelled Custom Program projects.

After completing these steps, the final sample frame contained 49 unique decision-makers representing 78 projects (Table 4-10). Cadmus attempted to contact all 49 and completed surveys with 24 unique participants representing 26 projects. However, three surveyed participants did not answer the NTG questions; therefore, the NTG analysis was based on completed surveys with 21 unique decision-makers representing 23 projects.

**Table 4-10: PY7 Custom Incentive Program Sampling Strategy for NTG Research**

| Stratum | Stratum Boundaries | Population Size[1] | Assumed Cv or Proportion in Sample Design | Assumed Levels of Confidence & Precision | Target Sample size | Number of Records Selected for Sample Frame[2] | Achieved Sample Size[3] | Percent of Sample Frame Contacted to Achieve Sample[4] |
|---|---|---|---|---|---|---|---|---|
| **Participants** | **Telephone** | **82** | **0.5** | **85/15** | **15** | **78** | **21** | **100%** |

[1] Represents number of paid projects in PY7.
[2] Removed four record from the population because they participated in another survey in the last three months..
[3] Twenty-four unique respondents completed surveys about 26 facilities. Three of the respondents did not answer the net analysis questions and are not included in this table.
[4] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means the percentage of the sample frame called to complete surveys.

### 4.3.3 Net-to-Gross Ratio Findings

#### 4.3.3.1 Freeridership

In PY7, surveys with 21 companies representing 23 projects indicated 39% freeridership, as shown in Table 4-11. The overall PY7 freeridership is weighted by each surveyed participant's verified energy savings at the property discussed in the survey. This ensures that respondents whose properties achieved higher energy savings have greater influence on the freeridership estimate than do properties that achieved lower energy savings.

**Table 4-11: Custom Incentive Program Summary of Evaluation Results for NTG Research**

| Stratum | Number of Survey Respondents | Verified kWh/yr Savings Represented | Percentage of Total Verified Program Savings | Estimated Freeridership [1] | Estimated Participant Spillover | NTG Ratio | Observed Cv or Proportion | Relative Precision 90% C.L. | Relative Precision 85% C.L. |
|---|---|---|---|---|---|---|---|---|---|
| PY5 Sample | 11 respondents (14 projects) | 1,474,508 | 27% | 45% | 0% | 0.55 | 0.12 | 22% | 19% |
| PY6 Sample | 13 respondents (15 projects) | 2,934,016 | 13% | 61% | 0% | 0.39 | 0.12 | 21% | 18% |
| PY7 Sample | 21 respondents (23 projects) | 9,162,948 | 31% | 39% | 0% | 0.61 | 0.10 | 18% | 15% |
| [1] Estimate is weighted by the survey sample-verified program kWh/yr savings. | | | | | | | | | |

The PY7 NTG analysis sample is the largest of the three program years presented in Table 4-11 above. PY7 net impacts are derived solely from PY7 respondents. For the PY6 net impact results report, Cadmus combined the individual PY6 and PY5 survey analyses presented in Table 4-11 above to increase the sample size and to account for project variability. It used a savings weighted freeridership estimate of 55% that encompassed both PY6 and PY5 survey respondents for PY6 net impact reporting because it was a more applicable estimate of freeridership for the program.

In PY6, freeridership was 61% and the NTG ratio was 39%. Freeridership improved in PY7 to 39% and the NTG ratio was 61%.

In PY7, 15 of 21 respondents (71%) reported a contractor or consultant provided the most assistance in the design of the project and their savings weighted freeridership estimate was 35%. Five out of 21 (24%) respondents reported someone within their company provided the most assistance in the design of the project and their savings weighted freeridership estimate was 50%. Previous knowledge about the program may have influenced the way the contractor or consultant designed or sold the project. Cadmus did not assess program influence among contractors and consultants in the PY7 evaluation but plans to do this in the Phase III evaluation.

Cadmus compared the freeridership and distribution of savings across PY6 and PY7 respondents who stated they would have been *very likely* to complete the project without the incentive from PPL Electric Utilities. As shown in Table 4-12, eight of 15 PY6 respondents and nine of 21 PY7 respondents indicated they would have been *very likely* to complete the project without the incentive from PPL Electric Utilities.

Table 4-12 also shows three key metrics—average weighted freeridership, percentage of total surveyed projects, and percentage of analysis sample verified savings—all of which decreased by 10% from PY6 to PY7. This drop in freeridership indicates the program population, measures installed, and factors influencing their decisions to participate may have changed from PY6 to PY7.

Survey respondents who completed compressed air projects in PY7 had a lower freeridership compared to surveyed PY6 compressed air participants; these projects were a main driver in the decrease in freeridership from the PY6 sample to the PY7 sample. Notably, in the PY6 sample, the percentage of compressed air projects among survey respondents was 54% (7 out of 13) with a weighted freeridership estimate (by verified energy savings) of 60%. In PY7, the percentage of compressed air projects among survey respondents was 45% (9 out of 21) with a freeridership estimate (weighted by energy savings) of 11%, a 47% drop from the PY6 sample estimate.

**Table 4-12: Custom Incentive Program Freeridership Comparison of PY7 and PY6 Key Respondent Group**

| Stratum | Likelihood to Complete Project without PPL Electric Incentive | Number of Respondents | Weighted Freeridership[1] | Percentage of Total Surveyed Projects | Percentage of Analysis Sample Verified Savings |
|---|---|---|---|---|---|
| PY6 Sample | Very likely | 8 of 13 | 70% | 54% | 76% |
| PY7 Sample | Very likely | 9 of 21 | 54% | 43% | 39% |

Source: Survey question G8, "How likely is it that your business would have paid the full cost to complete the exact same project at the same time without the rebate from PPL Electric Utilities? Would you say… [READ LIST]?"
[1] Estimate is weighted by the survey sample's verified kWh/yr savings.

The freeridership scores of the four survey respondents with the largest savings was another factor driving the program-level freeridership decrease from PY6 to PY7:

- In PY7, the savings-weighted freeridership score was 44% for the four largest projects represented in the survey. These projects represented 65% of the analysis sample's savings. The four projects accounted for 28 percentage points of the program-level freeridership estimate of 39%.
- In PY6, the savings-weighted freeridership score was 65% for the four largest projects in the survey. These projects represented 67% of the analysis sample's savings. The four projects accounted for 44 percentage points of the program-level freeridership estimate of 61%.

#### 4.3.3.2 Spillover

One PY7 respondent reported installing other energy-efficient equipment since participating in the program and reported participation in the Custom Incentive Program was *very influential* in the purchasing decision. The respondent converted existing lights to LEDs but did not know how many. Although there were potential energy savings associated with this action, Cadmus could not quantify these savings attributable to spillover.

## 4.4 PROCESS EVALUATION

### 4.4.1 Research Objectives

The process evaluation compared Custom Incentive Program operations to its intended design and identified gaps between expected outcomes and actual results. The main issues concerned the program's delivery infrastructure, technical support, and customer response.

### 4.4.2 Evaluation Activities

For the Custom Incentive Program, the PY7 process evaluation activities were these:

- Interviews with program and ICSP staff (n=2)
- Participant surveys (n=24 unique participants representing 26 properties)

The research activities were consistent with the PY7 evaluation plan. Plans from the last annual report to interview contractors and other project designers and to conduct additional benchmarking research to investigate eligibility requirements of other custom programs will be conducted in Phase III.

Table 4-13 summarizes the survey sampling strategy for the Custom Incentive Program for PY7.

**Table 4-13: PY7 Custom Incentive Program Process Evaluation Sampling Strategy**

| Stratum | Stratum Boundaries | Population Size | Assumed Proportion or CV in Sample Design | Assumed Levels of Confidence & Precision | Target Sample Size | Number of Records Selected for Sample Frame | Achieved Sample Size | Percent of Population Frame Contacted[1] | Evaluation Activities |
|---|---|---|---|---|---|---|---|---|---|
| PPL Electric Utilities Program and ICSP Staff | Staff | 2 | N/A | N/A | 2 | 2 | 2 | 100% | Process, Impact, Program Staff Interview, Census |
| Participants | Online | 82 | N/A | N/A | All eligible | 49[2] | 24 [3] | 100% | Process, Participant Survey, Census |
| | Telephone | 82 [4] | 0.50 | 85/15 | 15 | 49 [2] | | 100% | Process, Impact, Participant Survey, Census |
| **Program Total** | | | | | | | **26 [2]** | | |

[1] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means the percentage of the sample frame called to complete interviews
[2] The final sample frame includes unique records. After selecting all unique records, Cadmus removed any records from the population if they participated in survey in the last three months.
[3] Between both online and telephone methodologies, 24 unique respondents represented 26 facilities. Three completed the telephone and online questions, three completed the online questions only, and 18 completed the telephone surveys only. The questions addressing net savings were administered to the 21 unique respondents (21 properties) who completed the telephone survey.
[4] This represents projects, not unique contacts.

### 4.4.3 Methodology

#### 4.4.3.1 Interviews with Program and ICSP Staff

Cadmus conducted interviews with the program managers at PPL Electric Utilities and the ICSP in February 2016. The interviews focused on key performance indicators and implementation successes and challenges.

#### 4.4.3.2 Participant Surveys

Cadmus offered both online and telephone surveys to broaden participation and sample size (three respondents representing five projects took both surveys). Both survey instruments asked identical questions about satisfaction. The telephone survey also asked questions to assess net savings.[43]

Cadmus fielded the online customer satisfaction surveys from February until June 2016 and the telephone net savings surveys in July 2016. For both surveys, Cadmus removed records of any customers who had completed another PPL Electric Utilities or Cadmus survey in the past three months.

Because some customers completed multiple custom projects, Cadmus generated a final survey sample of unique decision-makers to ensure that no customer was contacted more than once for the same survey. The final survey sample contained all unique decision-makers from the participant group. Details about sample attrition and the outcome of each record are contained in *Addendum A. Participant Survey Methodology*Addendum A. Participant Survey Methodology.

Potential sources of survey bias include nonresponse, recall, and social desirability biases. Cadmus addressed these by applying survey design and survey data collection best practices. Survey questions were not leading or ambiguous, were not double-barreled, and provided clear interviewing and programming instructions so that they were implemented consistently.

Cadmus attempted to reach all unique customers who participated in the Custom Incentive Program. All respondents with e-mail addresses received an initial survey invitation and two reminder e-mail invitations. It called respondents five times over several days at different times of the day and scheduled callbacks when possible.

The response rate between both online and telephone (49%; 24 of 49) was reasonable representing 35% of verified savings; therefore, Cadmus assumed that possible nonresponse bias was minimal.

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43 Three respondents (five properties) completed both the online and telephone survey questions, 18 respondents (18 properties) completed only the telephone survey, and three respondents (14 properties) completed only the online survey. The questions addressing net savings were administered to the 21 unique respondents (21 properties) who completed the telephone survey.

### 4.4.4 Achievements Against Plan

Table 4-14 contains the program's plans for energy savings and incentives and the program's progress.

**Table 4-14: Custom Incentive Program Savings**

| | PY5 Verified | PY6 Verified | PY7 Only | | | Phase II: PY5–PY7 | | |
|---|---|---|---|---|---|---|---|---|
| | | | Planned | Verified | Percentage of Planned | Planned[1] | Verified | Percentage of Planned |
| MWh/yr | 5,394 | 21,894 | 23,682 | 29,564 | 125% | 62,793 | 56,852 | 91% |
| MW | 0.48 | 2.57 | 3.9 | 4.341 | 111% | 10.30 | 7.39 | 72% |
| Participants [2] | 56 | 69 | N/A | 82 | N/A | 233 | 207 | 89% |

[1] PPL Electric Utilities' revised EE&C plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, Table N6, p. 126, Table P6, p. 144, and Table Q6, p. 154.
[2] Beginning in PY6 Q1, the methodology for counting participants for the Custom Incentive Program changed. The participant count is the number of jobs contributing to reported savings for the specified period and not the number of projects created in that period.

The program reached its planned MWh/yr and MW savings for PY7 but did not reach planned savings for Phase II. These are the reasons the program did not reach planned savings for Phase II:

- Products were verified with lower than expected savings from initial application (for large stratum projects) and lower than reported (for small stratum projects).
- Several projects that commenced in Phase II were not fully installed or commissioned until the start of Phase III. Those project's savings could not count toward PY7 and Phase II planned savings.

### 4.4.5 Program Delivery

Overall, the Custom Incentive Program ran smoothly in PY7. Customers were satisfied with the program (satisfaction improved over PY6). The program exceeded the PY7 planned MWh/yr and MW savings.

Survey respondents suggested that the program could be improved with more communication regarding the timing of each step and the availability of funding. Respondents thought the ICSP was helpful in answering questions. Both the ICSP and the PPL Electric Utilities program manager believed communication worked well and had a positive impact on the overall success of the program.

#### 4.4.5.1 Key Performance Indicators

In addition to planned energy savings, PPL Electric Utilities' only other key performance indicator was to have at least 80% of participants report that they are very satisfied with the program (rating satisfaction as a 8, 9, or 10 on a 10-point scale). This is measured through the survey question, *"Thinking about your overall experience with the program, how would you rate your satisfaction using a 1 to 10 scale where 10 means* outstanding *and 1 means* unacceptable*?"*

Overall, 87% of survey respondents (n=23) rated their satisfaction as an 8, 9, or 10, exceeding the goal for satisfaction.

Additionally, PPL Electric Utilities and the ICSP monitor other metrics—the number of applications received, the number of preapproved projects, the number of projects paid, and the number of projects expected to be paid in the following months. There are no goals for these metrics but they are reviewed at least monthly.

### 4.4.6 Participant Profile

Over half of the survey participants (66%; n=24) had participated in the Custom Incentive Program before and five of 24 worked with an energy services company (ESCO) in a performance contract for their project.

Fifteen (79%) of the 19 who answered said they owned the facility where the project was implemented. Seven (64%) of the 11 who answered said the heated and cooled space of their facilities was over 100,000 square feet. Nine (60%) of the 15 who answered said the facility had more than 50 employees.

Table 4-15 lists the types of projects customers completed in PY7.

**Table 4-15: Distribution of Types of Projects**

| Measure Description | Number of Projects | Percentage of Population (n=82) |
|---|---|---|
| Air Compressors | 17 | 21% |
| Process | 16 | 20% |
| Refrigeration | 14 | 17% |
| Controls | 10 | 12% |
| Cooling and Heating | 9 | 11% |
| VFDs and Motors | 5 | 6% |
| Equipment Upgrades | 4 | 5% |
| Other [1] | 3 | 4% |
| System Upgrades | 3 | 4% |
| Pumping | 2 | 2% |

[1] Other includes air handling, economizer, and other.
Source: EEMIS

### 4.4.7 Satisfaction

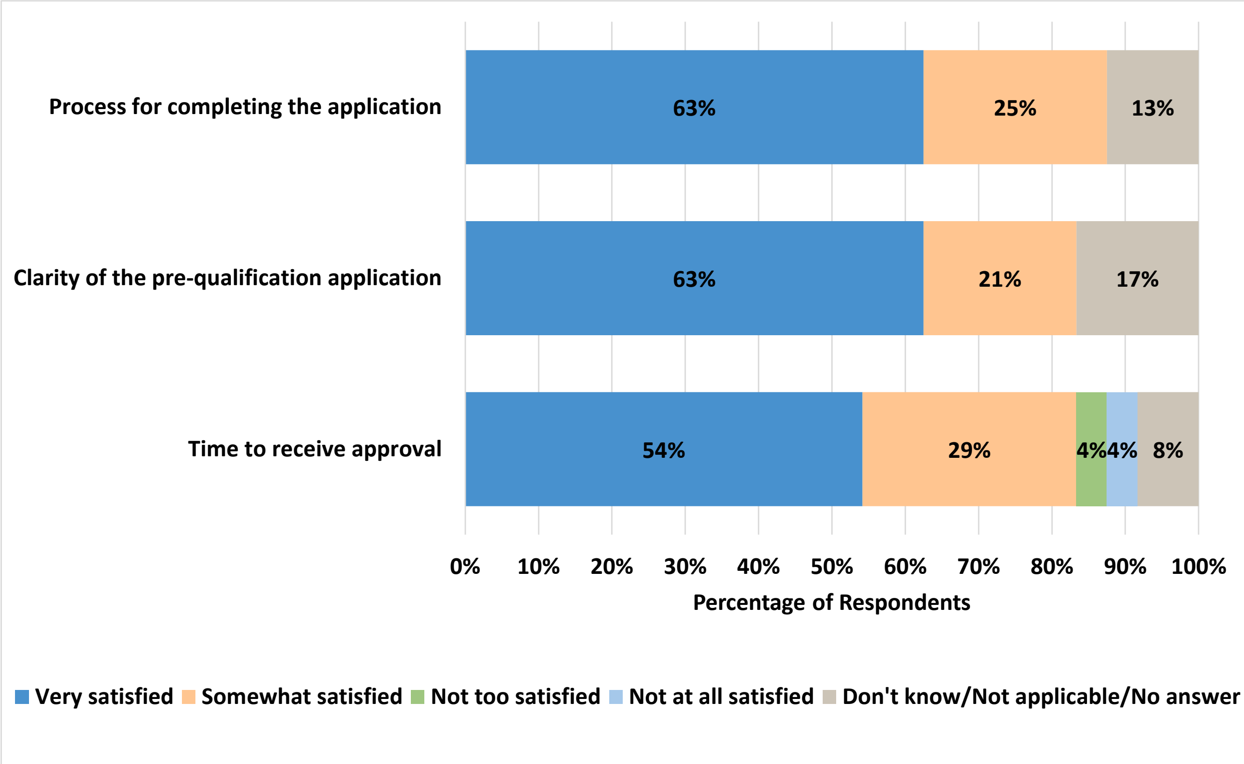
Cadmus asked questions about satisfaction with the application process, program requirements and process, the ICSP, PPL Electric Utilities, and the program overall in both the online and telephone surveys. Results are reported in this section. Because respondents could skip questions if they did not want to answer them, not all respondents provided an answer to every question. Some additional questions were only in the telephone survey; the number of participants responding varies by question.

#### 4.4.7.1 Application Process

*Participants*

Most respondents were *very* or *somewhat satisfied* with each aspect of the application process (Figure 4-1).

**Figure 4-1: Satisfaction with Application Process**

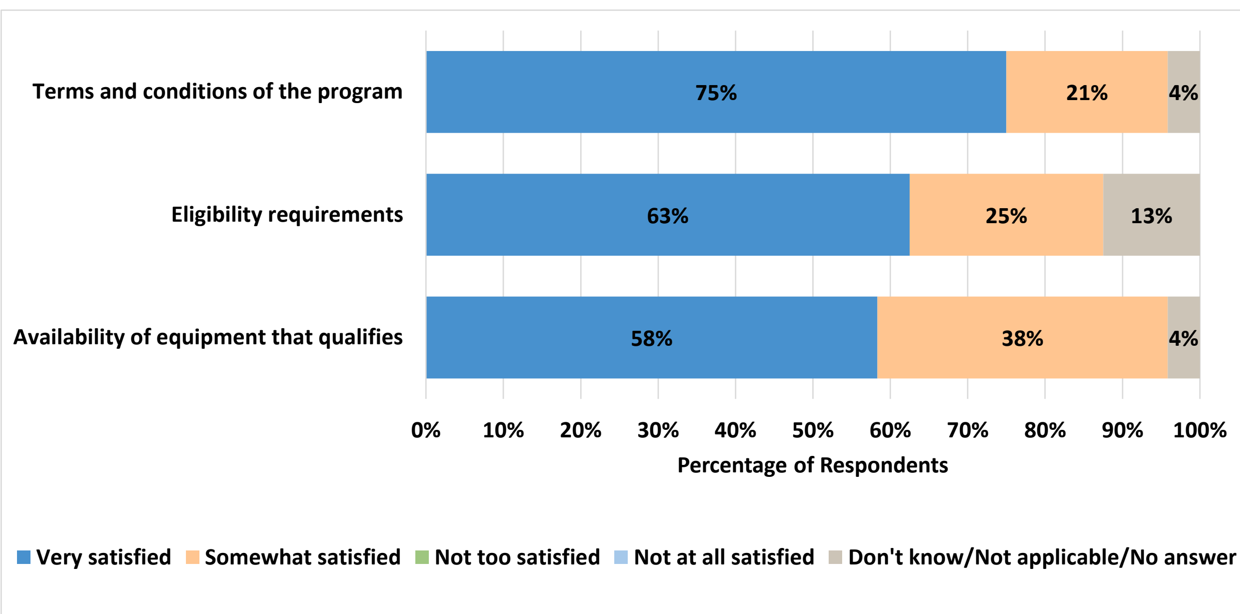



Source: Survey question D1, "Please rate your satisfaction with the following:" (n=24)

### 4.4.7.2 Program Requirements and Process

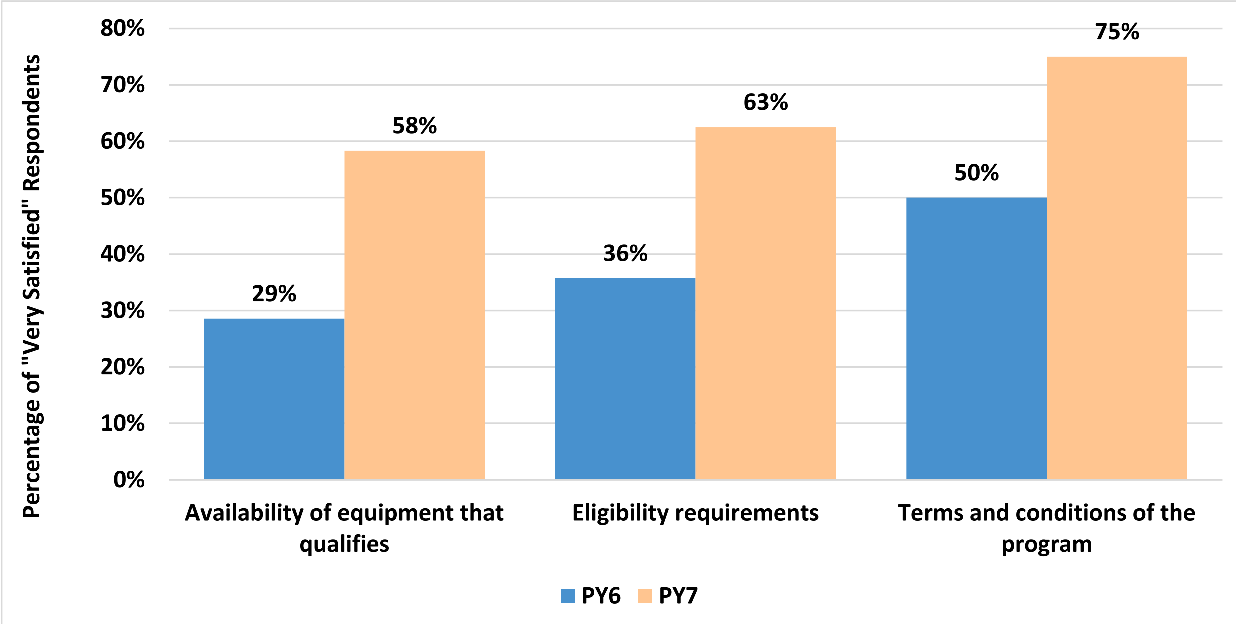
Respondents answered questions about their satisfaction with the program requirements and process. They were most satisfied with the terms and conditions of the program and least satisfied with the availability of eligible equipment that qualified for a rebate (Figure 4-2).

**Figure 4-2: Program Requirement Satisfaction**




Source: Survey question D1, "Please rate your satisfaction with the following:" (n=24)

**Figure 4-3: Program Requirement Satisfaction in PY6 and PY7**

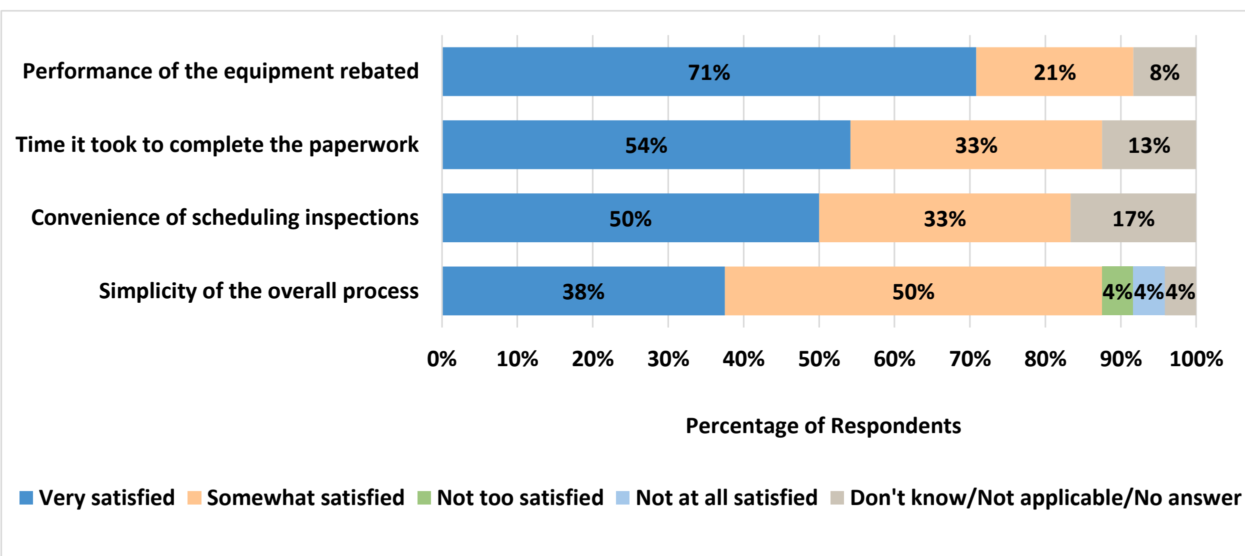



Source: Survey question D1, "Please rate your satisfaction with the following:" Represents respondents who said *very satisfied*. (PY6 n=14 and PY7 n=24)

Overall, respondents were most satisfied with the equipment they installed. Seventy-one percent (n=24) said they were *very satisfied* (Figure 4-4). This percentage of respondents was the same in PY7 as in PY6 (Figure 4-5).

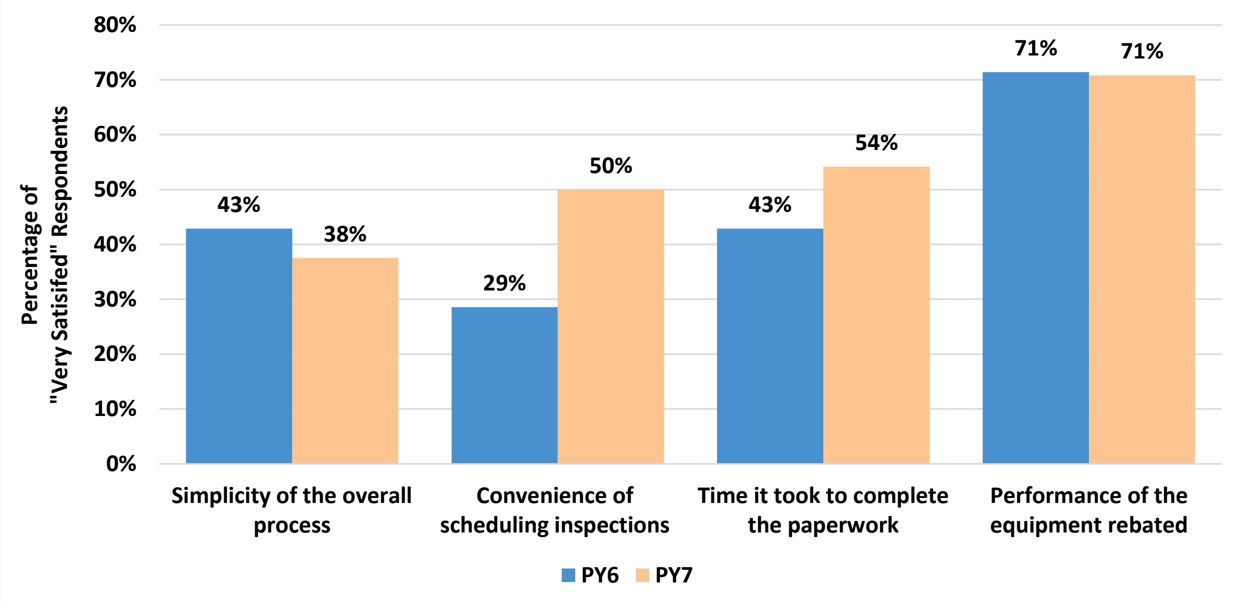
In PY7, respondents were least satisfied with the simplicity of the overall process (38% said *very satisfied*; n=24), a drop from the 43% in PY6 (n=14) shown in Figure 4-5, though this difference was not statistically significant. The percentage of respondents who were *very satisfied* with the convenience of scheduling inspections (50%) and the time it took to complete the paperwork (54%) improved in PY7 from PY6, though this difference was not statistically significant.

**Figure 4-4: Process Satisfaction**




Source: Survey question D1, "Please rate your satisfaction with the following:" (n=24)

**Figure 4-5: Process Satisfaction in PY6 and PY7**

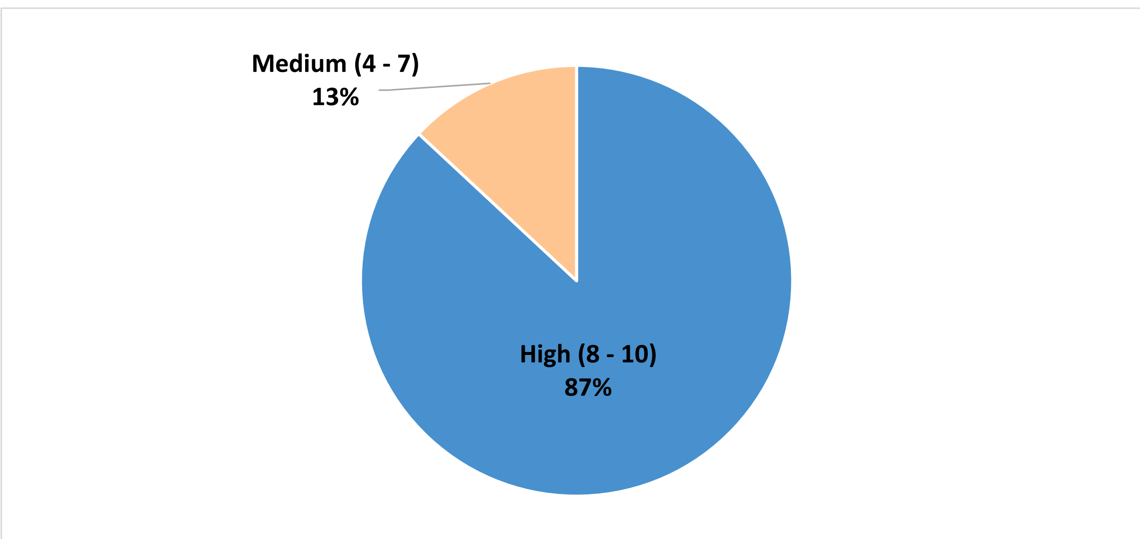



Source: Survey question D1, "Please rate your satisfaction with the following:" (PY6 n=14 and PY7 n=24) Includes respondents who said they were *very satisfied*.

#### 4.4.7.3 Overall Satisfaction

Overall, most participants were satisfied with the Custom Incentive Program (Figure 4-6). Eighty-seven percent (n=23) rated their satisfaction as high (8, 9, or 10 on a 10-point scale),[44] an increase from the 75% (n=11) in PY6. This difference is not statistically significant.

**Figure 4-6: Overall Program Satisfaction**




Source: Survey question, "Thinking about your overall experience with the program, how would you rate your satisfaction using the same 1 to 10 scale where 10 means "outstanding" and 1 means "unacceptable"? (n=23)

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44 Using a 1 to 10 scaled where 10 means *outstanding* and 1 means *unacceptable.*

**Satisfaction with PPL Electric Utilities**

Overall satisfaction with PPL Electric Utilities as a provider of electric service was good. Twelve survey respondents who answered this question (75%; n=16) rated their satisfaction as 8 or higher on a 10-point scale.[45] Satisfaction has increased since PY5 (54%; n=13) and PY6 (69%; n=13).

When asked if their opinion of PPL Electric Utilities had changed since participating in the Custom Incentive Program, 14 respondents out of 24 (58%) said their opinion had not changed. One said their opinion had *improved significantly,* and six said it had *improved somewhat.* One respondent said it had *decreased somewhat* because the requirement for light metering is time-consuming and complicated. Two respondents did not answer or did not have an opinion.

### 4.4.8 Areas Working Well

Throughout the survey, respondents provided comments about what was working well with the program. One respondent said that once the project started there were no delays. Another said PPL Electric Utilities was very easy to work with, and another said the experience was seamless because of the efforts of the contractor hired to help with the projects. One respondent said that although their company was slow at moving through the application steps, the ICSP contacted them and helped them move through the application process.

### 4.4.9 Suggestions for Improvement

Respondents provided comments about how PPL Electric Utilities and the ICSP could improve the program. The top suggestion was to provide better communication about timing and to complete the review of materials and application steps more quickly (7 responses from 13 respondents). Four comments related to providing more options for rebated equipment. Three comments related to the wait list; two people wanted more information about the availability of funding and one person wanted PPL Electric Utilities to adjust the way the customers were approved through the waitlist.

Thirteen respondents suggested these improvements:[46]

- Provide better communication about timing and improve the timing of inspections, application steps, and approval processing (7 responses)
- Include more options for rebated equipment, such as LED projects, and for process changes to make facilities more efficient (4 responses)
- Provide more information and clarity about the waitlist, timing and availability of funds (2 responses), and adjust the waitlist so that projects are automatically rolled to next funding cycle according to the wait list (1 response)
- Remove metering requirements for lighting projects (2 responses)
- Increase the types of projects receiving flat rebates, such as premium efficiency motors or VFDs (1 response)
- Offer higher rebate amounts (1 response)

45 Using a 1-to-10 scale where 10 means *outstanding* and 1 means *unacceptable.*

46 Respondents could provide multiple responses to this question so the total number of responses exceeds the number of respondents.

### 4.4.10 Equipment Purchase

During the telephone surveys (n=21), Cadmus asked participants about the equipment they purchased and installed. The most common reasons participants purchased the equipment was to replace old or outdated equipment (9 responses), to reduce energy costs and save money (7 responses), and to make improvements to existing systems (4 responses).

The most common reasons for choosing the exact model of equipment was the size or fit (6 responses), the brand of equipment (5 responses), and a recommendation from the contractor (5 responses). Other reasons were energy efficiency, equipment reliability, to meet the demand of the facility, service contract, and price.

Fifteen facilities (n=21) replaced existing equipment. Of these, one respondent said the equipment had failed and was not working, five said the equipment was in working condition with no problems, and eight said the equipment had problems but was still working. Five of the respondents (n=24) said the equipment was scheduled for replacement before their company decided to participate, and 15 said it was not. One did not know, and three did not answer the question.

### 4.4.11 Influence on Design

Respondents answered questions about what prompted them to starting thinking about their projects, when they started designing their projects, and who was involved in the design process. Most respondents said they began thinking about their projects because of staff recommendations or other internal observations (7 of 21). Four respondents said it was because a contractor or energy consultant recommended it, three said it was because they wanted to increase efficiency, two began thinking about the project following an audit, two said it was part of a company initiative, one started thinking about it after hearing about the rebate, and one wanted to reduce demand.

Nine of the 21 respondents (43%) began thinking about their projects in 2013 or earlier; 11 started thinking about their projects in 2014 through 2016. One respondent did not know when the company began thinking about the project.

Fifteen of 21 respondents said their contractor, vendor, or distributor provided the most assistance in designing their energy efficiency project. Sixteen of the 21 respondents said their contractor, vendor, or consultant provided information about the payback or possible savings potential from the project.

When deciding to complete the project, the most important criteria about whether the project would go forward was the return on investment (7 of 21), energy costs and operating costs (4 responses), and initial costs (2 responses).

## 4.5 CONCLUSIONS AND RECOMMENDATIONS

Overall, the program has been operating well. Customers have been satisfied, the program exceeded the PY7 planned MWh/yr and MW savings, and freeridership was reduced in PY7.

Based on the findings, Cadmus suggests that PPL Electric Utilities consider these recommendations in Phase III.

**Conclusion**

Participant satisfaction has improved. In PY7, 87% of survey respondents (n=23) were *very satisfied* with the program.[47] This exceeded PPL Electric Utilities' key performance goal of 80% overall customer satisfaction. Respondents generally believed that PPL Electric Utilities and the ICSP were helpful in answering questions, but they expressed some concern about communication. Customers suggested that PPL Electric Utilities and the ICSP provide more information about the progress of their application and about the availability of funding (see Sections 4.4.7, 4.4.8 and 4.4.9).

**Recommendation**

These are two ways customer satisfaction may be improved:

- Although PPL Electric Utilities has clarified the online information outlining the steps of the application process on its website, Cadmus recommends that it add a system for customers to track the progress of their application in real time. Customers could check progress and could follow up with PPL Electric if they had any specific concerns about an upcoming requirement or milestone.
- PPL Electric Utilities specified when the program initiated a waitlist on its website, but more detail about the process could improve overall customer satisfaction. PPL Electric Utilities could consider adding more information about the waitlist so customers would know what to expect during this period. This information could include a summary of how PPL Electric Utilities would use the waitlist, what customers should do while the waitlist was in effect, when and how customers would hear from PPL Electric Utilities when the waitlist ended, and when funding was expected to be available.

**Conclusion**

The small sample custom project realization rate, while acceptable overall, varied widely for individual projects. There is a variety of reasons for the discrepancy between reported and verified savings because of the wide range of measures that are eligible for an incentive under the Custom Incentive Program (see Sections 4.2.3 and 4.2.5).

**Recommendation**

Based on the evaluation findings for small sample projects, the following actions may help reduce or continue to reduce the discrepancy between reported and verified savings (realization rate) and should be implemented or continued for future phases of the program:

- Consider allowing the evaluator to review standard calculators used to determine *ex ante* savings in the Custom Incentive Program for projects in the small stratum. The evaluator could then determine if the correct conceptual (e.g., code or *in situ*) baseline is being used and that there is no inherent bias in the *ex ante* approach. Although the evaluator would not typically use the same calculators, the review should help align *ex ante* and *ex post* savings.
- Continue to have the ICSP request evaluator support to determine if certain projects that fall below the 500,000 kWh/yr threshold should be elevated to the large stratum if there is a high amount of

47 Rated their satisfaction as 8, 9, or 10 on a 1 to 10-point scale, where 10 means *outstanding* and 1 means *unacceptable.*

uncertainty in the measure, baseline, or calculation approach. This is a recommendation for new technologies or overly complicated measures.

- Consider allowing for the review of data collection protocols between the ICSP and the evaluator, particularly with compressed air and HVAC system measures. Both parties would then understand the data typically required to determine savings for installed measures by all other stakeholders. This is most important for the duration of collected data, which needs to represent the typical measure operation (e.g., metering a weather-dependent chilled water plant operation in a non-cooling season).

### 4.5.1 Status of Recommendations for Program

Table 4-16 contains the status of each PY7 process recommendation made to PPL Electric Utilities.

**Table 4-16: Custom Incentive Program Status Report on Process and Impact Recommendations**

| Recommendations | EDC Status of Recommendation (Implemented, Being Considered, Rejected AND Explanation of Action Taken by EDC) |
|---|---|
| **Custom Incentive Program** | |
| Consider providing customers with a tool to track the real time progress of their application through each application milestone | Implemented. |
| Consider providing additional detail regarding the waitlist and what customers should expect during this period | Being considered – Currently no waitlist for Phase III, but will consider this if a waitlist is implemented. |
| Consider allowing the evaluator to review standard calculators to determine if correct baseline is being used | Implemented. |
| Continue to request evaluator support to determine if certain projects that fall below the 500,000 kWh/hr threshold should be elevated to the large stratum when there is high uncertainty in the measure, baseline, or calculation approach for new or overly complicated measures. | Implemented. |
| Consider allowing for the ICSP and evaluator to review data collection protocols collaboratively | Implemented. |

## 4.6 FINANCIAL REPORTING

A breakdown of the Custom Incentive Program finances is presented in Table 4-17.

**Table 4-17: Summary of Custom Incentive Program Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs[6] ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs (Sum of rows 2 to 4) | $15,248 | $22,306 |
| 2 | EDC Incentives to Participants | $2,695 | $3,817 |
| 3 | EDC Incentives to Trade Allies | - | - |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $12,552 | $18,489 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6, 7, 8, 9, 10 ) | $931 | $2,822 |
| 6 | Design & Development | $0 | $0 |
| 7 | Administration, Management, and Technical Assistance[1] | $931 | $2,822 |
| 8 | Marketing[2] | $0 | $0 |
| 9 | EDC Evaluation Costs | $0 | $0 |
| 10 | SWE Audit Costs | $0 | $0 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | $0 | $1,699 |
| | | | |
| 12 | Total TRC Costs[3] (Sum of rows 1, 5 and 11) | $16,178 | $26,827 |
| 13 | Total NPV Lifetime Energy Benefits | $18,358 | $32,385 |
| 14 | Total NPV Lifetime Capacity Benefits | $1,944 | $3,004 |
| 15 | Total NPV O&M Saving Benefits | $0 | ($0) |
| 16 | Total NPV TRC Benefits[4] | $20,302 | $35,390 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | 1.25 | 1.32 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.
[2] Includes the marketing CSP and marketing costs by program CSPs.
[3] Total TRC Costs includes Total EDC Costs and Participant Costs.
[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.
[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[6] Phase II Costs in this table are discounted back to PY5, thus will not match cumulative costs reported in the PY6 Q4 quarterly report

# ADDENDUM A. PARTICIPANT SURVEY METHODOLOGY

## Contact Instructions

PPL Electric Utilities provided contact instructions for conducting surveys for the Custom Incentive Program. Customers cannot be contacted for a survey until three months have passed since they completed their last survey (with PPL Electric Utilities or Cadmus).[48] They cannot be contacted for a survey if they have opted out of a survey or have asked not to be contacted again. Telephone survey calls cannot take place on Sundays or national holidays.

Researchers called participants at different times of day and different days of the week to increase the probability of contact. Researchers attempted surveys with potential respondents up to five times each.

## Sample Cleaning and Attrition

Cadmus coordinated with PPL Electric Utilities' survey subcontractor to screen the sample provided by the ICSP and remove the records of customers contacted in the past three months (whether for a Cadmus survey or a PPL Electric Utilities survey) and who requested not to be contacted again.

In the Custom Incentive Program, multiple custom projects were completed by the same customer so Cadmus generated a final survey sample of unique decision-makers to ensure that no customer was contacted more than once for the online survey. This cleaning and survey sample preparation process reduced the available sample. Cadmus contacted all remaining records. Table 4-18 lists the total number of unique records included in the contact list and the outcome (final disposition) of each record.

**Table 4-18: Sample Attrition Table**

| Description of Call Outcomes | Number of Records |
|---|---|
| **Population** | **82** |
| Removed duplicate contacts | 33 |
| **Unique contacts** | **49** |
| Removed because completed in past three months | 1 |
| **Survey Sample Frame (sent to survey subcontractor)** | **48** |
| **Records Attempted** | **48** |
| Refused to complete survey | 5 |
| Remaining non-final records | 19 |
| **Completed survey** | **24** |

48 This policy changed in April of 2016. Prior to this, Customers could not be contacted for a survey until one year passed since they completed their last survey (with PPL Electric Utilities or Cadmus).

# ADDENDUM B. NET SAVINGS COMMON APPROACH

Cadmus used self-report surveys to assess net savings for the Custom Incentive Program, following the Evaluation Framework's recommended common method for assessing freeridership. The SWE team reviewed and approved the survey prior to fielding.[49]

The assessment includes two components of freeridership—intention to implement an energy-efficient project without a rebate and influence of the program in the decision to implement the energy-efficient project. When scored, each component has a value ranging from zero to 50 and a combined total freeridership score ranging from zero to 100.

## Intention

*Intention* is assessed through several brief questions used to determine how the project likely would have differed if the respondent had not received the program assistance. These questions focused on the project with the largest energy savings.

### *Intention Survey Questions*

A1. Prior to participating in PPL Electric Utilities' Custom Incentive rebate program, was the entire cost of the purchase and installation of the [PROJECT DESCRIPTION] included in your company's capital budget?
*Yes, no, don't know, refused*

A2. Had your organization ALREADY planned and designed your project BEFORE your organization heard about the PPL Electric Utilities rebates?
*Yes, no, don't know, refused*

A3. Which of the following is most likely what would have happened if you had not received the rebate from PPL Electric Utilities for [REBATE1]?
*Canceled or postponed the project at least one year; Reduced the size, scope, or efficiency; Done the exact same project [no change] on the same schedule; Don't know; Refused*

[ASK IF A3= 2]

A4. By how much would you have reduced the size, scope, or efficiency? Would you say a…[READ LIST]
*Small amount or reduced by less than 20%; Moderate amount or reduced by 20% to 50%; Large amount or reduced by over 50%; Don't know; Refused*

[ASK IF A3= 2]

A5. Please describe what your company would have reduced about the size, scope, or efficiency of the project.
*[RECORD ANSWER]; Don't know; Refused*

## Influence

*Influence* is assessed by asking about how much influence – from 1 (no influence) to 5 (extreme influence) – various program elements had on the decision to do the project the way it was done. The items selected for rating were specific components of the Custom Incentive Program.

[49] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase II Energy Efficiency and Conservation Programs*. Prepared by GDS Associates, Inc., and Nexant. June 1, 2014.

### *Influence Survey Questions*

A6. I'm going to read a list of items about the program. Please rate each item on how much influence it had on the decision to complete the project the way it was completed. Please use a scale from 1, meaning no influence, to 5, meaning the item was extremely influential in your decisions. [RANDOMIZE STATEMENTS]

| Item | No influence | | | | Extremely influential | Don't know | Not applicable |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 98 | 96 |
| a. PPL Electric Utilities staff such as your Key Account Manager | | | | | | | |
| b. E-power Solutions | | | | | | | |
| c. PPL Electric Utilities rebates for the equipment | | | | | | | |
| d. PPL Electric Utilities' marketing | | | | | | | |
| e. PPL Electric Utilities' information about energy efficiency | | | | | | | |
| f. Your company's decision making structure | | | | | | | |
| g. Past participation in a PPL Electric Utilities program | | | | | | | |
| h. Custom Incentive Program pre-approval process | | | | | | | |
| i. The contractor or vendor who helped design your project | | | | | | | |
| j. The consultant who helped design your project | | | | | | | |
| k. The payback period | | | | | | | |

A7. Was there anything else that was highly influential in your decision to complete the project in the way that you did?
*[RECORD:________________________]; Don't know / don't recall*

[ASK EVERYONE]
A8. How likely is it that your business would have paid the full cost to complete the exact same project at the same time without the rebate from PPL Electric Utilities? Would you say… [READ LIST]
*Very likely; Somewhat likely; Not too likely; Not at all likely; Don't know; Refused*

A9. Was your company considering any other energy efficiency projects that could have been implemented **instead** of the project that received funding from PPL Electric Utilities?
*Yes, no, don't know, refused*

***[ASK IF 0=1]***
A10. How did the assistance from PPL Electric Utilities influence which project was implemented?
*[RECORD ANSWER]; Don't know; Refused*

***[ASK IF 0=1]***
A11. Using the same scale of 1 to 5, with 1 meaning no influence, to 5 meaning the item was extremely influential in your decision, please rate how much influence the assistance from PPL Electric Utilities that you just described had on **which** project was implemented?
*[RECORD ANSWER]; Don't know; Refused*

# 5 RESIDENTIAL ENERGY-EFFICIENCY BEHAVIOR & EDUCATION PROGRAM

PPL Electric Utilities began offering the Residential Energy-Efficiency Behavior & Education Program in Phase I of Act 129. After a hiatus in PY5, the program launched again in the middle of PY6 and continued through PY7. The program informed customers about their home energy consumption and encouraged them to adopt energy-saving home improvements and behaviors. Customers received a home energy report sent by mail every other month. Each report provided a summary of the customer's household energy use, a neighbor comparison of energy use, and three energy-saving action steps. Customers with valid e-mail addresses also received the home energy reports via e-mail every month.[50] The program did not provide any financial incentives to participants who received the home energy reports.

The program used an experimental design, called a randomized control trial (RCT), wherein eligible customers were randomly assigned to either a treatment group (recipients of home energy reports) or a control group (non-recipients). The control group was not aware of the home energy reports and functions as a comparison group for measuring the treatment group's energy savings resulting from the program.

The objectives of the Residential Energy-Efficiency Behavior & Education Program were these:[51]

- Provide customers with a home energy report that encourages them to adopt energy-efficient behaviors, install energy-efficient products, and become more aware of how their behavior and practices affect their energy usage
- Educate customers about free or low-cost products and behavior changes that may reduce energy consumption
- Educate customers about PPL Electric Utilities' online resources
- Promote other PPL Electric Utilities energy efficiency programs
- Obtain participation of approximately 128,000 customers through 2016, with a total reduction of approximately 31,000 MWh/yr

A summary of Phase II program metrics is presented in Table 5-1. Opower, the ICSP, reported 39,786 MWh/yr of energy savings in PY7. Cadmus verified 39,078 MWh/yr of energy savings and reported a total resource cost (TRC) ratio of 2.50.

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50 The e-mailed home energy reports feature only the neighbor comparison. These e-mailed reports, because they are sent monthly, are intended to provide more current information on neighbor energy use than can be provided in the two-month intervals of the paper reports.

51 Program objectives are stipulated in PPL Electric Utilities' revised EE&C Plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, p.67.

**Table 5-1: Phase II Residential Energy-Efficiency Behavior & Education Program Summary**

| Program | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Net-to-Gross Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) | Program Acquisition Cost ($/Annual kWh) | Cost of Conserved Energy[1] (TRC $/kWh) | Phase II Participants [2] |
|---|---|---|---|---|---|---|---|---|---|
| Residential Energy-Efficiency Behavior & Education | 39,786 | 39,786 | 39,078 | 1.00 | 2.50 | $2,463 | $0.06 | $0.035 | 126,290 |
| **Total** | **39,786** | **39,786** | **39,078** | **1.00** | **2.50** | **$2,463** | **$0.06** | **$0.035** | **126,290** |

[1] Total TRC costs divided by levelized lifetime kWh savings.
[2] Number of participants at the beginning of PY7, including opt-outs and households that went inactive at some point during PY7.

## 5.1 PROGRAM UPDATES

Because of its strong savings performance in PY6, the program ceased delivery of the home energy reports at the end of the second quarter (Q2) of PY7. As a result, treatment group customers received around three paper reports by mail and five e-mail reports in PY7.

### 5.1.1 Definition of Participant

Participants were defined as residential customers who received at least one paper home energy report during PY7 and constituted the treatment group. Customers who opted out of the program in a previous year and have active accounts were still considered treated customers and were included in the treatment group counts.[52]

The treatment and control groups were divided into two legacy waves and one expansion wave. The legacy waves contained customers who were part of the program since Phase I, and the expansion wave contained customers new to the program in Phase II.

Three waves received the home energy reports through PY7:

- Legacy Wave 1 received first report in PY2, April or May 2010.
- Legacy Wave 2 received first report in PY3, June 2011.
- Expansion Wave received first report in PY6, October or December 2014.

In PY7, the Residential Energy-Efficiency Behavior & Education Program sent home energy reports to just over 126,000 homes.[53] These participants received at least one home energy report in PY7. The program did not add any new wave cohorts in PY7 (2015). Table 5-2 shows the PY7 program design, report delivery frequency, and number of customers.

52 Control group customers did not receive home energy reports but were assigned a treatment start date matching the treatment customers in that wave, reflecting the date they would have received their first home energy report had they been in the treatment group. Control group customers who were still active in PY7 were included in the billing analysis but did not count toward the total number of "treatment days" used to aggregate per-customer daily savings to the PY7 level.

53 The treatment group had 126,290 active participants who received home energy reports in the beginning of PY7 (June 2015).

**Table 5-2: PY7 Residential Energy Efficiency Behavior & Education Program Design**

| Group and Wave | Year First Launched | Delivery Frequency from Q1 to Q2 [1] | Number of Customers at Start of PY7 [1] |
|---|---|---|---|
| **Treatment Group** | | | |
| Legacy Wave 1 | 2010 | Three paper reports; five monthly e-mail reports | 37,472 |
| Legacy Wave 2 | 2011 | Three paper reports; five monthly e-mail reports | 42,907 |
| Expansion Wave | 2014 | Three paper reports; five monthly e-mail reports | 45,911 |
| **Total Treatment Group** | | | **126,290** |
| **Control Group** | | | |
| Legacy Wave 1 | 2010 | - | 37,577 |
| Legacy Wave 2 | 2011 | - | 19,441 |
| Expansion Wave | 2014 | - | 11,922 |
| **Total Control Group** | | | **68,940** |
| [1] Number of participants at the start of PY7. Excludes participants for which Cadmus did not receive billing data as well as participants who became inactive before the beginning of PY7. | | | |

## 5.2 IMPACT EVALUATION GROSS SAVINGS

### 5.2.1 Reported Gross Savings

The ICSP reported gross energy savings of 39,786 MWh/yr across all waves combined in PY7 at the sector level, as presented in Table 5-3. Cadmus followed the behavioral protocol assumption from the SWE that behavioral programs have a one-year measure life.[54] As such, Phase II savings reflect only the savings that occurred in PY7.

**Table 5-3: PY7 Residential Energy-Efficiency Behavior & Education Program Reported Results**

| Wave | Participants[1] | Adjusted Gross Energy Savings (MWh/yr) | Incentives ($1,000) |
|---|---|---|---|
| **PY7 Total** | 148,305 | 39,786 | $0 |
| [1] Cadmus derived this number from the PY7 savings data provided by the ICSP. This count of customers was provided by the ICSP, separately from the billing and tracking data. Counts for the billing and tracking data are presented in Table 5-2. The count of customers in the ICSP savings data is not the same as the count of customers in the billing and tracking data. | | | |

### 5.2.2 Database Review

Cadmus reviewed the database of PPL Electric Utilities residential and low-income customers assigned to either the treatment group or control group (and across all waves) to ensure that EEMIS data matched the ICSP's program tracking data. Cadmus did not separate the database review between the residential and low-income behavior program customers because the EEMIS data did not include a field to denote in which program the customer was included; Cadmus used a field in the ICSP data to identify customers' program and waves.

54 The Phase III Evaluation Framework's Behavioral Protocol assumption states: "To date, the PUC has not prescribed the measure life for behavioral programs and has identified persistence of behavioral savings as an area of investigation for the Phase III SWE team to inform targets and reporting protocols for future phases of Act 129. Unless an alternative EUL was submitted and approved in a Phase III EE&C plan, EDCs should report annual savings consistent with the status-quo assumed one-year measure life." Pennsylvania Public Utility Commission. *Phase III Evaluation Framework*. June 9, 2016. See Section 1.1.9.

The match rate was high; however, Cadmus found a discrepancy in the ICSP's program tracking data—the data did not include 8,587 of the records present in EEMIS. After thoroughly investigating its database, the ICSP discovered the upload to EEMIS had duplicated a number of accounts after assigning unique identifiers (account IDs). Ultimately, the ICSP left these duplicate EEMIS records out of the billing analysis and final estimate of savings. Cadmus determined that the most accurate data came from the ICSP's program tracking and billing files, so it also did not include the duplicate EEMIS records in its billing analysis and calculation of evaluated *ex post* savings.

Table 5-4 summarizes the findings of the database review.

**Table 5-4: Low-Income and Residential Energy-Efficiency Behavior & Education Program Database Review**

| Source | Population Size | Evaluation Activities |
|---|---|---|
| EEMIS[1] | 372,232 | Database Review, Census, Impact |
| ICSP Program Tracking Data[2] | 363,645 | Database Review, Census, Impact |
| **Difference** | **8,587** | Determined these were duplicate records and excluded these from analysis |
| **Program Total** | **363,645** | |

[1] Includes all records in EEMIS in the residential and low-income behavior and education program, including customers whose accounts became inactive. The EEMIS data did not include a field to denote in which program the customer was included; Cadmus used a field in the ICSP data to identify customers' program and waves.
[2] Includes all records in the program tracking data provided by the ICSP, including customers whose account became inactive.

Cadmus also found that some treatment customers (less than 1%) did not appear to have received the home energy reports at the same time as the rest of their wave. The ICSP explained that it was not possible to generate home energy reports for these treatment customers for a number of possible reasons including data "staleness," data incompleteness, or extremely low usage.[55] The ICSP's database has a field titled "first generated date," which confirmed that the treatment group customer was mailed a home energy report. In some instances; however, the ICSP's database system did not generate a date in this field and therefore did not mail out any home energy reports even though the customer was assigned to the treatment group.

In a randomized control trial, it is important to maintain the randomization of customers into treatment and control groups to control for the expected variation between customers. To preserve the randomization, Cadmus decided to leave these customers in the billing analysis and final savings estimation. Including these customers likely slightly dampened the estimate of average savings per customer but did not affect the estimate of the program savings.

Table 5-5 shows the number of treatment and control group homes by wave and the number of customer accounts used in each step of the savings estimation.

The difference in population counts between the customer accounts in the billing analysis and the number of PY7 participants reflects the program's attrition rate through time. All customers who had at least 12 months of billing data prior to the start of the treatment were included in the billing analysis dataset. However, as time progressed, some customers became inactive or opted out of the program and their bills stopped being collected by the ICSP. By the start of PY7, just over 83% of the original customer accounts had bills.

55 Personal communication with the ICSP. August 4, 2016.

**Table 5-5: PY7 Residential Energy-Efficiency Behavior & Education Program Impact Evaluation Sampling Strategy**

| Stratum | Strata Boundaries | Customer Accounts in Billing Analysis[1] | Evaluation Activity | PY7 Participants [2] | Evaluation Activity |
|---|---|---|---|---|---|
| Legacy Wave 1 | Treatment group customers who received first reports in PY2 | 48,539 | Regression analysis to estimate program treatment effect (decrease in average daily consumption) | 37,472 | Estimate program *ex post* corresponding to PY7 program participants |
| | Control group customers | 48,536 | | 37,577 | N/A |
| Legacy Wave 2 | Treatment Group customers who received first reports in PY3 | 52,636 | Regression analysis to estimate program treatment effect (decrease in average daily consumption) | 42,907 | Estimate program *ex post* corresponding to PY7 program participants |
| | Control group customers | 23,876 | | 19,441 | N/A |
| Expansion Wave | Treatment group customers who received first reports in PY6 | 48,274 | Regression analysis to estimate program treatment effect (decrease in average daily consumption) | 45,911 | Estimate program *ex post* corresponding to PY7 program participants |
| | Control group customers | 12,538 | | 11,922 | N/A |
| **Program Total** | **Treatment and control group customers** | **234,399** | | **195,230** | |

[1] Population includes all customers who were part of the randomized control trial and had at least 12 months of billing data prior to the start of treatment. The number of customer accounts included in the billing analysis is not necessarily the same as the count of PY7 Participants due to attrition. Customer accounts that became inactive *prior* to the beginning of PY7 are not included in the count of PY7 participants. However, these customers are retained in the billing analysis. (See footnote 58).
2] Population was calculated in the beginning of PY7 and includes all customers who were part of the randomized control trial and were active during PY7, including customers who became inactive at some point during PY7.

### 5.2.3 EM&V Sampling Approach

PPL Electric Utilities contracted with the ICSP to select eligible customers for the program and to produce and distribute the home energy reports. Cadmus provided the random assignment of the eligible customers to the treatment or control group for Phase II.

To estimate the energy savings, Cadmus analyzed the monthly consumption of PPL Electric Utilities customers for the census of treatment group and control group homes. Cadmus analyzed the energy use of Legacy Wave 1 between June 2009 and May 2016, Legacy Wave 2 between May 2010 and May 2016, and Expansion Wave between October 2013 and May 2016.

The impact evaluation's estimate of energy savings included the savings of homes that received at least one home energy report during PY7, including those who opted out of the program and homes whose accounts became inactive during the treatment period.[56] The estimate of energy savings did not include

56 Homes that opted out of the program were kept in the analysis sample to preserve the equivalence of the treatment and control groups. In order to remove opt-out homes, Cadmus would have to know which control group homes would have opted out if they had received a report and to drop these homes. Also, even homes that opted out of the pilot may have saved energy because of the program.

homes that went inactive or opted out before the beginning of PY7. Table 5-6 shows the number of treatment and control group homes included in the billing analysis.

**Table 5-6: PY7 Final Estimation Sample: Number of Homes by Group and Wave**

| Group | Legacy Wave 1 | Legacy Wave 2 | Expansion Wave |
|---|---|---|---|
| Treatment Group Homes | 37,472 | 42,907 | 45,911 |
| Control Group Homes | 37,577 | 19,441 | 11,922 |
| **Total Homes[1]** | **75,049** | **62,348** | **57,833** |

[1] Cadmus analyzed the monthly energy consumption bills of the census of the treatment and control group homes in PY7. Savings estimate included savings during all months with an active account in homes whose accounts became inactive during PY7. See *Appendix G: Energy-Efficiency Behavior & Education Program Savings Counted in Other Energy Efficiency Programs*.

### 5.2.4 *Ex Ante* Savings Methodology and Findings

The ICSP determined gross savings of 39,786 MWh/yr in PY7, based on regression analysis of monthly energy use of treatment and control group homes. Cadmus did not make any adjustments to the PY7 reported *ex ante* savings; therefore, adjusted *ex ante* savings are the same at 39,786 MWh/yr.

The ICSP reported *ex ante* demand savings of 39.2 MW/yr in PY7. Cadmus did not adjust *ex ante* demand savings.

### 5.2.5 *Ex Post* Savings Methodology and Findings

Cadmus used regression analysis of customer average daily consumption to estimate the electricity savings. Cadmus confirmed the number of customers in each wave and number of days in the treatment period. It then employed regression analysis of customer average daily electricity consumption using the approach of Allcott and Rogers (2014),[57] as recommended in the Statewide Evaluator's Program Year Six Annual Report.[58] This conforms with the Uniform Methods Protocol and the IPMV Option C.[59]

Savings estimates were expected to be unbiased because of the randomized assignment of eligible homes to treatment and control groups. Although the savings (treatment effect) was small relative to annual energy consumption, the regression analysis could detect it because the study groups were large and the analysis included billing data from all treatment and control customers. The details of the regression analysis are fully described in *Appendix M: Residential and Low-Income Energy-Efficiency Behavior & Education Program Impact Analsyis*.

Before evaluating savings, Cadmus analyzed pre-treatment average daily energy consumption in the treatment and control groups to ensure that the groups were balanced using a t-test of the difference in

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57 Allcott, Hunt, and Todd Rogers. 2014. "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation." *American Economic Review*, 104(10): 3003-37.

58 Pennsylvania Public Utility Commission. *Act 129 Statewide Evaluator Annual Report.* Prepared by GDS Associates, Inc., Research into Action, and Apex Analytics, LLC. Final Report, March 8, 2016. Available online: http://www.puc.state.pa.us/Electric/pdf/Act129/SWE_PY6-Final_Annual_Report.pdf

59 Efficiency Valuation Organization. *International Performance Measurement & Verification Protocol (IPMVP); Concepts and Options for Determining Energy and Water Savings: Volume 1*. September 2009. EVO 10000 – 1:2009. Available online: www.evo-world.org. Cadmus approach is also consistent with the SEE Action Network and DOE UMP protocols. See State and Local Energy Efficiency Action Network. 2012. *Evaluation, Measurement, and Verification of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations*. Prepared by A. Todd, E. Stuart, S. Schiller, and C. Goldman.

means. A p-value greater than 0.10 indicates that the groups are well balanced due to adequate randomization as there is *no* statistically significant evidence that the mean pre-treatment period consumption of the two groups was different at the 90% confidence level. Conversely, a p-value less than 0.10 suggests that there *is* a statistically significant difference between the groups' means and the random assignment may not have resulted in a well-balanced groups.

As shown in Table 5-7, no significant differences existed between the pre-treatment consumption of treatment and control groups in each wave.

**Table 5-7: T-Tests to Confirm Balance in Treatment and Control Groups**

| Statistic | Legacy Wave 1 | Legacy Wave 2 | Expansion Wave |
|---|---|---|---|
| Treatment Group Pre-Treatment Period Annual Consumption (kWh) | 18,530 | 27,393 | 23,205 |
| Control Group Pre-Treatment Period Annual Consumption (kWh) | 18,465 | 27,490 | 23,205 |
| Difference (kWh) | 66 | -97 | 0 |
| Percentage Difference | 0.4% | -0.4% | 0.0% |
| t-value | 1.5 | 1.4 | 0 |
| p-value (Pr>t) | 0.15 | 0.16 | 1.00 |

### 5.2.6 Savings Realization Rate Methodology

Cadmus calculated the realization rate for the program as the ratio of *ex post* verified gross savings to *ex ante* reported savings. Cadmus did not calculate a realization rate for each wave separately because the reported *ex ante* savings appeared in EEMIS for the program as a whole, and not for each wave.

### 5.2.7 Summary of Evaluation Results

#### 5.2.7.1 Energy Savings Estimation

Table 5-8 shows the program energy savings and realization rate in PY7. Note that EEMIS did not provide reported savings by wave; therefore Table 5-8 shows reported savings only at the program level. The ICSP reported program gross energy savings of 39,786 MWh/yr, which represents the 12-month period between June 2015 and May 2016. Cadmus estimated the *ex post* verified savings as 39,078 MWh/yr, which provided a realization rate of 99.7% in PY7. The 85% confidence interval for the *ex post* verified savings (the range from 34,902 MWh/yr to 43,254 MWh/yr) included the ICSP's reported savings, meaning the estimates were not statistically different.

**Table 5-8: PY7 Residential Energy-Efficiency Behavior & Education Program Summary of Evaluation Results for Energy**

| Stratum | PYTD Reported Gross Energy Savings (MWh/yr) | PYTD Adjusted *Ex Ante* Energy Savings (MWh/yr) | Energy Realization Rate (%) | PYTD Verified Gross Energy Savings (MWh/yr) | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 85% C.L.[1] |
|---|---|---|---|---|---|---|
| Legacy Wave 1 | - | - | - | 11,091 | 0.1025 | 14.76% |
| Legacy Wave 2 | - | - | - | 16,807 | 0.1229 | 17.69% |
| Expansion Wave | - | - | - | 11,180 | 0.1511 | 21.75% |
| Original Reported | 39,786 | 39,786 | - | - | - | - |
| **Program Total** | **39,786** | **39,786** | **99.7%** | **39,078** | **N/A** | **10.69%** |

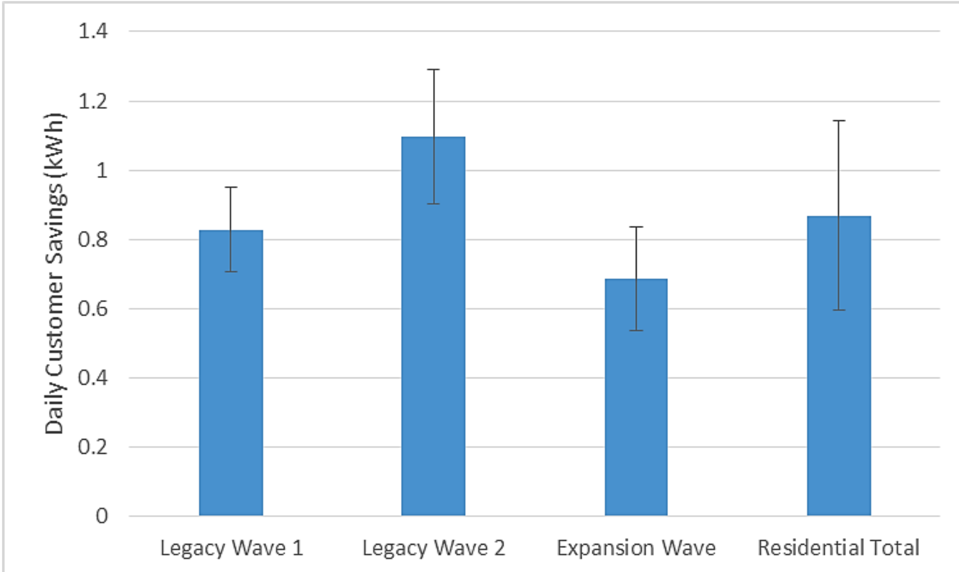
[1] This evaluation analyzed the census of randomized control trial treatment and control group homes; therefore, the final savings estimate was not subject to sampling error. Verified gross energy savings were based on regression analyses of monthly average daily consumption. Standard errors were adjusted for correlation over time in each customer's consumption using Huber-White robust standard errors.

The three waves yielded differing levels of energy savings in PY7, in terms of per-customer average kWh savings, normalized per-customer percentage savings, and total aggregated savings. The next three figures show these differences at the wave level

Figure 5-1 shows that Legacy Wave 2 had the highest per-customer average daily savings rates, at nearly 1.1 kWh, and the Expansion Wave had the lowest at 0.69 kWh. Across the three waves, the program's mean per-customer daily savings rate was 0.87 kWh. These differences in average kWh daily savings were most probably driven by a combination of factors, including the number of years customers in the wave had received home energy reports and the customers' mean annual consumption before the program began. Research and past studies have shown that savings ramp up through time and customers who use more energy have a greater potential to save.[60]

60 Cadmus. "Long-Run Savings and Cost-Effectiveness of Home Energy Report Programs." Winter 2014-15. Available online: http://www.cadmusgroup.com/papers-reports/long-run-savings-cost-effectiveness-home-energy-report-programs/.

**Figure 5-1: Per-Customer Average Daily Savings (kWh) by Wave**

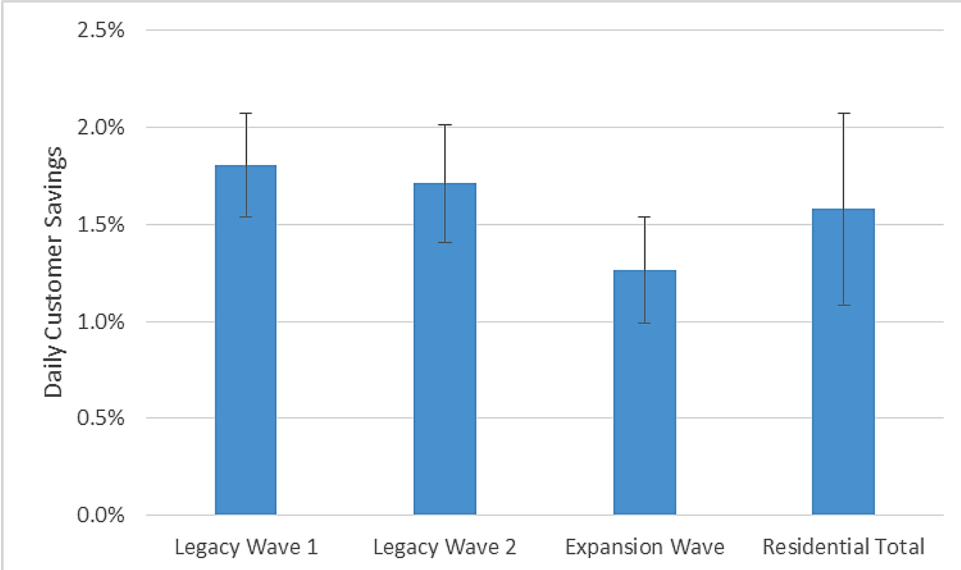



The program total is the mean per-customer daily savings, weighted by the waves' sum of treatment days, defined as the sum of all Treatment Group customers' number of days they were active (i.e., exposed to the treatment effect of the home energy reports) in PY7. The error bars represent the 85% confidence interval surrounding the point estimates.

Figure 5-2 shows the estimates of savings normalized by each wave's baseline usage.[61] It is useful to compare the waves' savings on a consumption-normalized basis to see how they compare in the *relative* magnitude of savings. Generally, the three waves saved within the expected 1% to 3% range for home energy reports programs with a weighted average of 1.58%. The two legacy waves' percentage savings were closely aligned when the daily per-customer savings were normalized by the waves' control group usage. Although Legacy Wave 2 saved more daily energy in kWh terms, its baseline was also higher (Figure 5-1 above). The Expansion Wave still showed the lowest daily savings, though it was the most recently added wave in the program.

[61] Cadmus defined the waves' baseline energy usage as the control group's daily mean consumption (kWh) in PY7, that is, the customers' typical consumption in the absence of the program.

**Figure 5-2: Per-Customer Percent Savings by Wave**



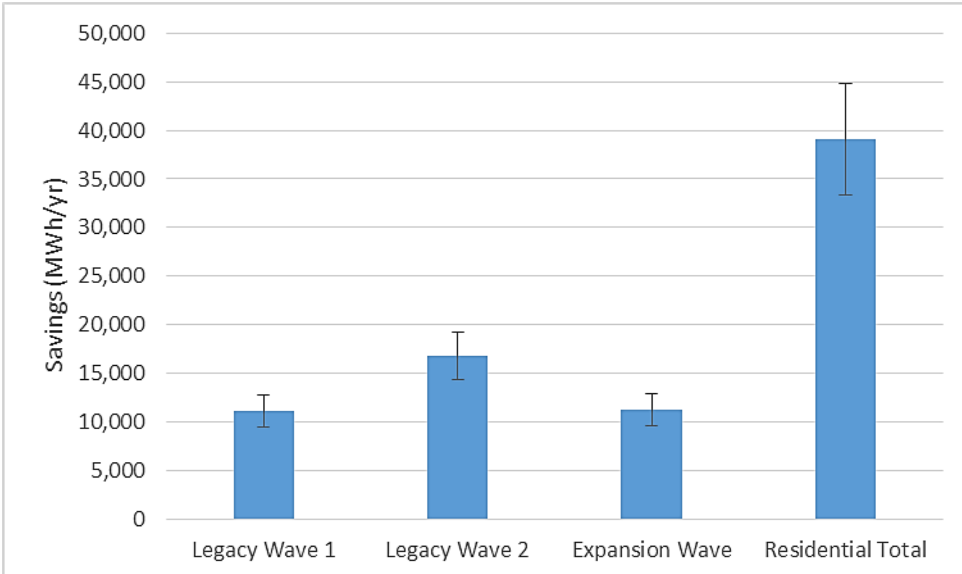

Cadmus calculated percentage savings as the quotient of daily savings (kWh) over the baseline daily usage, defined as mean Control Group customers' daily consumption (kWh) in PY7. The program total is the mean per-customer daily savings, weighted by the waves' sum of treatment days, defined as the sum of all Treatment Group customers' number of days they were active (i.e., exposed to the treatment effect of the home energy reports) in PY7. The error bars represent the 85% confidence interval surrounding the point estimates.

Figure 5-3 shows the total PY7 *ex post* savings by wave, estimated as the product of per-customer daily savings and total number of days across customers that treatment group customers had active accounts in PY7. Because the Legacy Wave 2 had the highest per-customer daily kWh savings, it follows that this wave also had the highest total savings. Although Legacy Wave 1 had higher per-customer savings than the Expansion Wave, it had more than 8,000 fewer treatment group customers, making the two waves' total savings nearly identical, at 11,090 MWh/yr for Legacy Wave 1 and 11,180 MWh/yr for the Expansion Wave. As shown in Table 5-8 above, the total savings is 39,078 MWh/yr for the three waves.

Cadmus also evaluated the savings for these three waves over time to determine if there was a ramp-up trend, any seasonal effects, and any ways that savings generally persisted or decayed. The next three figures show the monthly energy savings for each wave.

Generally, the waves appeared to have a ramp-up savings trend in their first program year, in which treatment groups began to adopt more energy-efficient behaviors than control group customers. After six to 12 months of treatment, the waves appeared to have reached a plateau in savings, at which point savings have hovered seasonally for the remainder of the treatment. For Legacy Wave 1 and Legacy Wave 2, Cadmus also observed that savings decayed during the period in PY5 in which treatment group customers stopped receiving home energy reports.

**Figure 5-3: Total Savings by Wave**




Cadmus calculated total savings by wave as the product of per-customer daily savings and total treatment days. The error bars represent the 85% confidence interval surrounding the point estimates.

Figure 5-4 shows positive energy savings throughout the course of the Legacy Wave 1, with savings fluctuating cyclically and periods of highest energy savings concurring with periods of peak energy consumption in the summer and winter.

**Figure 5-4: Legacy Wave 1 Monthly Savings over Time**

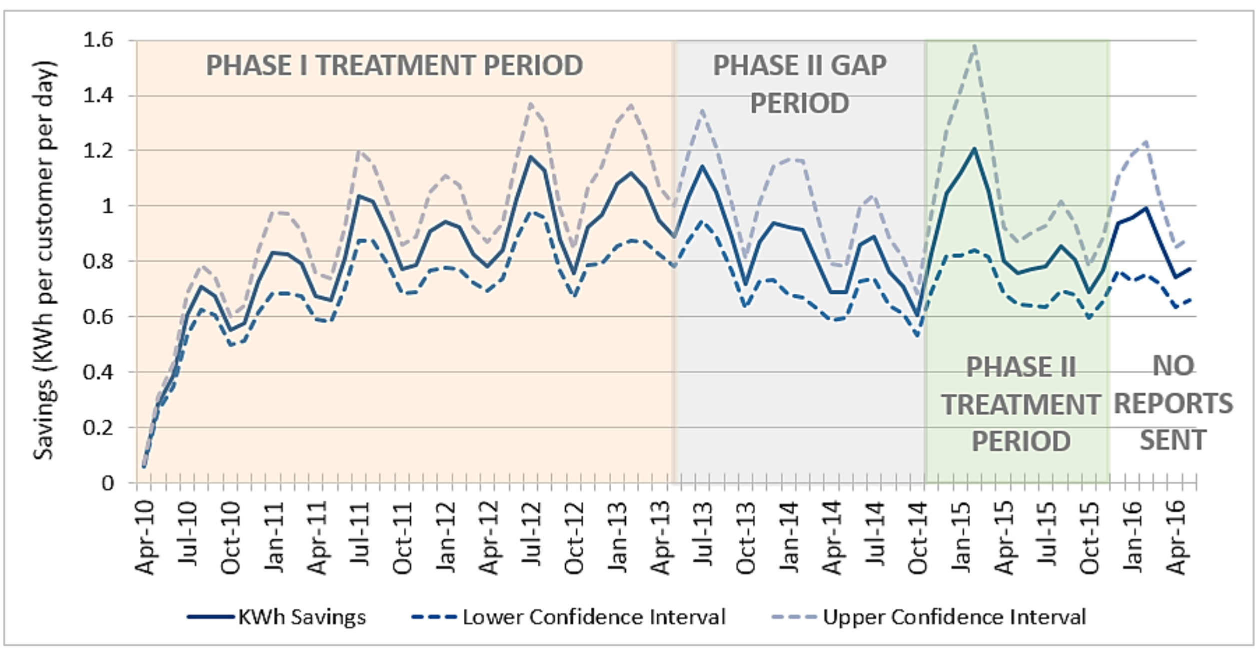
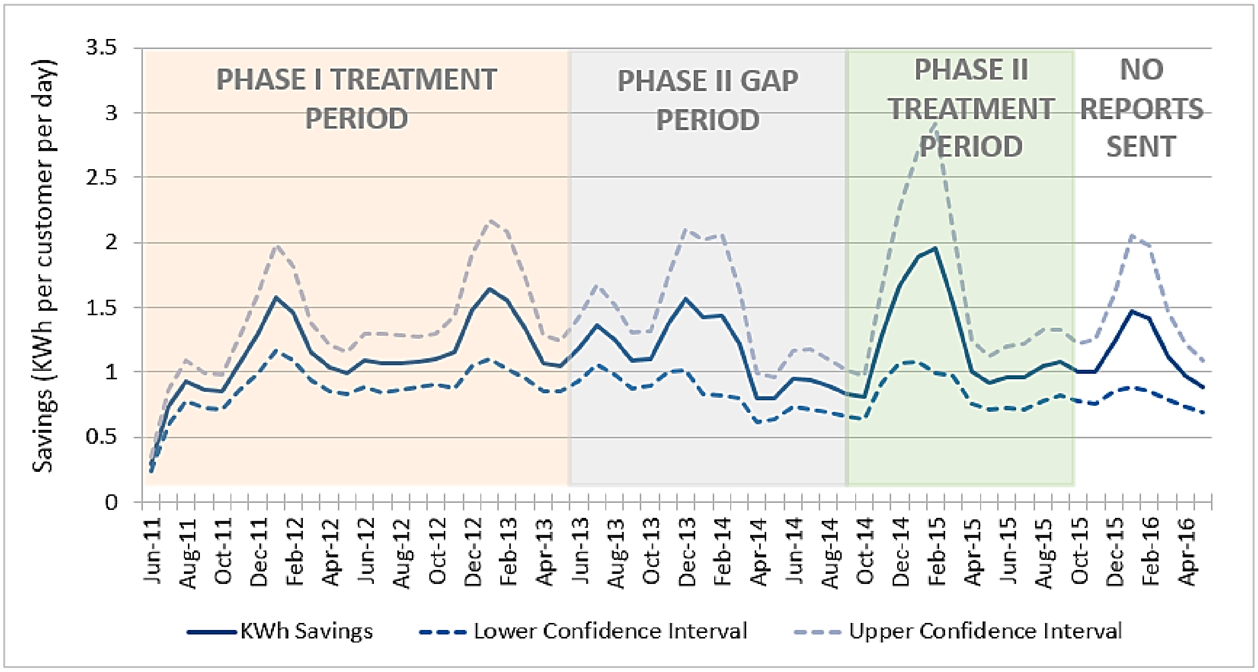


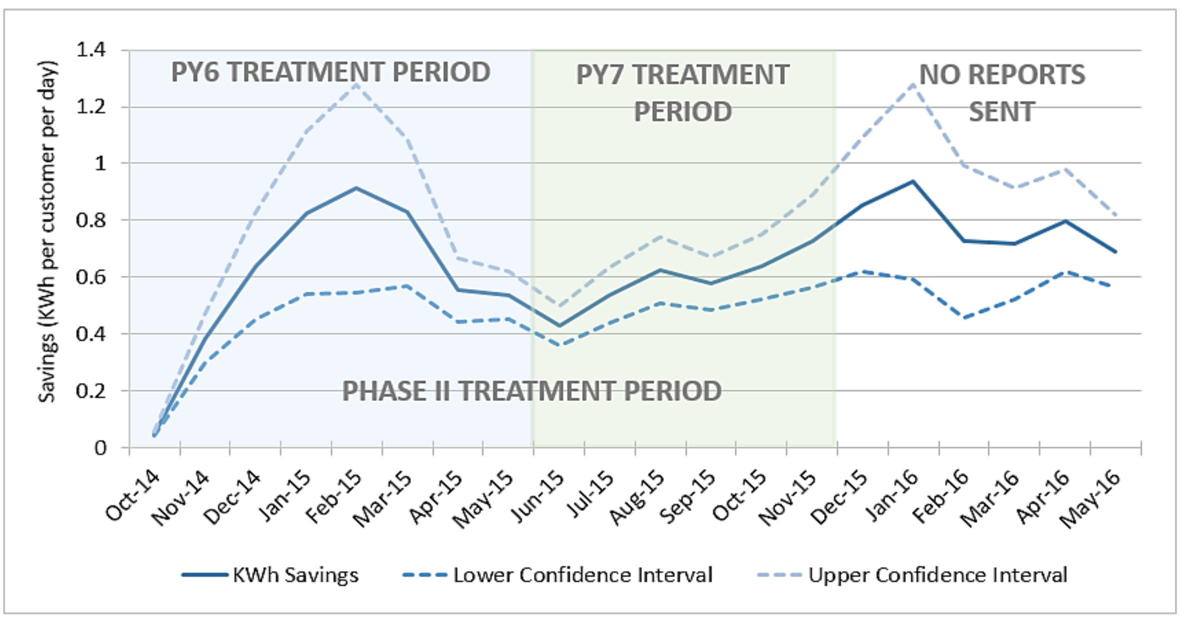

Figure 5-5 shows positive energy savings throughout the course of the Legacy Wave 2, with savings fluctuating cyclically but with periods of highest energy savings concurring with periods of peak energy consumption primarily in the winter.

**Figure 5-5: Legacy Wave 2 Monthly Savings over Time**




As shown in Figure 5-6, savings in the Expansion Wave follow a similar pattern as the Legacy Wave 2 though Legacy Wave 2 customers show less summer seasonality, perhaps indicating lower saturation of central air conditioning.

**Figure 5-6: Expansion Wave Monthly Savings over Time**




The final figures, Figure 5-7 and Figure 5-8, show the three waves' savings on a single graph, with the same y-axis scale (percent savings) across the same calendar months. Legacy Wave 1 and Legacy Wave 2 reached near parity by PY3, after which point their percent savings closely mirrored each other, following similar seasonal trends and a similar decay rate in PY5 during the hiatus of home energy report delivery. The Expansion Wave, which came online during PY6, appeared to have had a "slower" or "longer" ramp-up period than the two legacy waves, though it also nearly reached the same levels of percent savings by the end of PY7.

**Figure 5-7: Residential Waves' Percentage Savings over Time: Through Calendar Months**

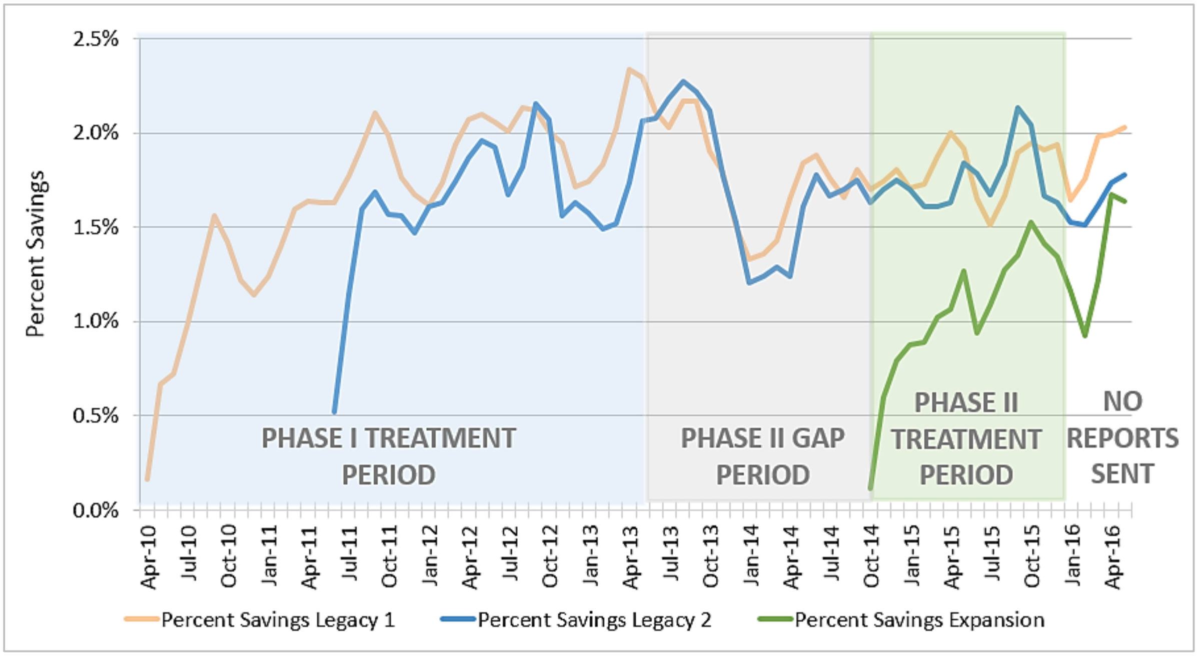
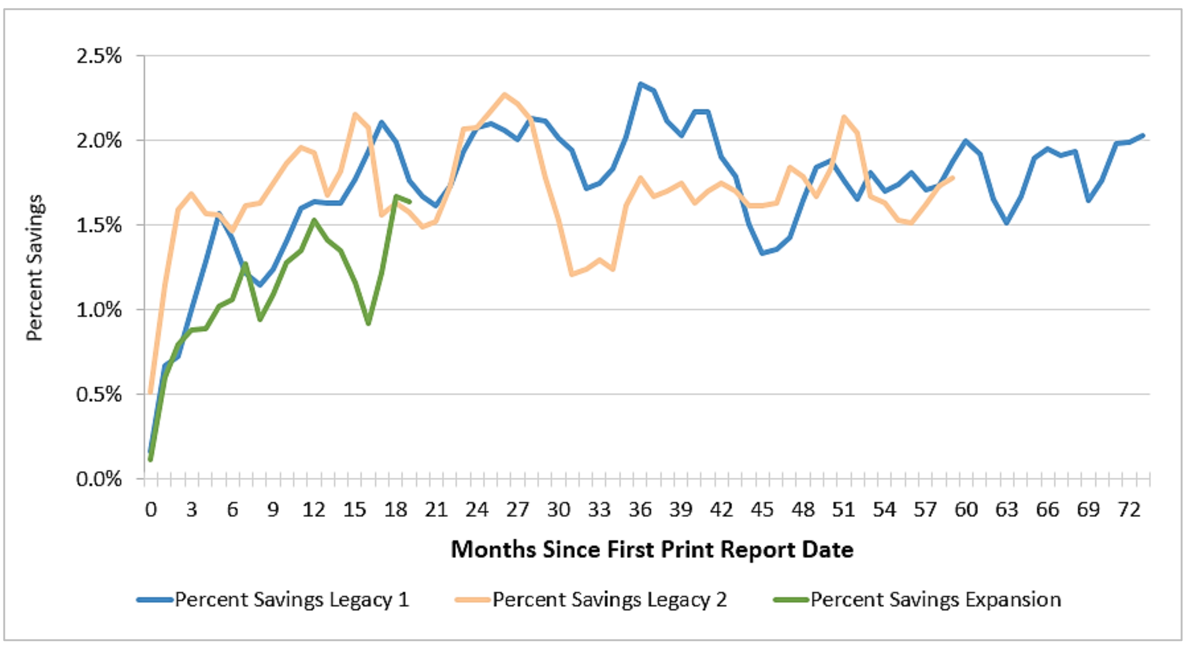



**Figure 5-8: Residential Waves' Percent Savings over Time: Treatment Start Dates Aligned**




### 5.2.7.2 Demand Reduction Estimation

The ICSP reported program demand savings of 39.178 MW in PY7. Since PPL Electric Utilities did not have compliance targets for demand savings, Cadmus did not evaluate demand savings in PY7 using customers' hourly interval data, as was done in PY4.

In the PY4 evaluation, across Legacy Wave 1 and Legacy Wave 2, Cadmus found an average per-customer demand reduction of 0.041 kWh/hr and 0.056 kWh/hr, respectively. These peak demand reduction values were 193% and 108% of the waves' average per-customer energy savings per hour, respectively. Assuming those ratios stay constant through time, and using the weighted average of these ratios (148%), Cadmus converted each wave's PY7 average energy savings into demand reductions, allowing the impacts to be scaled by the magnitude of the current program year's energy savings.

Therefore, as shown in Table 5-9, the waves' average demand reduction ranged from a total of 2.069 MW to 3.134 MW, totaling 7.305 MW, for a combined realization rate of 17%.

**Table 5-9: PY7 Residential Energy-Efficiency Behavior & Education Program Summary of Evaluation Results for Demand [1]**

| Stratum | PYTD Reported Gross Demand Savings [1] (MW) | PYTD Adjusted *Ex Ante* Demand Savings [2] (MW) | Demand Realization Rate (%) | PYTD Verified Gross Demand Savings [3] (MW) | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Legacy Wave 1 | - | - | - | 2.07 | 0.34 | 48.58% |
| Legacy Wave 2 | - | - | - | 3.13 | 0.34 | 49.20% |
| Expansion Group | - | - | - | 2.10 | 0.35 | 50.22% |
| Original Reported | 39.178 | 42.442 | 0% | - | N/A | 0.00% |
| **Program Total** | **39.178** | **42.442** | **17%** | **7.31** | **N/A** | **29.05%** |

[1] Reported gross demand reductions do not include the gross-up to reflect T&D losses.
[2] *Ex ante* and verified gross demand reductions include T&D losses.
[3] PY7 verified gross demand savings were derived using PY4 evaluated demand savings.

## 5.3 IMPACT EVALUATION NET SAVINGS

### 5.3.1 Net-to-Gross Ratio Methodology

Cadmus did not conduct a separate NTG savings analysis because there was no evidence of significant spillover from treatment to non-treatment homes in information feedback programs. The savings estimates, which were based on an analysis of a randomized control trial, inherently included freeridership and spillover in program homes (Table 5-10).

**Table 5-10: PY7 Residential Energy-Efficiency Behavior & Education Program Summary of Evaluation Results for NTG Research**

| Target Group or Stratum (if appropriate) | Estimated Freeridership | Estimated Participant Spillover | NTG Ratio | Observed Coefficient of Variation or Proportion | Relative Precision |
|---|---|---|---|---|---|
| **Residential Energy-Efficiency Behavior & Education** | N/A | N/A | 1.0 | N/A | N/A |

Spillover in treatment group homes would have included the adoption of energy-efficient products or behaviors other than those encouraged by the program. Because home energy reports encouraged general energy conservation in addition to promoting the adoption of energy-efficient products, spillover savings in treatment group homes was not well defined. Spillover in homes that were not participants in the Energy-Efficiency Behavior & Education Program (i.e., PPL Electric Utilities customers who did not belong to the treatment or control group of any waves) would have to have been the adoption of energy-efficient products because of the influence of home energy reports, which these homes did not receive.

The regression methodology does not capture spillover from treatment to control group homes. Such spillover would have lowered the consumption of control group homes and potentially biased the program impact estimates downward to the extent that neighboring homes used as comparisons in the home energy reports would have to have been included in the control group. However, to date, there is no evidence that such spillover in information feedback programs was significant; therefore, Cadmus did not account for this type of spillover.

## 5.4 UPLIFT ANALYSIS

The Residential Energy-Efficiency Behavior & Education Program savings reflected both behavioral changes, such as turning off lights in unoccupied rooms and adjusting thermostat settings, and investments in energy-efficient products, such as high-efficiency furnaces and LEDs. In PY7, some customers who installed efficiency products because of home energy reports may have received rebates from PPL Electric Utilities through other Act 129 programs. Customers could also have received rebates in previous program years following receipt of their first home energy report, and these efficiency products could have continued to yield savings in PY7. In these cases, savings from home energy reports and from the rebate program would be double-counted. To avoid this, Cadmus subtracted cross-participation savings from the residential portfolio savings.

Cadmus conducted an uplift analysis to estimate the impacts of the Energy-Efficiency Behavior & Education Program on participation in PPL Electric Utilities' residential efficiency programs and the energy savings from that participation.[62] In PY7, Cadmus updated its uplift methodology to conform to the Phase III Evaluation Framework.[63] This new method did not conflict with the method described in the Phase II Evaluation Framework but was useful because Cadmus could look not only at cross-program participation in PY7 but could also compare these data to all Residential Energy-Efficiency Behavior & Education Program treatment and control group customers starting with the launch of each wave.

### 5.4.1 Participation Uplift

Cadmus defined participation uplift as the effect of the program on the participation rate of other PPL Electric Utilities efficiency programs. The baseline participation rate captured the business-as-usual effect of marketing and word-of-mouth impacts on customers' participation in other PPL Electric Utilities' Act 129 programs in the absence of the Behavior & Education Program's effects. This baseline participation rate is defined as the number of control group customers who participated in at least one other Act 129 program in PY7 divided by the total number of control group customers. If this cross-program participation rate were greater for treatment group customers, then the home energy reports had an additive effect in encouraging these treatment group customers to participate in the other programs, and therefore participation uplift would be positive and vice versa.

Table 5-11 shows the results for PY7. The participation uplift shows the impact of home energy reports on the number of customers participating in at least one other Act 129 program. For all three waves, Cadmus found a positive participation uplift, meaning the home energy reports spurred treatment group customers to participate at higher rates in other Act 129 programs than control group customers' baseline rate, at an overall uplift rate of 12.4%.

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62 Cadmus conducted an uplift analysis for downstream rebate programs, in which participation was tracked at the individual customer level, in EEMIS. Cadmus did not estimate the impact of the Behavior and Education Program on participation in upstream PPL Electric Utilities lighting programs.

63 Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs.* August 29, 2016. See Section 6.1.1.8, pg 128.

**Table 5-11: PY7 Participation Uplift Summary**

| Wave | Baseline Participation Rate (per 1,000 Customers) | Participation Uplift (Treatment Effect on Participation Rate) | Percentage Participation Uplift |
|---|---|---|---|
| Legacy Wave 1 | 26.0 | 1.5 | 5.7% |
| Legacy Wave 2 | 34.1 | 4.0 | 11.6% |
| Expansion Wave | 26.6 | 3.1 | 11.7% |
| **Program Total [1]** | **28.3** | **3.5** | **12.4%** |

[1] The overall program rates are calculated as the total number of cross-program participants across the three waves divided by the total number of customers across the three waves. The percentage of participation uplift for the entire program is the overall participation uplift rate divided by the overall baseline rate.

### 5.4.2 Savings Uplift

Cadmus also calculated savings uplift to determine whether treatment group customers also *saved* more than control group customers from downstream energy efficiency program participation. Cadmus calculated savings uplift for each wave as the difference in average cross-program savings per customer between treatment group customers and control group customers multiplied by the number of treatment group customers. Savings uplift was positive if the treatment group saved more per customer in PY7 from their current or previous participation in other Act 129 programs than did the control group.

In estimating savings uplift, Cadmus accounted for measure install dates, customer account inactive dates, the weather-sensitivity of measure savings, and measure life. *Appendix G: Energy-Efficiency Behavior & Education Program Savings Counted in Other Energy-Efficiency Programs* describes the details of the uplift methodology.

In PY7, the total Residential Behavior & Education Program savings from other efficiency program participation in PY7 or during other program years of Act 129 Phase I or Phase II was 2,127 MWh/yr (or 5.4% of the program's total PY7 *ex post* savings), as shown in Table 5-12. These savings were subtracted from the residential portfolio, not from the Behavior & Education Program.

**Table 5-12: PY7 Savings Uplift Summary**

| | Legacy Wave 1 | Legacy Wave 2 | Expansion Wave | Program Total |
|---|---|---|---|---|
| Average Uplift Savings per PY7 Treatment Customer (kWh/yr) | 264 | 233 | 38 | 171 |
| Average Uplift Savings per PY7 Control Customer (kWh/yr) | 236 | 212 | 33 | 194 |
| Cross-Program Savings Uplift Difference per PY7 Treated Customer (kWh/yr) | 28 | 21 | 5 | 17 |
| **Total Savings Uplift in PY7 (MWh/yr)[1]** | **1,032** | **886** | **210** | **2,127** |
| **Percentage of Program Savings Double-Counted** | **9.3%** | **5.3%** | **1.9%** | **5.4%** |

[1] Total savings uplift is the product of the uplift difference and the total number of treatment customers in PY7.

Though participation and savings uplift figures are both also shown in percentages, their denominators are different (i.e., they are being compared to different things), so it is challenging to directly compare and draw conclusions between the 12.4% participation uplift (Table 5-11) and the 5.4% savings uplift (Table 5-12). They are both positive, however, which means that the additional participation in other programs caused by the home energy reports was also associated with higher levels of savings from that participation.

Percentage savings uplift is correlated with the length of treatment. Customers in the Expansion Wave received their energy reports most recently and had the smallest uplift savings per customer and percent savings. Customers in Legacy Wave 1 have received home energy reports for the longest duration and have had the highest savings per customer and percent savings. This relationship makes sense because longer treatment duration should be associated with more cross-program participation. Also, it is worth pointing out that the uplift savings from PY7 included savings from previous program participation. Legacy Wave 2 customers received their reports about one year after Legacy Wave 1 customers but their percentage uplift savings were less than half of that of Legacy Wave 1 customers. This was likely because Legacy Wave 2 customers were selected from PPL Electric Utilities customers who had already participated in an Act 129 program, meaning there was probably less opportunity for the home energy reports to increase program participation.

Cadmus deducted Residential Energy-Efficiency Behavior & Education Program uplift savings from the residential portfolio savings.

## 5.5 PROCESS EVALUATION

### 5.5.1 Research Objectives

The Phase II evaluation of the program involved these research objectives:

- Assess the effectiveness of the energy efficiency and behavior program model
- Assess the level of influence the home energy reports have on customers
- Identify the energy-saving improvements and behavioral actions taken by customers in response to information provided through the home energy reports
- Determine the readership of and reception to the home energy reports
- Identify attitudes toward and barriers to saving energy and any differences between the treatment and control groups
- Evaluate customer satisfaction with the home energy reports and with PPL Electric Utilities

### 5.5.2 Evaluation Activities

Cadmus conducted a full process evaluation in PY6, meeting the Phase II Evaluation Framework's requirement to conduct one process evaluation per program per phase.[64] In PY7, Cadmus conducted only program staff and implementer interviews (n=2), consistent with Cadmus' evaluation plan.

### 5.5.3 Methodology

Cadmus conducted one interview each with the PPL Electric Utilities program manager and the ICSP's program staff in January 2015. The interviews focused on program design changes, key performance indicators, implementation successes and challenges, and a general discussion of program implementation in PY7.

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64 Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase II Energy Efficiency and Conservation Programs.* Prepared by GDS Associates, Inc., and Nexant. June 1, 2014. Section 3.7.1 (process evaluation).

### 5.5.4 Achievements Against Plan

The Residential Energy-Efficiency Behavior & Education Program exceeded its PY7 planned MWh/yr verified savings and nearly met its planned participation (Table 5-13).[65] At the end of PY7, the program had achieved these:

- 127% of its 30,749 MWh/yr three-year planned savings
- 99% of its three-year planned participation of approximately 128,000 customers

**Table 5-13: Residential Energy-Efficiency Behavior & Education Program Savings**

| Unit | PY6 | | PY7 | | | PY5–PY7 [1] | |
|---|---|---|---|---|---|---|---|
| | Verified | Planned | Planned [2] | Verified | Percentage of Planned | Verified | Percentage of Planned |
| MWh/yr | 29,568 | 10,925 | 30,749 | 39,078 | 127% | 39,078 [4] | 127% |
| Participation [3] | 130,626 | 128,000 | 128,000 | 126,290 | 99% | 126,290 | 99% |

[1] The program was not delivered in PY5.
[2] PPL Electric Utilities' revised EE&C plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, Table G6, p.66.
[3] Number of households receiving home energy reports at the start of PY7.
[4] The expected measure life is one year. Savings are not cumulative over multiple program years.

The program exceeded its planned savings for PY7, despite ceasing delivery of the home energy reports, because of the program's long history. The participants in the two legacy waves, which represent the majority of program participants, had been receiving the home energy reports over several years, allowing them time to adopt energy-saving products and behaviors. A Cadmus white paper states that savings typically increase over the first three or four years customers receive the home energy reports.[66]

### 5.5.5 Program Delivery

The program worked well in PY7; PPL Electric Utilities' program manager and the ICSP did not report any implementation challenges in PY7. Because of the program's strong savings performance in PY6, and PY7's forecasted savings that showed the program would exceed its planned savings, the ICSP ceased delivery of the home energy reports to all participants (treatment group customers) at the end of PY7 Q2. Participants received their last home energy report via mail and e-mail in October or November 2015.

PPL Electric Utilities made the right decision to cease report delivery because it could also strategically set up its participants to make the transition to a new, though similar, behavior program design for Phase III.

#### 5.5.5.1 Key Performance Indicators

In addition to the program's energy savings, PPL Electric Utilities and the ICSP monitored two key performance indicators on a monthly basis, shown in Table 5-14. During PY7, the program sent reports to fewer than its goal of 128,000 customers because of attrition in PY6. The shortened report delivery period for PY7 reduced the number of customer calls to the call center.

65 Planned savings are reported in PPL Electric Utilities' revised EE&C Plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, Table G6, p.66.

66 Cadmus. "Long-Run Savings and Cost-Effectiveness of Home Energy Report Programs." Winter 2014-15. Available online: http://www.cadmusgroup.com/papers-reports/long-run-savings-cost-effectiveness-home-energy-report-programs/.

**Table 5-14: PY7 Residential Energy-Efficiency Behavior & Education Program Key Performance Indicators**

| Key Performance Indicator | Metric | Goal | PY7 Result |
|---|---|---|---|
| Home Energy Report Recipients | Number of home energy report recipients | Minimize attrition (opt-outs, move-outs, and inactive accounts) so that the number of report recipients does not fall below 128,000 customers | Did not achieve goal. The program experienced high attrition during PY6 largely due to inactive accounts, and as a result, started PY7 with 126,290 report recipients. No new waves were added in PY7. |
| Call Center (operated by ICSP) | Number of calls received to ICSP's call center, number of calls that get routed to PPL Electric Utilities, length of call time, and documentation of customer issue | No goals established even though call center metrics are tracked | Since the program ceased delivery of the reports, the number of calls received substantially decreased and eventually stopped altogether |

### 5.5.6 Participant Profile

Cadmus did not conduct customer surveys in PY7. Demographic data collected through the customer surveys (n=357) in PY6 shows the majority of treatment group customers had these characteristics:

- Lived in a single-family home (92%)
- Had an average household size of 3.1 people
- Had completed at least some college education (72%)
- Had an annual household income of at least $60,000 (67%)

## 5.6 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings, Cadmus offers the following conclusions and recommendations in PY7. The new Phase III behavior program will merge the Phase II residential and low-income behavior program populations into one. See the Low-Income Energy-Efficiency Behavior & Education Program chapter for additional recommendations pertaining to both this residential program and the low-income program.

**Conclusion**

Despite ending the delivery of the home energy reports halfway through the program year, the Residential Energy-Efficiency Behavior & Education Program exceeded its PY7 planned savings (see Section 5.5.4). PPL Electric Utilities made the right decision to cease report delivery because it could then strategically set up the transition of participants to a new behavior program design in Phase III. Although the key performance indicators revealed that the program operated with fewer participants than had been planned to receive the home energy reports, this did not impact the program's energy savings performance (see Section 5.5.3).

Participants from Phase II will be carried over into the new Phase III behavior program. Because these participants have been receiving the home energy reports from the same ICSP over the years, introducing a new home energy report and its related services, provided by a new ICSP, may incur transition challenges.

**Recommendation**

Closely monitor the monthly savings and customer support calls and e-mails of the new behavior program in Phase III as participants adjust to the new program. Specifically, consider setting up some key performance indicators derived from observations of Phase II historical monthly savings and call center data to understand how participants are responding to the new behavior program.

**Recommendation**
Compare the energy-savings performance between Phase II and Phase III to note program design impacts and any transition challenges, especially through comparisons of PY7 and PY8.

**Conclusion**
All three treatment waves—Legacy Wave 1, Legacy Wave 2, and Expansion Wave—contributed to the program's achievement of its planned savings in PY7 (see Section 5.2.7). Legacy Wave 1 saved 1.81% of consumption. Legacy Wave 2 saved 1.71% of consumption. The Expansion Wave saved 1.27% of consumption. All three waves showed a seasonal savings pattern with periods of highest energy savings concurring with periods of peak energy consumption in the summer or winter.

**Conclusion**
The home energy reports provided a relatively strong uplift in participation (12%) and savings (6%) in other PPL Electric Utilities energy efficiency programs (see Section 5.4.1 and 5.4.2). There was very little difference in the average number of other programs that PPL Electric Utilities' customers participated in between the treatment and control groups.

### 5.6.1 Status of Recommendations for Program

Table 5-15 contains the status of each PY7 process recommendation made to PPL Electric Utilities.

**Table 5-15: Residential Energy-Efficiency Behavior & Education Program Status Report on Process and Impact Recommendations**

| Recommendations | EDC Status of Recommendation (Implemented, Being Considered, Rejected AND Explanation of Action Taken by EDC) |
|---|---|
| **Residential Energy-Efficiency Behavior & Education Program** | |
| Closely monitor the monthly savings and customer support calls and e-mails of the new behavior program in Phase III by setting up some key performance indicators derived from observations of Phase II. | Implemented. |
| Compare the energy-savings performance between Phase II and Phase III to note program design impacts and any transition challenges, especially through comparisons of PY7 and PY8. | Will be implemented (Phase III savings will be determined late in Phase III). Will also be evaluated by Cadmus in PY8. |

## 5.7 FINANCIAL REPORTING

A breakdown of the Residential Energy-Efficiency Behavior & Education Program finances is presented in Table 5-16.

**Table 5-16: Summary of Residential Energy-Efficiency Behavior & Education Program Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs[6] ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs (Sum of rows 2 to 4) | $0 | $0 |
| 2 | EDC Incentives to Participants | $0 | $0 |
| 3 | EDC Incentives to Trade Allies | - | - |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $0 | $0 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6, 7, 8, 9, 10 ) | $504 | $2,296 |
| 6 | Design & Development | $0 | $0 |
| 7 | Administration, Management, and Technical Assistance[1] | $504 | $2,296 |
| 8 | Marketing[2] | $0 | $0 |
| 9 | EDC Evaluation Costs | $0 | $0 |
| 10 | SWE Audit Costs | $0 | $0 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | $0 | $0 |
| | | | |
| 12 | Total TRC Costs[3] (Sum of rows 1, 5 and 11) | $504 | $2,296 |
| 13 | Total NPV Lifetime Energy Benefits | $3,531 | $5,435 |
| 14 | Total NPV Lifetime Capacity Benefits | $363 | $310 |
| 15 | Total NPV O&M Saving Benefits | $0 | $0 |
| 16 | Total NPV TRC Benefits[4] | $3,894 | $5,745 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | 7.73 | 2.50 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.
[2] Includes the marketing CSP and marketing costs by program CSPs.
[3] Total TRC Costs includes Total EDC Costs and Participant Costs.
[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.
[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[6] Phase II Costs in this table are discounted back to PY5, thus will not match cumulative costs reported in the PY6 Q4 quarterly report.

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# 6 APPLIANCE RECYCLING PROGRAM

PPL Electric Utilities' Appliance Recycling Program offers a financial incentive and the free pick-up and recycling of operating-but-inefficient refrigerators, freezers, and room air conditioners. The program's overarching goal is to prevent the continued operation of older, inefficient appliances.

PPL Electric Utilities suspended the Phase II program in November, 2016 (Q2 of PY7). This report reflects the program as implemented in PY7, before suspension. Table 6-1 shows the appliance eligibility parameters and incentive amounts.

**Table 6-1: Eligible Appliances and Incentives**

| Appliance | Eligibility Rating | Incentive |
|---|---|---|
| Refrigerator | Working unit; ≥ 10 cubic feet and ≤ 30 cubic feet | Between $25 and $50 |
| Freezer | Working unit; ≥ 10 cubic feet and ≤ 30 cubic feet | Between $25 and $50 |
| Room Air Conditioner | Working unit | Between $10 and $25 |

Refrigerators and freezers must be 10 to 30 cubic feet in size to qualify for the program, and both primary and secondary refrigerators and freezers are eligible. Room air conditioners are picked up with a refrigerator or freezer but are not picked up as a stand-alone service. Eligible appliances must be plugged in and functioning at the time of pick-up. The program is also available to nonresidential PPL Electric Utilities customers with a working, residential-grade refrigerator, freezer, or room air conditioner.

The Appliance Recycling Program's ICSP, JACO Environmental, confirms that the units are operational upon pick-up. The ICSP disposes of participating units in an environmentally responsible manner. This involves removing hazardous materials from the refrigerant and foam insulation (e.g., chlorinated fluorocarbons), preparing the refrigerant for reclamation, and recycling other materials (e.g., metal and plastic).

PPL Electric Utilities' energy efficiency program staff provide overall strategic direction and program management. The ICSP provides turnkey services to administer and manage marketing, call center services such as customer intake and scheduling, processing applications and rebates, tracking program data, and providing customer and transaction information to PPL Electric Utilities.

The ICSP tracks the customer sector using the customer account number and address on the application, which is tied to a rate code that identifies the customer sector. PPL Electric Utilities reports units, savings, and costs allocated to the appropriate customer sector.[67]

Additionally, PPL Electric Utilities and the ICSP partnered with Sears (in PY7) to offer optional recycling services with the purchase of a new energy-efficient unit. Through this service—known as the "Buy New and Recycle" component—customers can opt to have their old unit picked up for recycling when the new unit is delivered by the retailer, making appliance recycling convenient for customers.

[67] Allocation to the low-income sector will be determined as part of the annual impact evaluation of low-income participation in general residential programs.

Best Buy was also a partner through PY6 but decided to end the integrated Appliance Recycling Program offering throughout its retail locations around June of 2015, a decision that affected not only PPL Electric's program but programs nationally.

The program's primary objectives are these: [68]

- Encourage customers to dispose of their existing, inefficient appliances when they purchase new ones or eliminate a second unit that may not be needed
- Reduce the use of secondary, inefficient appliances
- Ensure that appliances are disposed of in an environmentally responsible manner
- Conduct on-site decommissioning to ensure that appliances are not resold in a secondary market
- Promote other PPL Electric Utilities energy efficiency programs
- Collect and recycle no fewer than 11,720 appliances in PY7, with a total energy reduction of 8,243 MWh/yr and demand reduction of 1.12 MW

A summary of Phase II program metrics is presented in Table 6-2. Program metrics are shown by sector in Table 6-3.

**Table 6-2: Phase II Appliance Recycling Program Summary**

| Program | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II NTG Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) | Program Acquisition Cost ($/Annual kWh) | Cost of Conserved Energy[1] (TRC $/kWh) | Phase II Participants[2] |
|---|---|---|---|---|---|---|---|---|---|
| Appliance Recycling | 25,668 | 25,809 | 25,012 | 0.72 | 3.68 | $4,026 | $0.16 | $0.026 | 26,784 |
| **Total** | **25,668** | **25,809** | **25,012** | **0.72** | **3.68** | **$4,026** | **$0.16** | **$0.026** | **26,784** |

[1] Total TRC costs divided by levelized lifetime kWh savings.
[2] Participants are defined as the number of unique CSP Job IDs. In Phase II, the Appliance Recycling Program recycled 30,980 units.

68 Program objectives are stipulated on PPL Electric's revised EE&C Plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, p.41.

**Table 6-3: Phase II Appliance Recycling Program Executive Summary Table by Sector**

| Sector | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Net- to -Gross Ratio[1] | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) | Program Acquisition Cost ($/Annual kWh) | Cost of Conserved Energy[2] (TRC $/kWh) | Phase II Participants[3] |
|---|---|---|---|---|---|---|---|---|---|
| Residential | 24,760 | 24,897 | 24,137 | 0.72 | N/A | $3,890 | $0.16 | $0.026 | 25,995 |
| Low-Income | - | - | - | - | - | - | - | - | - |
| Small C&I | 588 | 590 | 567 | 0.73 | N/A | $88 | $0.16 | $0.026 | 571 |
| Large C&I | 5 | 6 | 6 | 0.67 | N/A | $1 | $0.24 | $0.039 | 6 |
| GNE | 315 | 317 | 302 | 0.74 | N/A | $47 | $0.15 | $0.026 | 212 |
| **Total [4]** | **25,668** | **25,809** | **25,012** | **0.72** | **3.68** | **$4,026** | **$0.16** | **$0.026** | **26,784** |

[1] NTG is not calculated by sector for the Appliance Recycling Program because residential customers account for 96% of participants and there is little reason to suspect that the disposal behavior of residential and nonresidential customers is any different and stratifying surveys with such small populations would add considerable cost in trying to reach sufficient sample sizes. Additionally, with nonresidential surveys, it would probably be more difficult to reach the person who would have made the disposal decision absent the program. The NTG ratio was determined in PY6 and applied to PY7.
[2] Total TRC costs divided by levelized lifetime kWh savings.
[3] Participants are defined as the number of unique CSP Job IDs. In Phase II, the Appliance Recycling Program recycled 30,980 units.
[4] Total does not add due to rounding.

## 6.1 PROGRAM UPDATES

In Q2 of PY7, the ICSP, JACO Environmental, ceased operations after going into receivership with no advanced notice. PPL Electric Utilities contracted another ICSP for part of Q3 to pick up appliances from customers who had scheduled a pick-up but had had the appointment canceled after JACO ceased operations.

Because of the complications with the ICSP, the program achieved 71% of planned participation for PY7 with a total of 8,310 appliances recycled.

However, in PY7, the program was able to surpass its planned savings targets despite the lower participation. In 2015, the Pennsylvania TRM was changed and no longer requires accounting for appliance replacement as an adjustment to gross savings. The change resulted in an increase in the gross per-unit savings.[69] The program achieved 121% of its MWh/yr planned savings and 125% of its MW planned savings.

### 6.1.1 Definition of Participant

Participant refers to the number of unique participants defined by unique CSP Job number. Each customer who has an appliance picked up and recycled through the program is assigned a job number. A customer can recycle more than one unit at the same time. A customer who recycles more than one appliance, on multiple dates within the program year, will have two or more distinct job numbers, equal to the number of unique pick up dates.

69 Replacement is now accounted for in the net savings adjustments.

## 6.2 IMPACT EVALUATION GROSS SAVINGS

### 6.2.1 Reported Gross Savings

Table 6-4 shows the cumulative reported results by sector for the Appliance Recycling Program for Phase II, through the end of PY7. As expected, the vast majority of participants were in the residential sector. The table also shows the smaller number of participants in small commercial and industrial; large commercial and industrial; and government, nonprofit, and education.

**Table 6-4: Phase II Appliance Recycling Reported Results by Customer Sector**

| Sector | Participants | Reported Gross Energy Savings (MWh/yr) | Reported Gross Demand Reduction (MW) | Incentives ($1,000) |
|---|---|---|---|---|
| Residential | 25,995 | 24,760 | 4.06 | $1,043 |
| Low-Income | - | - | - | - |
| Small Commercial and Industrial | 571 | 588 | 0.10 | $23 |
| Large Commercial and Industrial | 6 | 5 | 0.00 | $0 |
| Government/Nonprofit/Education | 212 | 315 | 0.04 | $12 |
| **Phase II Total [1]** | **26,784** | **25,668** | **4.19** | **$1,080** |
| [1] Total does not add due to rounding. | | | | |

### 6.2.2 Database Review

Cadmus inspected a census of PY7 participant records from the EEMIS database to verify reported savings and quantities. It was not able to reconcile EEMIS records with the ICSP's database because the ICSP did not provide PY7 data prior to ceasing operations. Since discrepancies were rare in prior evaluations and the ICSP tracking data was unavailable, Cadmus verified all records in EEMIS.

### 6.2.3 EM&V Sampling Approach

Cadmus included all records in the *ex ante* and *ex post* savings analyses.

### 6.2.4 *Ex Ante* Savings Methodology and Findings

Savings for recycled appliances are deemed on a per-unit basis in accordance with the 2015 Pennsylvania TRM.[70] Deemed savings for a portion of refrigerators and freezers in PY7 were carried over from PY6 and were lower than the deemed savings in the TRM, so Cadmus made *ex ante* adjustments.

There were a total of 434 refrigerators with reported savings of 777 kWh/yr per unit and 104 freezers with reported savings of 758 kWh/yr per unit. After adjusting for part use, Cadmus adjusted the savings to reflect the deemed savings in the TRM of 1,231.97 kWh/yr for refrigerators and 1,088.14 kWh/yr for freezers.

Reported savings for room air conditioners assumed average of the locations specified in the 2015 Pennsylvania TRM rather than mapping savings to the exact locations. Cadmus made *ex ante* adjustments by mapping each ZIP code to the specified climate zone city specified in the 2015 Pennsylvania TRM. The climate zone determines the annual hours of operation ($EFLH_{RAC}$ in Table 6-5).

70 Pennsylvania Public Utility Commission. *Technical Reference Manual*. June 2014. Page 113-117. Available online: http://www.puc.pa.gov/pcdocs/1300345.docx

### 6.2.5 *Ex Post* Savings Methodology and Findings

Cadmus produced final weighted savings of 131 kWh/yr per unit, as shown in Table 6-5. The table also lists the TRM savings assumptions for each city represented in the PY7 participant population, the number of room air conditioning units picked up in each climate zone, the percentage of units overall, and the overall weighted average savings value.

**Table 6-5: PY7 Room Air Conditioner Retirement – Savings Assumptions and Participation Mapped to the Nearest City**

| City | Original Hours ($EFLH_{ES-RAC}$)[1] | Corrected Hours ($EFLH_{RAC}$) [1] | Energy Impact (kWh/yr) | Demand Impact (kW) | City Counts | City Proportions |
|---|---|---|---|---|---|---|
| Allentown | 487 | 151 | 131 | 0.2603 | 208 | 33% |
| Erie | 389 | 121 | 105 | | 0 | 0% |
| Harrisburg | 551 | 171 | 148 | | 160 | 25% |
| Philadelphia | 591 | 183 | 159 | | 45 | 7% |
| Pittsburgh | 432 | 134 | 116 | | 0 | 0% |
| Scranton | 417 | 129 | 112 | | 142 | 22% |
| Williamsport | 422 | 131 | 114 | | 84 | 13% |
| **TRM Adjusted Weighted Average** | | | **131** | **0.2603** | **639** | -- |
| [1] TRM-specified columns. See table 2-27, page 62 of the 2015 TRM | | | | | | |

#### 6.2.5.1 Surveys

No surveys were conducted in PY7. Verification rates and net savings adjustments from PY6 were applied in PY7.

#### 6.2.5.2 Quantity Verification

*Ex post* verified gross savings for the Appliance Recycling Program reflect discrepancies identified through the records reviews and survey verification activities. Cadmus' PY6 survey verification revealed no discrepancies for the quantity or type of appliances in the tracking data. Cadmus applied the same verification rate of 100% to PY7 records.

### 6.2.6 Summary of Evaluation Results

Table 6-6 shows the program's evaluation results for energy savings, and Table 6-7 shows its evaluation results for demand savings.

**Table 6-6: PY7 Appliance Recycling Summary of Evaluation Results for Energy [1]**

| Stratum | Reported Gross Energy Savings (MWh/yr) | Adjusted *Ex Ante* Energy Savings (MWh/yr) | Energy Realization Rate (%) | Verified Gross Energy Savings (MWh/yr)[2] | Observed Coefficient of Variation (Cv), Error Ratio (ER), or Proportion in Sample Design | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Not Assigned | 9,100 | 9,320 | 100% | 9,320 | N/A | N/A |
| **Program Total** | **9,100** | **9,320** | **100%** | **9,320** | N/A | N/A |

[1] Values in this table refer to savings at the point of consumption. (Planned savings for MWh/yr refer to values at the point of consumption.) Due to line losses, savings at the point of generation are systematically larger.
[2] Adjusted *ex ante* multiplied by the realization rate will not equal verified gross energy savings due to rounding.

**Table 6-7: PY7 Appliance Recycling Summary of Evaluation Results for Demand**

| Stratum | Reported Gross Demand Savings (MW) [1] | Adjusted *Ex Ante* Demand Savings (MW) [2] | Demand Realization Rate (%) | Verified Gross Demand Savings (MW) [2] | Observed Coefficient of Variation (Cv) or Proportion in Sample Design | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Not Assigned | 1.19 | 1.30 | 100% | 1.30 | N/A | N/A |
| **Program Total** | **1.19** | **1.30** | **100%** | **1.30** | N/A | N/A |

[1] Reported gross demand reductions do not include the gross-up to reflect T&D losses.
[2] Adjusted *ex ante* and verified gross demand reductions include T&D losses.

## 6.3 IMPACT EVALUATION NET SAVINGS

Cadmus applied NTG adjustments and verification rates from the PY6 evaluation to PY7, in accordance with its evaluation plan. Net savings are determined only for future program planning purposes. Energy savings and demand reduction compliance plans are met using verified gross savings.

### 6.3.1 Net-to-Gross Ratio Methodology

Cadmus used PY6 net savings findings that it calculated using the methodology described in the SWE's "Common Approach for Measuring Net Savings for Appliance Retirement Programs."[71] The SWE approach lists four major factors in the net savings analysis:

- Freeridership
- Secondary market impacts
- Induced replacement
- Spillover

### 6.3.2 Net-to-Gross Ratio Sampling

Cadmus did not conduct surveys in PY7 for the Appliance Recycling Program. Cadmus conducted an analysis using PY6 results to determine net savings for the Appliance Recycling Program in PY7.

### 6.3.3 Net-to-Gross Ratio Findings

For the Appliance Recycling Program, Cadmus did not estimate a NTG ratio in PY7 but instead applied the product-level NTG ratio estimated in PY6 cited in table 5-12 of the annual report for PY6.[72] PPL Electric Utilities did not make substantial changes to the program delivery or target market, therefore the PY6 NTG should apply to PY7.

Market effects for appliance recycling programs are difficult to assess. There is not a clear mechanism to transform the market nor a succinct way to assess the market transformation. Presumably the program decreases, to some degree, the number of inefficient secondary appliances operating on the grid. But this does not constitute a lasting transformation. It is quite likely that, if the program were discontinued, the used or secondary appliance market would have an increase in the supply of older, inefficient appliances. Therefore, no market effects were quantified for this program.

71 Research Into Action. *Common Approach for Measuring Net Savings for Appliance Retirement Programs.* March 2014.

72 PPL Electric Utilities. *Annual Report Program Year 6: June 1, 2014 – May 31, 2015.* Presented to Pennsylvania Public Utility Commission. Prepared by Cadmus. November 16, 2015. Available online: http://www.puc.pa.gov/pcdocs/1395299.pdf

Table 6-8 shows the historical NTG ratio from PY2 to PY7.

**Table 6-8: Historical Program Net-to-Gross Ratio**

| Program Year | Net-to-Gross Ratio |
|---|---|
| **PY7** | 60% |
| **PY6** | 60% |
| **PY5** | 74% |
| **PY4** | 68% |
| **PY3** | 63% |
| **PY2** | 61% |

Direct comparison between Phase II and Phase I program years is limited because of changes in methodology prescribed in the annual TRMs. Beginning in PY5, the NTG ratio included both induced replacement and secondary market impacts. However, the NTG ratio for PY6 (and applied in PY7) is on the high end, but within the range of recent evaluation results from other programs that use similar methodology as well as the range of values observed in other program years.

**Table 6-9. Benchmarking NTG Ratios**

| Program [1] | Year(s) | NTG Ratio | |
|---|---|---|---|
| | | Refrigerators | Freezers |
| **PPL Electric** | **2014-2015** | **58%** | **71%** |
| Mid-Atlantic Utility 1 | 2015 | 47% | 30% |
| Mid-Atlantic Utility 2 | 2015 | 39% | 51% |
| Midwest Utility 1 | 2015 | 36% | 48% |
| Midwest Utility 2 | 2013-2014 | 52% | 62% |
| [1] Reports from the Mid-Atlantic and Midwest utilities are unpublished. | | | |

Based on the NTG findings, Cadmus concludes that the Appliance Recycling Program has no design issues that would lead to freeridership which need to be addressed.

## 6.4 ACHIEVEMENTS AGAINST PLAN

Table 6-10 contains the program's plans for energy savings and incentives and the program's achievements.

**Table 6-10. Appliance Recycling Savings**

| | PY5 Verified | PY6 Verified | PY7 Only | | | Phase II: PY5–PY7 | | |
|---|---|---|---|---|---|---|---|---|
| | | | Planned | Verified | Percentage of Planned | Planned [1] | Verified | Percentage of Planned |
| MWh/yr | 9,255 | 6,437 | 7,729 | 9,320 | 121% | 25,224 | 25,012 | 99% |
| MW[2] | 1.86 | 1.19 | 1.04 | 1.30 | 125% | 3.50 | 4.45 | 127% |
| Participants [3] | 13,486 | 9,190 | 11,720 | 8,310 | 71% | 36,920 | 30,986 | 84% |

[1] Planned savings are based on PPL Electric's revised EE&C plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, Table D7, p.46.
[2] Planned and verified MW savings include line losses.
[3] Participation is defined in the EE&C plan as the number of appliance units recycled.

## 6.5 PROCESS EVALUATION

Cadmus did not complete a process evaluation for PY7.

### 6.5.1 Status of Recommendations for Program

Cadmus has no recommendations for the program in Phase III based on the PY7 evaluation.

## 6.6 FINANCIAL REPORTING

A breakdown of the Appliance Recycling Program finances is presented in Table 6-11.

**Table 6-11: Summary of Appliance Recycling Program Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs [6] ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs | $0 | $0 |
| 2 | EDC Incentives to Participants | $370 | $1,005 |
| 3 | EDC Incentives to Trade Allies | - | - |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $0 | $0 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6, 7, 8, 9, 10 ) | $871 | $2,758 |
| 6 | Design & Development | $0 | $0 |
| 7 | Administration, Management, and Technical Assistance[1] | $871 | $2,758 |
| 8 | Marketing[2] | $0 | $0 |
| 9 | EDC Evaluation Costs | $0 | $0 |
| 10 | SWE Audit Costs | $0 | $0 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | $0 | $0 |
| | | | |
| 12 | Total TRC Costs [3] (Sum of rows 1, 5 and 11) | $1,240 | $3,763 |
| 13 | Total NPV Lifetime Energy Benefits | $5,419 | $12,878 |
| 14 | Total NPV Lifetime Capacity Benefits | $363 | $979 |
| 15 | Total NPV O&M Saving Benefits | ($0) | ($0) |
| 16 | Total NPV TRC Benefits[4] | $5,782 | $13,857 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | 4.66 | 3.68 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.
[2] Includes the marketing CSP and marketing costs by program CSPs.
[3] Total TRC Costs includes Total EDC Costs and Participant Costs.
[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.
[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[6] Phase II Costs in this table are discounted back to PY5, thus will not match cumulative costs reported in the PY6 Q4 quarterly report.

# 7 RESIDENTIAL HOME COMFORT

The Residential Home Comfort Program offers a wide range of energy-efficient products, rebates, education, and services for new construction and retrofitting of existing homes. CLEAResult is the ICSP. Through the program, participants can customize solutions to increase their home's energy efficiency. The program has five components:

- **New homes** encourages construction of energy-efficient new homes through two paths:
  - **Prescriptive path** offers a $2,000 rebate to builders for installing these six efficient products—SEER 16+ air source heat pump, EF 2.3+ heat pump water heater, ENERGY STAR refrigerator, ENERGY STAR dishwasher, R20+ wall insulation, and R49+ ceiling insulation.
  - **HERS approach** offers builders a rebate of $0.30 per annual kWh saved (up to $2,000) for homes built above the state code minimum.[73]
- **Manufactured homes** offers a $1,200 rebate to buyers of an ENERGY STAR manufactured home and an additional rebate of up to $300 for the installation of an efficient air source heat pump or ductless mini-split heat pump.
- **Audit** provides customer rebates for professional comprehensive home energy audits or a less comprehensive home survey. From the audit or survey, customers receive a customized home energy report listing actions they can take to reduce energy costs in their home, along with directly installed energy efficiency products like LEDs, low-flow showerheads, and furnace whistles.
- **Weatherization**, based on recommendations from an audit, provides rebates for ceiling and wall insulation and air sealing.
- **Energy-efficient equipment** provides rebates for purchasing high-efficiency air source heat pumps, ductless heat pumps, above-ground or in-ground pool pumps, central air conditioning, ECM furnace fans, whole house fans, and fuel-switching.

The objectives of the Residential Home Comfort Program are to accomplish these:[74]

- Encourage customers to view energy efficiency in a holistic manner.
- Introduce and educate customers on new energy-saving technologies.
- Promote construction of energy-efficient new homes.
- Educate construction industry professionals about the benefits of energy-efficient new homes.
- Provide customers with home energy audits and surveys and energy-saving solutions.
- Provide immediate energy savings to customers by providing free direct install products.
- Obtain participation by approximately 14,500 customers and trade allies through 2016, with a total reduction of approximately 15,300 MWh/yr.

A summary of program metrics can be found in Table 7-1.

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73 HERS is the Home Energy Rating System developed by RESNET, the Residential Energy Services Network.

74 Program objectives are stipulated on PPL Electric Utilities' revised EE&C Plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, p.57.

**Table 7-1: Phase II Residential Home Comfort Summary**

| | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Net-to-Gross Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) | Program Acquisition Cost ($/Annual kWh) | Cost of Conserved Energy[1] (TRC $/kWh) | Phase II Participants |
|---|---|---|---|---|---|---|---|---|---|
| Residential Home Comfort | 18,354 | 18,427 | 18,649 | 0.61 | 0.66 | $10,330 | $0.55 | $0.176 | 14,770 |
| **Total** | **18,354** | **18,427** | **18,649** | **0.61** | **0.66** | **$10,330** | **$0.55** | **$0.176** | **14,770** |

[1] Total TRC Costs divided by levelized lifetime kWh savings.

## 7.1 PROGRAM UPDATES

In PY7, PPL Electric Utilities added these rebates to the Residential Home Comfort Program:

- **Air sealing.** Up to $100 to customers who received air sealing services from a Building Performance Institute (BPI)-certified contractor.
- **ECM furnace fan.** $100 for the purchase and installation of an ECM furnace fan added to existing HVAC equipment.
- **Whole house fan.** $200 for the purchase and installation of a whole house fan.
- **Central air conditioner.** $250 for a 16+ SEER central air conditioner.
- **Above-ground pool pump.** $150 for installing a variable-speed pool pump in an above-ground pool.

### 7.1.1 Definition of Participant

A participant in the Residential Home Comfort Program is defined by a database record with a unique CSP Job ID. Multiple products, such as the low-cost efficiency products installed at the time of the audit, may be (and often are) installed by a single participant. All products with the same CSP Job ID are associated with and counted as one participant.

## 7.2 IMPACT EVALUATION GROSS SAVINGS

### 7.2.1 Reported Gross Savings

Table 7-2 shows the cumulative reported gross energy savings and incentives paid in Phase II. The number of participants was for all Residential Home Comfort Program components—audit, weatherization, efficient equipment, new construction, and manufactured homes. In Phase II, the program served 14,770 participants and reported gross energy savings of 18,354 MWh/yr and gross demand reduction of 5.03 MW.

**Table 7-2: Phase II Residential Home Comfort Program Reported Results by Customer Sector**

| Sector | Phase II Participants | Phase II Reported Gross Energy Savings (MWh/yr) | Phase II Reported Gross Demand Reduction (MW) [1] | Incentives ($1,000) |
|---|---|---|---|---|
| Residential | 14,759 | 18,345 | 5.02 | $6,407 |
| Small Commercial and Industrial | 8 | 8 | 0.00 | - |
| Government/Nonprofit/Education | 3 | 1 | 0.00 | - |
| **Phase II Total** | **14,770** | **18,354** | **5.03** | **$6,407** |

[1] Differences are due to rounding.

Energy savings and demand reductions were calculated using the Pennsylvania TRM or Guidance Memo in effect on the date the product was installed. In PY7, 11% of all rebates had installation dates that occurred in PY6, and 89% had installation dates that occurred in PY7.

### 7.2.2 Database Review

Cadmus reviewed the tracking database extracts for the Residential Home Comfort Program for the process evaluation survey effort. Program tracking data are stored in five separate EEMIS extracts because products and components have different parameter collection requirements. The EEMIS database provided data about these products and services:

- Audit and weatherization
- HVAC (air source heat pumps, central air conditioner, and electric-to-fossil fuel-switching)
- Ductless heat pumps
- New homes whole house (prescriptive homes, manufactured homes, ECM furnace fans, and whole house fans)
- New homes HERS approach
- Pool pumps

The database review assessed the completeness of fields necessary to conduct PY7 participant telephone surveys and analysis. Cadmus determined that a key field, labeled "Is natural gas available," was fully populated in the PY7 extracts. This is a marked improvement from PY6.

The database review also examined the data in the "How did you hear about the program?" field, which varied by data extract. The HVAC extract contained the most information for this field. The extract for audit and weatherization, however, contained very little information; almost all of the values were blank or reported as N/A.

### 7.2.3 EM&V Sampling Approach

For verification activity sampling, records were assigned to one of 11 strata, defined in Table 7-3.

**Table 7-3: PY7 Residential Home Comfort Program Strata Definitions**

| Sector | Stratum | Products Included |
|---|---|---|
| Residential | Audits | Energy education, LEDs, faucet aerators, showerheads, water heater pipe insulation, smart power strips, water heater temperature setback, furnace whistles |
| | Weatherization | Ceiling and wall insulation and air sealing in existing homes |
| | Air Source Heat Pumps | SEER 15 or SEER 16 |
| | Ductless Heat Pumps | SEER 15 or greater |
| | Central Air Conditioner | SEER 16 or greater |
| | ECM Furnace Fans | Must replace existing Permanent split capacitor (PSC) motor fan on an electric furnace or heat pump with an ECM fan |
| | Whole House Fans | No minimum criteria |
| | Fuel-Switching | Gas-fired furnaces, propane-fired furnaces |
| | Pool Pumps | Variable-speed pumps |
| | New Homes | Air source heat pump 16, HPWH EF 2.3, ENERGY STAR appliances, ceiling and wall insulation |
| | Manufactured Homes | ENERGY STAR manufactured homes, air source heat pump SEER 15 or greater, or ductless heat pump SEER 15 or greater |

The EM&V sample plan was designed to meet levels of at least 85% confidence and 15% precision at the program level.[75] Table 7-4 summarizes the sampling strategy and the approaches used to evaluate savings for each program stratum. These approaches are discussed in detail in the following sections.

**Table 7-4: PY7 Residential Home Comfort Program Impact Evaluation Sampling Strategy**

| Stratum | PY7 Population Size | Target Levels of Confidence & Precision | Target Sample Size | Achieved Sample Size | Evaluation Activity |
|---|---|---|---|---|---|
| Audits | 707 | 85/15 at program level<br><br>90/10 at sector level | 28 | 28 | Records review |
| Weatherization | 271 | | 40+ | 60 | Records review |
| Air Source Heat Pumps | 3,527 | | 40 | 40 | Records review |
| Ductless Heat Pumps | 1,582 | | 40 | 40 | Records review |
| Central Air Conditioning | 1,062 | | 40 | 40 | Records review |
| ECM Furnace Fans | 5 | | Census | 5 | Records review |
| Whole House Fans | 3 | | Census | 3 | Records review |
| Pool Pumps | 248 | | 40+ | 95 | Records review |
| Fuel-Switching (Electric to Gas) [1] | 23 | | Census | 23 | Records review |
| New Homes | 518 | | 40+ | 42 | Records review |
| Manufactured Homes | 1 | | Census | 1 | Records review |
| **Program Total** | **7,947** | | **N/A** | **377** | **N/A** |

[1] Projected population of 100 over Phase II, in multiple programs.

Cadmus reviewed all records and the supporting documentation for the selected sample of PY7 projects. The records review verified information in the EEMIS database using program intake forms, which included rebate forms, AHRI certificates, and audit home energy reports.

For the quarterly records reviews, Cadmus drew sample points from these strata—audit, air source heat pump, ductless heat pump, central air conditioner, and HERS new homes. Cadmus front-loaded sampling to the first three quarters to have ample time to finalize evaluation activities for Phase II and in case any issues arose on rebate forms or in EEMIS. Cadmus found that EEMIS did not have all of the necessary inputs to calculate air sealing, pool pump, and central air conditioner energy savings, but the ICSP was able to rectify this issue by sending input data from its internal database so Cadmus could calculate *ex ante* adjusted savings for these populations.

In PY7 Q4, Cadmus reviewed the stratum populations and confirmed that sampling targets were sufficiently met for the audit, air source heat pump, ductless heat pump, central air conditioner, and HERS new homes strata.

Cadmus reviewed all fuel-switching records because EEMIS did not provide all of the parameters necessary to calculate *ex ante* adjusted and *ex post* verified savings. Because populations were small, Cadmus reviewed all records for these strata—new construction prescriptive path (two), ECM furnace fan (five), whole house fan (three), and manufactured homes project (one).

Cadmus requested additional records for the weatherization stratum to verify savings for air sealing services, which were added in PY7. A review of a census of air sealing records in PY7 Q1 and PY7 Q2 found

75 Cadmus. *PPL Electric Utilities EM&V Plans Act 129 Phase II*. PY7 Revision: August 2015.

no discrepancies between the EEMIS energy savings and the energy savings Cadmus calculated using inputs on the rebate forms.

Lastly, Cadmus requested additional records for the pool pump stratum because of changes in the 2015 TRM algorithm (discussed in more detail about pool pumps in Section 7.2.5.1).

Table 7-5 lists the sample sizes for each stratum by quarter. The records review exceeded the sample design targeting levels of 85% confidence and 15% precision by program.

**Table 7-5: PY7 Residential Home Comfort Program Sampling by Quarter**

| Stratum | Q1 | Q2 | Q3 | Q4 | Q4+ | Total | Participation in PY7 |
|---|---|---|---|---|---|---|---|
| Audits | 10 | 9 | 9 | 0 | 0 | 28 | 707 |
| Weatherization | 18 | 32 | 10 | 0 | 0 | 60 | 271 |
| Air Source Heat Pumps | 14 | 13 | 13 | 0 | 0 | 40 | 3,527 |
| Ductless Heat Pumps | 14 | 13 | 13 | 0 | 0 | 40 | 1,582 |
| Central Air Conditioner | 20 | 10 | 10 | 0 | 0 | 40 | 1,062 |
| ECM Furnace Fans | 2 | 1 | 2 | 0 | 0 | 5 | 5 |
| Whole House Fans | 0 | 1 | 2 | 0 | 0 | 3 | 3 |
| Pool Pumps | 14 | 13 | 11 | 2 | 55 | 95 | 248 |
| Fuel-Switching (Electric to Gas) | 3 | 8 | 7 | 5 | 0 | 23 | 23 |
| New Homes | 7 | 18 | 16 | 0 | 1 | 42 | 518 |
| Manufactured Homes | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| **Total Sample Points** | **102** | **118** | **94** | **7** | **56** | **377** | **7,947** |

### 7.2.4 *Ex Ante* Savings Methodology and Findings

Reported gross energy savings and demand savings for participant records with installation dates in PY6 were deemed or calculated according to the 2014 Pennsylvania TRM.[76] Reported gross energy savings and demand savings for participant records with installation dates in PY7 were deemed or calculated using the algorithms in the 2015 Pennsylvania TRM.[77] Cadmus calculated adjusted *ex ante* energy savings and demand savings using the input parameters reported in EEMIS for each record in the population. Where input parameters were not provided in EEMIS, Cadmus used default values provided in the TRM to calculate *ex ante* adjusted savings and demand reductions.

Cadmus used EEMIS inputs and zip code mapping to calculate adjusted *ex ante* savings to check the quality of EEMIS' reported savings. For two strata—weatherization and fuel-switching—EEMIS did not provide the necessary inputs, so Cadmus passed through *ex ante* reported savings and made all adjustments to *ex post* savings through records reviews.

76 Pennsylvania Public Utility Commission. *Technical Reference Manual*. June 2014. Available online: http://www.puc.pa.gov/pcdocs/1300345.docx

77 Pennsylvania Public Utility Commission. *Technical Reference Manual*. June 2015. Available online: http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

### 7.2.4.1 Summary of *Ex Ante* Adjustments by Stratum

#### *Audit*

Cadmus determined that energy savings reported in EEMIS were calculated using 1.75 gpm for low-flow showerheads. However, the ICSP confirmed that PPL Electric Utilities distributed 1.5-gpm showerheads in PY7. Cadmus recalculated savings using TRM algorithms for a 1.5-gpm showerhead, which led to higher adjusted *ex ante* energy savings and demand reduction.

Cadmus could not replicate the savings reported in EEMIS for the thermostatic restriction valve and low-flow showerhead and thermostatic shower restriction valve combo products. Cadmus used all of the default values from the 2015 TRM and applied these to adjusted *ex ante* savings and demand reduction.

#### *Weatherization*

Cadmus did not make an adjustment to *ex ante* savings.

#### *HVAC Efficient Equipment*

Beginning with the 2015 TRM, air source heat pump stipulated values for $SEER_b$, $EER_b$, and $EER_e$ are based on the customer's existing cooling equipment, as shown in Table 7-6.

**Table 7-6: Pennsylvania PUC TRM Values for Air Source Heat Pumps**

| Component | 2015 TRM Value[1] | 2014 TRM Value[2] |
|---|---|---|
| $SEER_b$ | Replace on Burnout: 13 SEER (Central Air Conditioner) or 14 SEER (Air Source Heat Pump) | Replace on Burnout: 13 SEER |
| | Early Retirement<br>EDC Data Gathering<br>Default = 11 (Central Air Conditioner) or 12 (Air Source Heat Pump) | Early Retirement: Default 10 SEER or EDC Data Gathering |
| $EER_b$ | Replace on Burnout: 11.3 (Central Air Conditioner) or 12 (Air Source Heat Pump) | Replace on Burnout: 11.3 |
| | Early Retirement:<br>EDC Data Gathering<br>Default = 8.69 | Early Retirement: Default 8.69 EER or EDC Data Gathering |
| $EER_e$ | For Central Air Conditioner: (11.3/13) x $SEER_e$<br>For Air Source Heat Pump: (12/14) x $SEER_e$ | (11.3/13) x $SEER_e$ |
| [1] Pennsylvania Public Utility Commission Technical Reference Manual. June 2015. Table 2-10. Page 37.<br>[2] Pennsylvania Public Utility Commission Technical Reference Manual. June 2014. Table 2-1. Page 23. | | |

The PY7 PPL Electric Utilities air source heat pump rebate form did not ask for customers' existing cooling equipment. Therefore, Cadmus assumed the conservative estimate of no previous cooling equipment as the baseline. The 2015 TRM does not offer guidance on the baseline equipment when there is no previous cooling equipment, but the 2016 TRM states that when assuming no existing cooling, a standard efficiency central air conditioner should be used as the cooling baseline.[78] EEMIS assumed an air source heat pump baseline when calculating PY7 savings.

For whole house fans, TRM energy savings are deemed based on location. EEMIS assumed that all whole house fans would be installed in Allentown, Pennsylvania, so every whole house fan had the same savings estimate of 204 kWh/yr. From zip code mapping, Cadmus determined that some whole house fans were installed in other cities and adjusted *ex ante* savings according to the results of zip code mapping.

[78] Pennsylvania Public Utility Commission. *Technical Reference Manual.* June 2016. Table 2-11. Page 34-35. Available online: http://www.puc.pa.gov/Electric/pdf/Act129/Act129_TRM-2016_Redlined-Final.pdf

For the ductless heat pump, central air conditioner, and ECM furnace fan strata, Cadmus calculated adjusted *ex ante* savings using inputs from EEMIS and the TRM and found no discrepancies.

### Pool Pumps

For PY7 pool pumps, substantial changes to algorithms between the 2014 TRM and the 2015 TRM led to much lower energy savings and demand reductions for installations in PY7 that used the 2015 TRM to calculate savings.

One of the most significant changes to the 2015 TRM pool pump algorithms was that hours of use and kilowatts were broken out by filter mode and clean mode. Table 7-7 shows the differences between 2014 TRM and 2015 TRM efficient pool pump energy algorithms.

**Table 7-7. Pennsylvania PUC TRM Pool Pumps Energy Algorithms**

| | |
|---|---|
| **2014 TRM[1]** | $\Delta kWh/yr = kWh/yr_{base} - kWh/yr_{VFD}$<br>$kWh/yr_{base} = HOU_{ss} \times kW_{ss} \times Days$<br>$\mathbf{kWh/yr_{VFD} = (HOU_{VFD} \times kW_{VFD}) \times Days}$ |
| **2015 TRM[2]** | $\Delta kWh/yr = kWh/yr_{base} - kWh/yr_{VFD}$<br>$kWh/yr_{base} = HOU_{ss} \times kW_{ss} \times Days$<br>$\mathbf{kWh/yr_{VFD} = [(HOU_{VFD,clean} \times kW_{VFD,clean}) + (HOU_{VFD,filter} \times kW_{VFD,filter})] \times Days}$ |
| [1] Pennsylvania Public Utility Commission Technical Reference Manual. June 2014. Page 183.<br>[2] Pennsylvania Public Utility Commission Technical Reference Manual. June 2015. Page 210. | |

For pool pumps installed in PY6, Cadmus used the 2014 TRM and a default value of 0.171 for $kW_{VFD}$. For pool pumps installed in PY7, Cadmus used the 2015 TRM and $kW_{VFD, clean}$ and $kW_{VFD, filter}$ values recorded by the ICSP because EEMIS does not record these inputs and the TRM does not offer default values. This change led to lower kWh/yr savings using the 2015 TRM because $kW_{VFD, clean}$ and $kW_{VFD, filter}$ values were much higher than the 2014 deemed value of 0.171.

This breakout of hours of use and kilowatts by filter mode and clean mode also affected demand reduction calculations. Table 7-8 shows the differences between 2014 TRM and 2015 TRM efficient pool pump demand algorithms.

**Table 7-8. Pennsylvania PUC TRM Pool Pumps Demand Algorithms**

| | |
|---|---|
| **2014 TRM** | $\Delta kW_{peak} = kW_{basepeak} - kW_{VFDpeak}$<br>$kW_{basepeak} = (CF_{SS} \times kW_{SS})$<br>$\mathbf{kW_{VFDpeak} = (CF_{VFD} \times kW_{VFD})}$ |
| **2015 TRM** | $\Delta kW_{peak} = kW_{basepeak} - kW_{VFDpeak}$<br>$kW_{basepeak} = (CF_{SS} \times kW_{SS})$<br>$kW_{VFDpeak} = \frac{[(HOU_{peak,clean} \times kW_{VFD,clean}) + (HOU_{peak,filter} \times kW_{VFD,filter})]}{4\ hours} \times CF_{VFD}$ |

The most substantial change in demand was because of the coincidence factor of the efficient pool pump ($CF_{VFD}$). In the 2014 TRM, $CF_{VFD}$ has a deemed value of 0 (zero), so that the $kW_{VFDpeak}$ algorithm always equaled 0 (zero). With the 2015 TRM, $CF_{VFD}$ is determined using data gathered from the participant's records. From the ICSP's inputs of $HOU_{peak, filter}$ Cadmus determined that the $CF_{VFD}$ equaled 1. This change led to substantially lower demand reductions for units installed in PY7. Demand reductions ranged from 0.61 to -7.22 kW for pool pump records with installation dates in PY7.

### Fuel-Switching

EEMIS does not supply the necessary inputs for Cadmus to calculate *ex ante* adjusted savings so Cadmus did not adjust EEMIS' *ex ante* reported savings.

### *HERS Approach New Homes*

Cadmus reviewed the supporting documentation for 40 HERS approach rebate applications in PY7.[79] The HERS approach requires that the home receive a HERS rating from an accredited rater.[80] The rater performs energy modeling, typically using the software REM/Rate, to forecast the energy savings of the homes.

Cadmus reviewed the REM/Rate files and fuel reports provided with the rebate applications and modeled the savings using REM/Rate and the program's user-defined reference home (UDRH) specifications. Cadmus calculated *ex ante* adjusted savings using the temperature-sensitive savings found on the fuel reports.

The program reported only demand reduction for dishwashers and refrigerators.

Cooling equipment demand reduction came from both the direct savings of installing a high-efficiency cooling system and from the reduced load on the cooling system from proper air sealing and efficiency windows and insulation. This approach is defined in the TRM. EEMIS does not contain the necessary information to calculate cooling equipment demand reduction, so Cadmus calculated this using the cooling load reduction contained in the REM/Rate files. Because the demand reduction from cooling was quite large, the adjustment factor for demand savings was 7,210%.

A home's construction process can span months or even years. Additionally, different parts of home construction have baselines defined by either state or federal minimum standards. Envelope improvements such as windows, insulation, and air sealing have minimum standards defined by the state energy code in effect when the home received its building permit. Appliances and HVAC equipment such as heat pump water heaters, heat pumps, dishwashers, and refrigerators have minimum standards defined by federal regulation in effect when the system was installed. Because of these factors, both the 2014 TRM and the 2015 TRM were used to calculate *ex post* evaluated savings depending on building permit date and the installed date of equipment. A significant update raised the baseline of air source heat pump from 7.7 HSPF and 13 SEER in the 2014 TRM to 8.2HSPF and 14 SEER in the 2015 TRM.

### *Prescriptive Path New Homes*

Cadmus reviewed the supporting documentation for both of the prescriptive path new construction rebate applications and, as with the HERS new homes approach, used the 2014 and the 2015 TRMs to calculate *ex ante* adjusted savings according to the date on the building permit and installed equipment.

### *Manufactured Homes*

Cadmus reviewed the supporting information for the one rebate submitted for manufactured homes in PY7 and modeled savings using REM/Rate and the supporting documentation. Cadmus found the home to be better insulated and tighter than the minimum requirements of ENERGY STAR manufactured homes, leading to an adjustment factor of 111% for energy savings and 234% for demand reduction.

## 7.2.5 *Ex Post* Savings Methodology and Findings

Cadmus calculated *ex post* verified energy savings and demand reductions for each product in the sample using parameter values sourced from the supporting documentation provided by the ICSP and the algorithms in the 2014 and 2015 TRMs (for installations in PY6 and PY7, respectively). From the verified savings, Cadmus calculated weighted realization rates by stratum using findings from the projects selected

79 HERS is the Home Energy Rating System developed by RESNET, the Residential Energy Services Network.

80 A HERS Rating involves an independent rater gathering data on a home during several visits during the construction process. The rater verifies the energy improvements and performs tests to develop an energy model of the home.

into the verification sample then applied the appropriate realization rate to all records in the stratum to calculate the *ex post* evaluated savings in PY7.

Cadmus' final estimate of program-wide savings employed a single realization rate, which was calculated by first aggregating savings by customer (for adjusted *ex ante* and for *ex post*) then calculating a single realization rate that applied to the program-wide adjusted *ex ante* total. Because this approach employed a single realization rate, rather than a collection of interdependent realization rates, standard variance calculations yielded valid program-wide precision estimates.

Evaluation results of energy savings, demand reduction, and realization rates are provided in Table 7-11 and Table 7-12 (in Section 7.2.7 Summary of Evaluation Results).

#### 7.2.5.1 Summary of *Ex Post* Analysis by Stratum

##### *Audit*

For the records review of the audit stratum, Cadmus selected a random sample stratified by audit type (home audits and home surveys) then calculated the *ex post* energy savings and demand reduction. Cadmus did not separate realization rates by audit type; instead, it used the realization rate for the entire audit stratum.

Cadmus found no discrepancies in quantities in the PY7 records reviews. Because the Residential Home Comfort Program contributes a small percentage of savings to PPL Electric Utilities' portfolio, Cadmus did not conduct surveys of audit participants in PY7. Instead, it compared PPL Electric Utilities' PY5 survey installation rates with the in-service rate assumptions in the 2014 and 2015 TRMs, as shown in Table 7-9. Where noted, Cadmus assumed the in-service rate determined through the PY5 surveys.

**Table 7-9: PY7 Residential Home Comfort Program In-Service Rate Adjustments**

| TRM | Measure Category | PY7 Population | Reviewed in PY7 Verification Sample | In-Service Rate | |
|---|---|---|---|---|---|
| | | | | TRM Default | Cadmus Verified |
| 2014 | Aerators | 5 | 0 | None | Assume PY5 97% |
| | Showerheads | 5 | 0 | None | Assume PY5 88% |
| | LEDs | 37 | 0 | 97% | 97% |
| | LED Nightlights | 16 | 0 | 97% | 97% |
| | Smart Strips | 11 | 0 | None | None |
| | Pipe Insulation | 3 | 0 | None | None |
| 2015 | Aerators | 94 | 4 | None | Assume PY5 97% |
| | Showerheads | 141 | 5 | None | Assume PY5 88% |
| | Thermostatic Restriction Valve | 12 | 0 | None | Assume PY5 88% |
| | LEDs | 1,003 | 40 | 97% | 97% |
| | LED Nightlights | 519 | 22 | 97% | 97% |
| | Furnace Whistles | 15 | 1 | 47% | 47% |
| | Smart Strips | 443 | 20 | 100% | 100% |
| | Pipe Insulation | 228 | 11 | None | None |
| | Water Heater Setback | 64 | 5 | None | None |

Because there were so few thermostatic restriction valves installed in PY7, Cadmus did not confirm in-service rates through phone surveys and instead applied the 88% showerhead in-service rate from the PY5 phone surveys. Cadmus determined that the showerhead in-service rate was the most appropriate to apply to thermostatic restriction valves because there were no substantial changes in the delivery of the products or recipients receiving the products and the products have very similar applications.

For the audit component, the realization rate for energy savings and demand reduction was 100%.

### *Weatherization*

In the PY7 review, Cadmus found three records where the square footage and R-base recorded in EEMIS did not match the rebate form; therefore, it calculated *ex post* savings using the quantities from the rebate form.

Cadmus found six weatherization records where the measure code reported in EEMIS did not match the heating or cooling equipment recorded on the rebate form. Energy savings and demand reduction algorithms vary depending on the heating and cooling equipment present in the home. Cadmus calculated *ex post* energy savings using the algorithm corresponding to the heating or cooling equipment found on the rebate form.

Cadmus found eight records with incorrectly assigned baseline R-values. For insulation products, both the 2014 TRM and 2015 TRM savings algorithms employ parameters for the baseline and efficient R-values of insulation. Both TRMs stipulate a minimum baseline R-value of R5 for an uninsulated space. The baseline R-value recorded in EEMIS and on the rebate form should be R5 and not 0 (zero). Cadmus used the TRM-stipulated minimum of R5 to calculate *ex post* savings.

Lastly, Cadmus used inputs from rebate forms to update the existing cooling equipment seasonal energy efficiency rating (SEER) and existing heating equipment heating seasonal performance factor (HSPF) for 27 records.

Once Cadmus updated inputs from the records review, it calculated *ex post* savings using TRM algorithms. Cadmus found several errors in the ICSP's *ex ante* savings calculations that affected the realization rate, including using incorrect $UES_{COOL}$ values for air sealing products, using the incorrect TRM algorithm for cooling savings, and not calculating cooling savings for products with room air conditioners as the cooling type.

The PY7 weatherization component's realization rate was 88% for energy savings and demand reduction.

### *HVAC Efficient Equipment*

All verified input parameters for air source heat pumps matched those reported in EEMIS, with three exceptions. For these three records, Cadmus found discrepancies between the capacity and efficiency values reported in EEMIS and on the AHRI certificate or on the rebate forms. To calculate *ex post* savings for these records, Cadmus used the parameters found on the AHRI certificates or rebate forms.

Cadmus found 11 ductless heat pump records with inaccuracies in parameter values such as the SEER, capacity, HSPF, or baseline heating system of either the existing or installed equipment. Cadmus calculated verified savings using values observed on the application forms and AHRI certificates.

For central air conditioners, all verified input parameters matched those reported in EEMIS, with one exception. One record was a ductless heat pump, not a central air conditioner. Cadmus removed this record from the *ex post* savings analysis.

For ECM furnace fans and whole house fans, all verified input parameters matched those reported in EEMIS.

Based on these adjustments, the HVAC efficient equipment stratum's realization rate was 99% for energy savings and 96% for demand reduction.

#### *Pool Pumps*

Because changes to the pool pump stratum were made as *ex ante* adjustments, its PY7 realization rate was 100% for energy savings and demand reduction.

#### *Fuel-Switching*

Fuel-switching rebates were offered to customers who used electric heat and installed new efficient non-electric space-heating equipment. Cadmus reviewed the supporting documentation for all 23 fuel-switching rebates reported in PY7. Fourteen records provided the complete information necessary to calculate savings using the algorithms from the 2014 TRM and 2015 TRM protocols. However, Cadmus could not verify savings for the remaining nine records, for which the existing heating equipment capacity was missing.

Of the 14 records that could be verified, two of the records' previous heating equipment was a natural gas furnace, leading to 0 (zero) savings for those records. A separate furnace was not ENERGY STAR-rated; therefore, the unit did not qualify and no savings were verified.

The PY7 fuel-switching stratum had a 227% energy savings realization rate. The fuel-switching pilot produces only heating savings; therefore, it does not produce demand reduction.

#### *HERS Approach New Homes*

Cadmus calculated *ex post* savings, using the values it produced by checking and rerunning the REM/Rate models. These adjustments resulted in realization rates of 101% for energy savings and 100% for demand reduction.

#### *Prescriptive Path New Homes*

Cadmus calculated *ex post* savings using the rebate application data and TRM algorithms for all rebated equipment , resulting in 100% realization rates for energy savings and demand reduction.

#### *Manufactured Homes*

Cadmus calculated *ex post* savings using the values it produced by checking and rerunning the REM/Rate models, resulting in 100% realization rates for energy savings and demand reduction.

### 7.2.6 Site Visits

The ICSP conducted verification site visits for the Residential Home Comfort Program, with a goal to visit about 5% of the jobs. These site visits were for QA/QC purposes; therefore, Cadmus did not use the ICSP's data to verify savings. Table 7-10 lists high-level information about the ICSP's site visits.

**Table 7-10: PY7 Residential Home Comfort Summary of Site Visits Conducted by ICSP**

| Measure | Inspection Firm | Inspections Conducted | Sites with Discrepancies from Reports | Resolution of Discrepancies |
|---|---|---|---|---|
| Pool Pumps | ICSP | 12 | 0 | N/A |
| Air Source Heat Pump | ICSP | 387 | 0 | N/A |
| ECM Fan | ICSP | 0 | 0 | N/A |
| Ductless Heat Pump | ICSP | 69 | 0 | N/A |
| Central Air Conditioner | ICSP | 140 | 0 | N/A |
| Weatherization | ICSP | 89 | 0 | N/A |
| Survey | ICSP | 52 | 1 | ▪ Customer did not receive energy report; surveyor sent report |
| Audit | ICSP | 37 | 2 | ▪ Rebate issued to contractor; customer will contact contractor to resolve<br>▪ Blower door test number had large variance; determined reason for variance |
| New Home | ICSP | 13 | 0 | N/A |
| Manufactured Home | ICSP | 8 | 0 | N/A |
| Fossil Fuel Furnace or Boiler | ICSP | 7 | 1 | ▪ Heat pump replaced with heat pump and gas auxiliary; contractor could not be identified |

## 7.2.7 Summary of Evaluation Results

Table 7-11 provides the verified gross energy savings, the realization rates, and the precision around the estimates by stratum and for the program in aggregate. The Residential Home Comfort Program achieved verified gross energy savings of 12,157 MWh/yr and a realization rate of 99% over adjusted *ex ante* energy savings with precision of 2.45% at the 85% confidence level.

**Table 7-11: PY7 Residential Home Comfort Program Summary of Evaluation Results for Energy [1]**

| Stratum | Reported Gross Impact (MWh/yr) | Adjusted *Ex Ante* Energy Savings (MWh/yr) | Energy Realization Rate (%) | Verified Gross Energy Savings (MWh/yr) [2] | Observed Coefficient of Variation (Cv) Error Ratio (ER ), or Proportion in Sample Design | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Audit | 254 | 260 | 100% | 260 | N/A | 0.00% |
| Efficient Equipment - HVAC | 9,912 | 10,195 | 99% | 10,102 | 0.0886 | 1.12% |
| Efficient Equipment - Pool Pumps | 415 | 295 | 100% | 295 | N/A | 0.00% |
| Fuel-Switching | 102 | 58 | 227% | 131 | 1.2660 | 0.00% |
| New Homes - HERS | 971 | 968 | 101% | 976 | 1.2807 | 28.56% |
| New Homes - Manufactured Homes | 3 | 4 | 100% | 4 | N/A | 0.00% |
| New Homes - Prescriptive | 6 | 6 | 100% | 6 | N/A | 0.00% |
| Weatherization | 435 | 435 | 88% | 383 | 0.3876 | 6.44% |
| **Program Total [3]** | **12,099** | **12,220** | **99%** | **12,157** | **N/A** | **2.45%** |

[1] Values in this table refer to savings at the point of consumption. (Savings targets for MWh refer to values at the point of consumption.) Due to line losses, savings at the point of generation are systematically larger.
[2] Adjusted *ex ante* multiplied by the realization rate will not equal verified gross energy savings due to rounding.
[3] Differences in total due to rounding.

Table 7-12 provides the verified gross demand savings, the realization rates, and the precision around the estimates by stratum and for the program in aggregate. The Residential Home Comfort Program achieved verified gross demand savings of 3.406 MW/yr, plus or minus 1.64%, and a realization rate of 96% over adjusted *ex ante* demand savings.

**Table 7-12: PY7 Residential Home Comfort Program Summary of Evaluation Results for Demand**

| Program | Reported Gross Demand Savings [1] (MW) | Adjusted *Ex Ante* Demand Savings [2] (MW) | Demand Realization Rate (%) | Verified Gross Demand Savings (MW) [2] | Observed Coefficient of Variation (Cv) Error Ratio (ER ), or Proportion in Sample Design | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Audit | 0.024 | 0.027 | 100% | 0.027 | N/A | 0.00% |
| Efficient Equipment - HVAC | 2.517 | 3.178 | 96% | 3.043 | 0.1458 | 1.85% |
| Efficient Equipment - Pool Pumps | 0.012 | (0.026) | 100% | (0.026) | N/A | 0.00% |
| Fuel-Switching | - | - | N/A[3] | - | N/A[3] | N/A[3] |
| New Homes - HERS | 0.004 | 0.336 | 100% | 0.336 | N/A | 0.00% |
| New Homes - Manufactured Homes | 0.000 | 0.000 | 100% | 0.000 | N/A[4] | N/A[4] |
| New Homes - Prescriptive | 0.001 | 0.001 | 100% | 0.001 | N/A | 0.00% |
| Weatherization | 0.027 | 0.029 | 88% | 0.025 | 0.4771 | 7.93% |
| **Program Total [5]** | **2.585** | **3.544** | **96%** | **3.406** | **N/A** | **1.64%** |

[1] Reported gross demand reductions do not include the gross-up to reflect T&D losses.
[2] Adjusted *ex ante* and verified gross demand reductions include T&D losses.
[3] Fuel-switching does not realize demand reduction, so realization rates and precision are not applicable.
[4] There was only one sample point in the New Homes – Manufactured Homes stratum, so realization rates and precision are not applicable.
[5] Difference in total due to rounding.

## 7.3 IMPACT EVALUATION NET SAVINGS

The methods used to determine net savings for downstream programs are provided in the Evaluation Framework and Guidance Memos, which discuss the common methods to determine freeridership and spillover in downstream programs. Freeridership is a measure of the savings that participants would have achieved on their own in the absence of the program; these savings are subtracted from verified gross savings. Participant spillover, on the other hand, credits additional savings that participants achieved on their own, where their experience with the program was highly influential in their decision to install energy-efficient equipment without the incentive of rebates. Participant spillover adds to gross savings.

Net savings are determined only for future program planning purposes. Energy savings and demand reduction compliance targets are met using verified gross savings. Cadmus determined net savings by assessing freeridership and spillover.

### 7.3.1 Net-to-Gross Ratio Methodology

In PY7, Cadmus determined freeridership and spillover using data collected from efficient equipment self-report surveys with participating customers in the Residential Home Comfort Program. *Addendum B* provides additional detail about the net savings methodology and survey questions used for this analysis.

Cadmus used the PY5 audit and weatherization freeridership and spillover estimates that were calculated from data collected through participant telephone surveys. These two program components had no significant changes, rebates were the same in PY7 as they were in PY5 and PY6, and there were no significant changes in the participant population. Therefore, no significant changes in freeridership and spillover were expected, and Cadmus applied PY5 results.

There was one participant in the manufactured homes component in PY7. Because of low participation, Cadmus did not conduct an interview with the manufactured homes purchaser. Furthermore, the PY6 surveys with four manufactured home purchasers did not draw meaningful conclusions about freeridership and spillover.

### 7.3.2 Net-to-Gross Ratio Sampling

Cadmus selected a stratified, random sample by equipment type for its NTG research and set these targets for completed surveys:

- 70 each for air source heat pump, central air conditioner, ductless heat pump, and pool pump participants
- 4 ECM furnace fan participants
- 3 whole house fan participants

Cadmus met its sampling targets for air source heat pump and central air conditioner participants, exceeded its ductless heat pump sampling target by one participant, and completed 13 pool pump participant surveys. However, it was not able to contact any ECM furnace fan or whole house fan participants.

Table 7-13 reports the sampling strategy for the equipment participants receiving rebates who were contacted in PY7.

**Table 7-13: PY7 Residential Home Comfort Program Sampling Strategy PY7 Net-To-Gross Research**

| Stratum | Stratum Boundaries | Population Size[1] | Assumed Cv or Proportion in Sample Design | Assumed Levels of Confidence & Precision | Target Sample Size | Achieved Sample Size | Percent of Sample Frame Contacted to Achieve Sample[2] |
|---|---|---|---|---|---|---|---|
| Equipment | PPL Electric Utilities customers receiving a rebate for equipment | 5,929 | 0.5 | 90/10 | 287 | 224 | 55% |

[1] Survey population size is from PY7 Q1 – Q4 and does not include Q4+ participants. Therefore, the survey population is smaller than the total PY7 population.
[2] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means of all the sample frame how many were called to achieve the targeted completes.

### 7.3.3 Net-to-Gross Ratio Findings

The freeridership and spillover ratio estimates for the Residential Home Comfort Program, estimated in accordance with the Evaluation Framework, are shown in Table 7-14. In PY7, primary research was conducted only for the efficient equipment stratum (program component). Cadmus applied NTG ratios developed in PY5 for the audit and weatherization strata to arrive at a NTG ratio of 61% for PY7, weighted by verified energy savings.

**Table 7-14: PY7 Residential Home Comfort Program**
**Summary of Evaluation Results for Net-to-Gross Research**

| Target Group or Stratum | Estimated Freeridership[1] | Estimated Participant Spillover | NTG Ratio | Observed Coefficient of Variation or Proportion | Relative Precision at 90% C.L. |
|---|---|---|---|---|---|
| Audit | 18% | 10% | 0.92 | PY5 results | |
| Efficient Equipment | 47% | 4% | 0.57 | 0.134 | 22% |
| Weatherization | 35% | 8% | 0.73 | PY5 results | |
| New Construction | N/A | | | | |
| Manufactured Homes | N/A | | | | |
| **Program Total** | ***Ex Post* Savings Weighted program level NTG estimate: 0.61[2]** | | | | |

[1]These estimates were weighted by the survey sample-verified program kWh/yr savings. This method ensures that respondents who achieved higher energy savings through the program products have a greater influence on the measure-level freeridership estimate than do the respondents who achieved lower energy savings.
[2]The product-level NTG estimates were weighted by the measure's *ex post* kWh/yr program population savings to arrive at the final NTG estimate of 61%.

Table 7-15 presents the product-level freeridership, spillover, and NTG ratios for the efficient equipment stratum. The overall efficient equipment average freeridership estimate of 47% is weighted by each measure type's verified gross population energy savings.

**Table 7-15: PY7 Residential Home Comfort Program**
**Summary of Evaluation Results for Net-to-Gross Research of Efficient Equipment Stratum**

| Measure | n | Estimated Freeridership | Estimated Participant Spillover | NTG Ratio | Verified Gross Energy Savings (MWh/yr) |
|---|---|---|---|---|---|
| Air Source Heat Pump | 70 | 39% | 7% | 0.68 | 3,087 |
| Central Air Conditioning | 70 | 58% | 5% | 0.47 | 280 |
| Ductless Mini Split Heat Pump | 71 | 51% | 2% | 0.51 | 6,732 |
| Pool Pump | 13 | 29% | 1% | 0.72 | 295 |
| **Efficient Equipment Verified Gross Energy Savings (MWh/yr) Weighted Average** | **224** | **47%** | **4%** | **0.57** | |

In PY7, product-level efficient equipment stratum freeridership was lower than the freeridership estimated in PY5 for comparable equipment types,[81] as shown in Table 7-16. No primary NTG analysis was conducted in PY6.

**Table 7-16: PY7 Residential Home Comfort Program**
**Efficient Equipment Stratum Measure-Level Net-to-Gross for PY5 and PY7**

| Measure | PY5 Estimated Freeridership | PY7 Estimated Freeridership |
|---|---|---|
| Air Source Heat Pump | 61% | 39% |
| Ductless Mini Split Heat Pump | 55% | 51% |
| Pool Pumps | 56% | 29% |

81 Central air conditioning was not included in the PY5 efficient equipment stratum analysis sample.

The drop in freeridership for air source heat pumps and pool pumps from PY5 to PY7 can be attributed to the higher rebate amounts in PY7 compared to PY5. In PY5, 97% of the air source heat pump survey respondents received a program rebate of $200 or less. In PY7, 80% of air source heat pump survey respondents received a program rebate of $1,200. In PY5, all pool pump survey respondents received a $150 rebate. In PY7, 92% of pool pump survey respondents received a $350 rebate.

## 7.4 PROCESS EVALUATION

### 7.4.1 Research Objectives

Process evaluation topics were these:

- Program delivery
- Customer response
- Participant purchase patterns and decision-making
- Recommendations for program improvements and other process issues

### 7.4.2 Evaluation Activities

For the Residential Home Comfort Program, the PY7 process evaluation activities included these:

- Program staff and implementer interviews (n=2)
- Participant surveys (n=286) [82]
- Program database review for survey efforts

The Evaluation Framework requires one process evaluation per program per phase. Cadmus conducted a full process evaluation for this program in PY6, for Phase II. In PY7, research activities were limited and consistent with the evaluation plan, except for the surveys with manufactured homes purchasers. Because only one customer participated in this component of the program, Cadmus did not survey the manufactured homes purchaser in PY7.

Originally, Cadmus planned to conduct 62 audit and weatherization surveys and 210 equipment surveys. Cadmus added these three new rebated products to the equipment survey sample—central air conditioners, ECM furnace fans, and whole house fans. Because the survey sample was prorated by equipment type, this raised the survey target from 210 to 287.

### 7.4.3 Methodology

Table 7-17 summarizes the process evaluation's sampling plan for the Residential Home Comfort Program for PY7. See *Addendum A. Participant Survey Methodology* for more details about the participant survey.

82 Cadmus administered a cross-program survey that included participants of the Appliance Recycling, Residential Retail, and Residential Home Comfort programs. Cadmus completed 480 cross-program surveys. This chapter discusses only the results from the Residential Home Comfort Program respondents (n=286).

**Table 7-17: Residential Home Comfort Process Evaluation Sampling Strategy for PY7**

| Stratum/ Survey | Stratum Boundaries | Population Size | Assumed Proportion or Cv in Sample Design | Assumed Levels of Confidence & Precision | Target Sample Size | Number of Records Selected for Sample Frame | Achieved Sample Size | Percent of Sample Frame Contacted to Achieve Sample[1] | Used For Evaluation Activities (Impact, Process, NTG) |
|---|---|---|---|---|---|---|---|---|---|
| PPL Electric Utilities Program and ICSP Staff | Staff | 2 | N/A | N/A | 2 | 2 | 2 | 100% | Process, program staff interviews, census |
| Participant Survey | Audit and Weatherization participants, Efficient Equipment participants | 6,880 | 0.5 | 90/10 | 349 | 4,341[2] | 286 | 62% | Process, estimate low-income participation, NTG, residential program participants, probability sample, simple random sample |

[1] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means the percentage of the sample frame called to complete interviews.
[2] The population consisted of 6,880 records; Cadmus removed 880 records because they were duplicates, were included in other sample frames, were inactive customers, were incomplete records, had completed a survey in the past three months, or had requested not to be contacted. Cadmus then selected a random sample of 4,341 records.

#### 7.4.3.1 Program Staff and Implementer Interviews

Cadmus conducted telephone interviews with two Residential Home Comfort Program managers—one at PPL Electric Utilities and the other at the ICSP. The purpose of these interviews was to ensure Cadmus thoroughly understood all of the program offerings, the delivery and marketing strategies, and to obtain stakeholder perspectives on program successes and challenges.

#### 7.4.3.2 Participant Survey

In July 2016, Cadmus conducted a survey that targeted customers who had participated in any one of these residential rebate programs—Appliance Recycling, Residential Home Comfort (equipment, weatherization, and audit), and Residential Retail (heat pump water heaters and refrigerators).

The participant surveys had four main objectives:

- Assess customer satisfaction
- Evaluate the program processes and net savings for the equipment stratum
- Determine the impact of the program on the decision to replace non-electric heating equipment with electric equipment
- Gather details about low-income participation

Participants of the equipment stratum were asked questions about program satisfaction, program processes, challenges to making energy efficiency upgrades, and questions that informed the net savings analysis. Participants who installed multiple products in the equipment stratum were asked about the product that generated the largest savings.

Participants of the program who switched from non-electric to electric heating equipment and received a rebate answered questions about the impact of the program on their decision to switch.

The audit stratum participants answered questions about their satisfaction with the program and provided demographic data. This survey was not used to gather details for the net savings analysis.

Cadmus selected a stratified, random sample by program and equipment type. It excluded any customers who had participated in surveys within the last three months, requested not to be contacted, were duplicates, had incomplete information, were included in samples selected for other program surveys, or were inactive accounts. Cadmus completed 286 surveys with participants of the Residential Home Comfort Program, 62 of whom participated in the audit and weatherization offering.

Potential sources of bias in the surveys included nonresponse, recall, and social desirability biases. Cadmus attempted to mitigate these sources of bias by applying random sampling whenever possible and using survey design and survey data collection best practices. Surveys were designed to include questions that were not leading or ambiguous, were not double-barreled, and provided clear interviewing and programming instructions so that they could be implemented consistently across interviewers and surveys. Cadmus also attempted to reach respondents up to five times over several days, calling at different times of the day, and scheduled callbacks whenever possible.

### 7.4.4 Achievements Against Plan

Table 7-18 contains the program's energy savings and incentive plans and the progress on these plans through the end of PY7.

**Table 7-18: Residential Home Comfort Program Savings**

| | PY5 Verified | PY6 Verified | PY7 | | | Phase II: PY5-PY7 | | |
|---|---|---|---|---|---|---|---|---|
| | | | Planned [1] | Verified | Percentage of Planned | Planned [1] | Verified [2] | Percentage of Planned |
| MWh/yr | 2,410 | 4,083 | 9,302 | 12,157 | 131% | 15,268 | 18,649 | 122% |
| MW | 1.0 | 1.75 | 1.49 | 3.41 | 174% | 2.34 | 6.15 | 263% |
| Participation | 2,554 | 4,269 | 7,280 | 7,947 | 109% | 14,375 | 14,770 | 103% |

[1] PPL Electric Utilities' revised EE&C plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, Table F6, p.65.
[2] Difference in total due to rounding.

The primary reason the program exceeded its planned MWh/yr and MW savings in Phase II was because the verified savings were calculated using rebate-specific parameters, which yielded higher savings than the deemed, reported savings. The updates to the 2015 TRM algorithm for ductless heat pump were the primary driver for exceeding planned energy savings in PY7.

### 7.4.5 Program Delivery

The Residential Home Comfort Program is an established program that was created from the Phase I Residential Home Assessment and Weatherization and Efficient Equipment programs. It provides residential customers with a selection of energy-saving products to increase the comfort of their home. PPL Electric Utilities program staff and the ICSP deliver the program.

Eligibility for weatherization rebates requires that the customer receive an energy audit first. For PY7, the conversion rate (percentage of audit customers who followed through and installed recommended weatherization products) was approximately 38%.

PPL Electric Utilities and the ICSP noted that the high upfront cost of an audit continued to be a barrier to participation in PY7 (the cost is typically $350 to $650 to the customer). The rebate returned up to $250 of the cost (depending on the heating and cooling equipment), but customers had to wait to receive it.

Ductless heat pumps were the top contributors to program savings in PY7, accounting for over half of the program's reported energy savings. The large increase in energy savings was attributed to the updates to the ductless heat pump algorithm in the 2015 TRM, which involved adding an oversize factor and duct leakage factor to the algorithm to account for the fact that the baseline unit is typically oversized and that a percentage of the energy is lost to duct leakage (in ducted systems, but not ductless systems).

In PY7, the new homes prescriptive path and manufactured homes offerings (described in the introduction of this chapter) continued not to perform as well as expected. Only two prescriptive path homes and one manufactured home participated. The ICSP noted it had difficulties promoting the manufactured homes component to manufacturers and salespeople. PPL Electric Utilities believed that the $1,200 rebate may not have been enough to entice manufactured homes buyers. In addition, in PY6, the four manufacturers Cadmus interviewed said that a very low percentage of manufactured homes used electric heat.

PPL Electric Utilities and the ICSP stated that the rigidity of the prescriptive path (namely, that the builder had to install specific products to receive a rebate) led to low participation; they said builders believed the product requirements were too strict. In PY6 builder interviews, builders stated that they wanted more flexibility to qualify a home for the program rebate. Builders also said they typically do not offer appliance packages in their new homes, yet two of the required products in the prescriptive option—ENERGY STAR refrigerators and dishwashers—are appliances.

The HERS new home approach, on the other hand, flourished in PY7. In this approach, builders received a rebate of $0.30 per annual kWh saved (up to $2,000) for homes built with any combination of a specific package of products. By the end of PY7, 516 new homes received program rebates. PPL Electric Utilities and the ICSP believed that the HERS program component's increased flexibility of allowing builders to pick from a list of products led to its success.

### 7.4.5.1 Key Performance Indicators

Besides energy savings and participation targets, PPL Electric Utilities and the ICSP identified two key performance indicators that they track internally to measure how well the program is performing. Table 7-19 shows these key performance indicators with the PY7 results.

**Table 7-19: Residential Home Comfort Program Key Performance Indicators**

| Key Performance Indicator | Metric | Goal | PY7 Result |
|---|---|---|---|
| Customer Satisfaction | Satisfaction rating determined from participant telephone or online surveys conducted by Cadmus | 80% of respondents satisfied with the program | Met goal. 81% were *very satisfied* and 17% were *somewhat satisfied.* |
| Customer Complaints | Number of complaints | 0 complaints | Did not meet goal |

In PY7, PPL Electric Utilities did not meet its internal key performance indicator goal for no customer complaints. Toward the end of PY7, PPL Electric Utilities received several complaints from customers who had mailed rebate applications after the deadline, which were consequently rejected by the ICSP. PPL Electric Utilities rectified all of the complaints by honoring the rebates.

The ICSP tracks several other metrics internally but does not set specific goals. These metrics include the number of applications rejected each month, the number of approved auditors, and rebate processing times. The ICSP also tracks traffic on the program webpage.

### 7.4.5.2 Program Updates and Outcomes

In PY7, PPL Electric Utilities added air sealing, ECM furnace fans, whole house fans, central air conditioners, and above-ground pool pumps to the Residential Home Comfort Program to increase energy savings and help PPL Electric Utilities meet its energy and demand reduction targets for Phase II. PPL Electric Utilities worked closely with the ICSP to determine which products customers would be most interested in and that trade allies could easily offer. These new products were successful in increasing savings. PPL Electric Utilities began ramping down its marketing efforts in mid-PY7 so that it would not exceed Phase II planned savings targets.

*Central Air Conditioners*

Central air conditioners were well-received by customers in PY7. More than 1,000 rebates were processed (for $250 each), leading to over 280,000 kWh/yr in reported energy savings. Both PPL Electric Utilities and the ICSP were pleasantly surprised at the number of customers who submitted central air conditioner rebate forms; PPL Electric Utilities had projected it would receive approximately 500 rebate forms in PY7.

The ICSP hypothesized that as customers replaced old furnaces, they took advantage of PPL Electric Utilities' rebate and replaced their central air conditioning equipment as well. The survey found that, of the 70 respondents who received a central air conditioner rebate, 44 (63%) stated they had decided to purchase a new central air conditioner to replace old or outdated equipment.

*Air Sealing*

Sixty-two air sealing projects were completed in PY7, accounting for approximately 55,000 kWh/yr in reported energy savings. PPL Electric Utilities elected to offer this measure in PY7 because BPI professionals recommended air sealing a home before insulating it to generate larger energy savings.

*ECM Furnace Fans, Whole House Fans, and Above-Ground Pool Pumps*

These equipment types experienced low uptake in PY7. Five ECM furnace fans, three whole house fans, and four above-ground pool pumps were installed through the program. The ICSP stated that installation costs most likely deterred customers from installing whole house fans. PPL Electric Utilities and the ICSP believed that the requirement that ECM furnace fans had to replace existing PSC motor fans led to low participation for that product.

### 7.4.6 Participant Profile

Table 7-20 compares participation for each stratum across Phase II.

**Table 7-20: Residential Home Comfort Program Phase II Participation**

| Stratum | PY5 | PY6[1] | PY7 | Phase II Total |
|---|---|---|---|---|
| Audit | 560 | 1,066 | 707 | 2,333 |
| Weatherization | 88 | 218 | 271 | 577 |
| Efficient Equipment - HVAC | 1,836 | 2,930 | 6,179 | 10,945 |
| Efficient Equipment – Pool Pumps | 70 | 55 | 248 | 373 |
| Fuel-Switching | N/A[2] | 24 | 23 | 47 |
| RNC – HERS Option | N/A[2] | 28 | 516 | 544 |
| RNC – Manufactured Homes | N/A[2] | 6 | 1 | 7 |
| RNC – Prescriptive Option | N/A[2] | 3 | 2 | 5 |
| **Total** | **2,554** | **4,330** | **7,947** | **14,831**[1] |

[1] In PY6, 4,330 participants (unique CSP Job No) (representing 4,269 households) received products and services in PY6; some participated in more than one stratum.
[2] Program component was not offered in PY5.

The weatherization, HVAC, and new homes HERS strata has increased participation year over year. The HVAC stratum had the largest increase in participation from PY5 to PY7 and accounted for over 70% of all participants in Phase II.

Table 7-21 shows a general increase of in-home surveys and audits, installations of weatherization products, and bonus rebates in Phase II, an indication that the program is influencing the retrofit residential market for these services and products. The year-after-year increase in the program conversion rate and the number of bonus rebates is statistically significant.[83]

**Table 7-21: Phase II Audit and Weatherization Completed Projects**

| Projects | PY5 | PY6 | PY7 |
|---|---|---|---|
| Total number of home surveys and home audits conducted | 555 | 991 | 704[1] |
| Number of home walk-through surveys conducted | 373 | 744 | 499 |
| Number of comprehensive home audits conducted | 182 | 247 | 207 |
| Number installing recommended weatherization (insulation or air sealing) | 88 | 218 | 270 |
| Program conversion rate percentage[2] | 16% | 22% | 38% |
| Number of bonus rebates | 3 | 63 | 77 |

[1] This count is slightly lower than previous tables because some participants in PY7 received audit measures but did not receive an audit.
[2] The conversion rate was calculated by taking the number of participants who installed recommended weatherization and dividing it by the total number of home surveys and audits conducted.

The PY6 and PY7 program surveys show that 90% of respondents said they lived in a single-family detached home (164 of 177 in PY6, and 251 of 286 in PY7). Additionally, 75% said they had completed at least some college (138 of 177 in PY6 and 210 of 286 in PY7).

## 7.4.7 Satisfaction

### 7.4.7.1 Program Satisfaction

Participants expressed high satisfaction with the Residential Home Comfort Program throughout Phase II (Figure 7-1). In Phase II, 95% (595; n=627) of respondents rated their satisfaction with the program as either *somewhat satisfied* (19%, 119 responses) or *very satisfied* (76%, 476 responses). Only 32 of the 627 respondents indicated they were less than satisfied with the program, and only seven of those 32 said they were *not satisfied at all*. In PY7, 98% (279; n=286) of respondents rated their satisfaction with the program as either *somewhat satisfied* (17%, 48 responses) or *very satisfied* (81%, 231 responses), and six respondents (2%) rated their satisfaction with the program as *not too satisfied*. The increase in *very satisfied* responses from PY5 and PY6 to PY7 is statistically significant.[84]

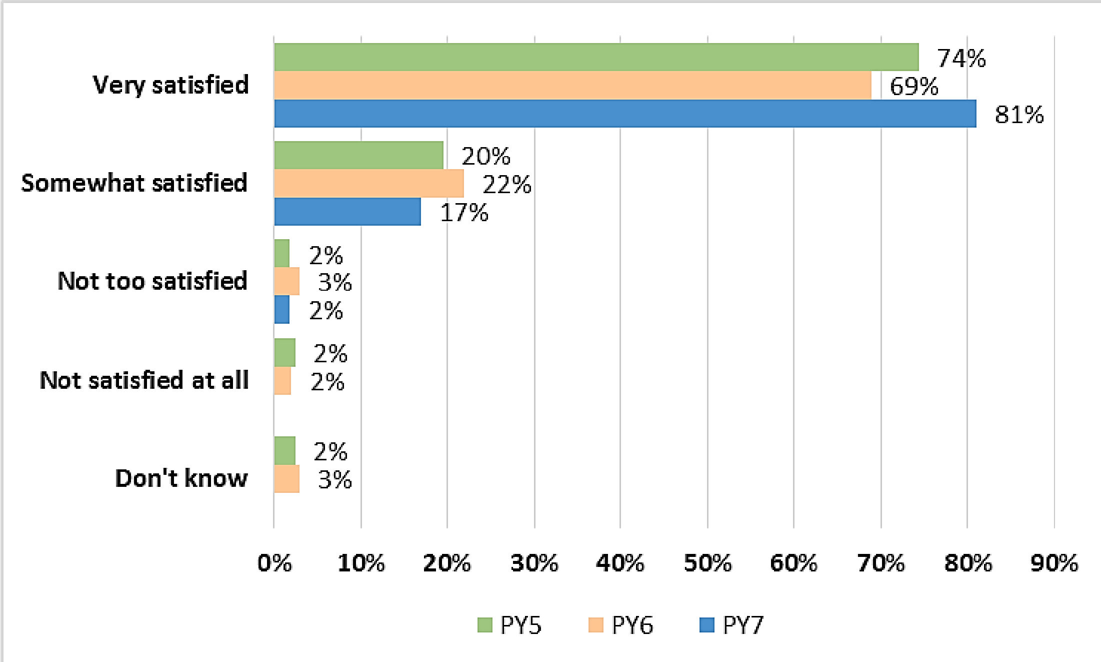
Respondents who did not give a satisfied rating were asked how PPL Electric Utilities could improve the program, and they made these comments:

- In PY5, two of the six respondents requested clearer rebate information.
- The three top ways to improve the program mentioned in PY6 were to lower rates (7; n=49), improve the rebate process (6; n=49), and make the audit more comprehensive (3; n=49).
- In PY7, the top ways to improve the program were to provide more clear rebate information (11; n=40), improve the rebate process (7; n= 40), and increase rebate amounts (4; n=40).

83 Statistically significant at p<0.05.

84 Statistically significant at p<0.05.

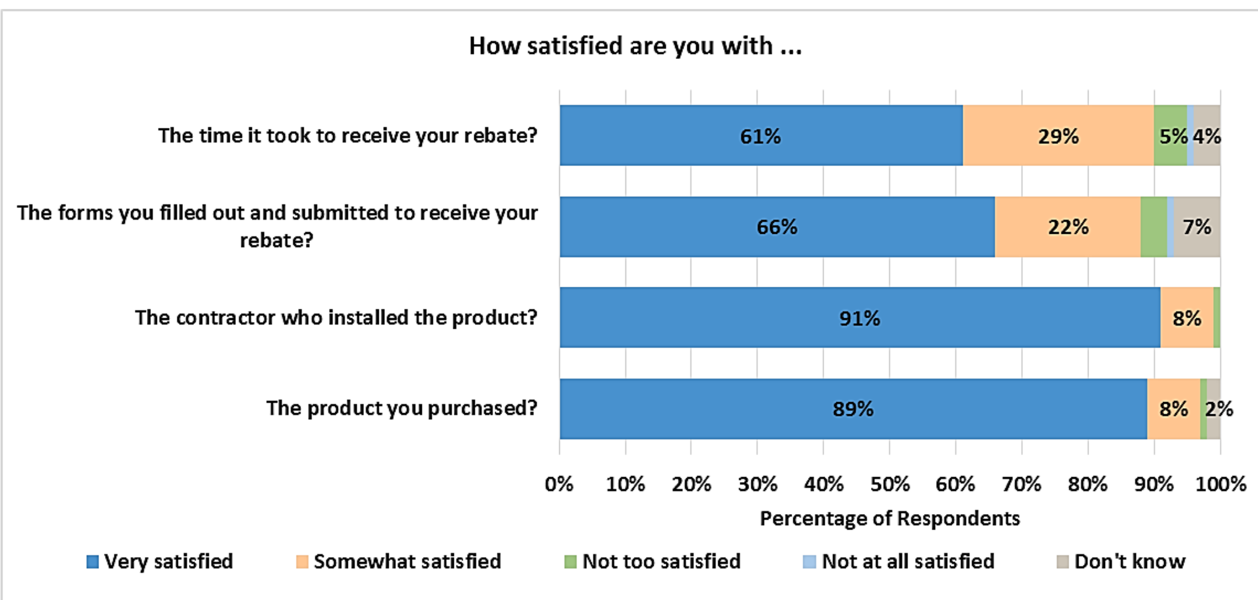
**Figure 7-1: Phase II Overall Program Satisfaction**




Source: Survey question, "Thinking about your overall experience with the program, how would you rate your satisfaction?" (PY5 n=164, PY6 n=177, PY7 n=286)

Survey respondents were asked about their satisfaction with various program components—the product they received, the contractor who installed the product, the application form, and the time it took to receive the rebate (Figure 7-2). Ninety-eight percent of participants were *very satisfied* or *somewhat satisfied* with the product they purchased and the contractor who installed the product. Customers were less satisfied with the application forms and the time it took to receive the rebate (88% and 90% satisfied, respectively; n=224).

**Figure 7-2: Satisfaction with Residential Home Comfort Program Components**




Source: PY7 participant survey question D9, "How satisfied are you with ..." (n=224)

Of the 30 respondents who were not satisfied with the program's various components, 15 noted difficulty submitting the rebate forms, either because the forms were too complicated or because the participants had to resubmit the forms multiple times before approval. Another six of 30 respondents stated that it took a long time to receive the rebate.

In PY7, the ICSP returned 24% (90 of 377) of application forms to customers because they were missing necessary information. Table 7-22 shows return rates by product type.

**Table 7-22: Returned Applications by Product Type**

| Product Type | Applications Reviewed | Returned Applications | Return Rate |
|---|---|---|---|
| Audits[1] | 28 | N/A | N/A |
| Weatherization | 60 | 14 | 23% |
| Air Source Heat Pumps | 40 | 4 | 10% |
| Ductless Heat Pumps | 40 | 11 | 28% |
| Central Air Conditioning | 40 | 7 | 18% |
| ECM Furnace Fans | 5 | 0 | 0% |
| Whole House Fans | 3 | 1 | 33% |
| Pool Pumps | 95 | 48 | 51% |
| Fuel-Switching | 23 | 4 | 17% |
| New Homes | 42 | 1 | 2% |
| Manufactured Homes | 1 | 0 | 0% |
| **Program Total** | **377** | **90** | **24%** |

[1] Audit participants are not required to fill out application forms in order to participate in the program.

During the records review, Cadmus found that the ICSP included a letter that requested each piece of missing information when it returned an application to the customer. Of the 90 applications that were returned, the ICSP followed up to request 165 missing items. The ICSP most frequently requested the invoice/receipt (18%, 30 of 165), followed by the model number (9%, 15 of 165), and the customer's signature (8%, 14 of 165). The next most frequently requested items were all related to pool pumps: clean mode wattage (13 of 165); general wattage (12 of 165); filter mode wattage (11 of 165); clean mode hours of use (10 of 165); and filter mode hours of use (9 of 165).

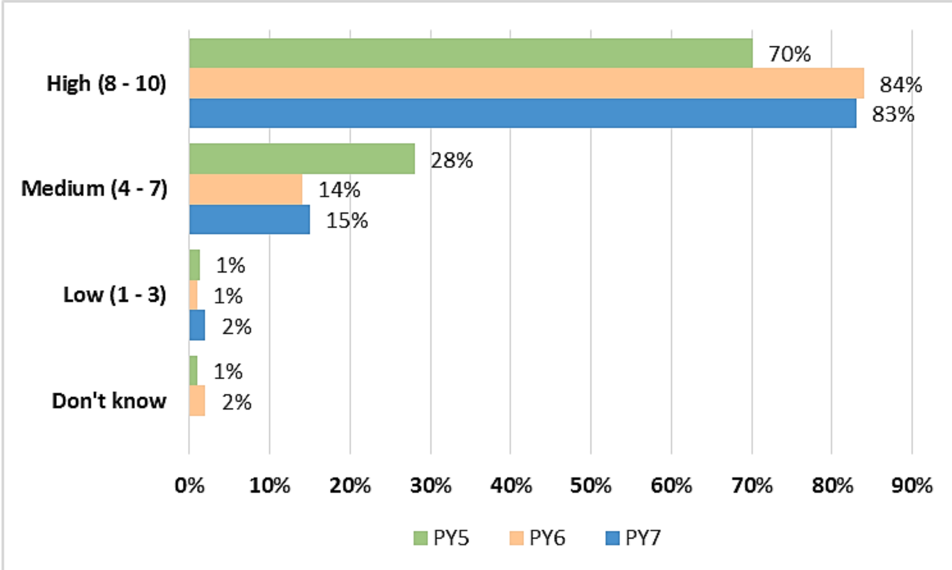
### 7.4.7.2 Satisfaction with PPL Electric Utilities

Phase II participants in the Residential Home Comfort Program were also satisfied with PPL Electric Utilities as an electric service provider, as shown in Figure 7-3. Eighty percent of respondents (501 of 627) rated their satisfaction with PPL Electric Utilities between 8 and 10, on a 10-point scale. An additional 18% (113 of 627) rated their satisfaction between 4 and 7.

In PY7, 83% of respondents (238 of 286) rated their satisfaction with PPL Electric Utilities between 8 and 10, and 15% (43 of 286) rated their satisfaction between 4 and 7. The increase in high (8 to 10) responses from PY5 to PY6 and PY7 is statistically significant.[85]

85 Statistically significant at $p<0.05$.

Figure 7-3: Satisfaction with PPL as a Provider of Electricity




Source: Survey question, "Using a 10-point scale where 1 means unacceptable and 10 means outstanding, using any number from 1 to 10, how do you rate PPL Electric Utilities overall as a provider of electric service to your home?" (PY5 n=164, PY6 n=177, PY7 n=286)

In Phase II, 47% of respondents (296 of 627) said they recommended the program to a friend, relative, or colleague since participating in the program. Since participating, 41% (257 of 627) said their opinion of PPL Electric Utilities had improved *somewhat* or *significantly*, and 55% (345 of 627) said their opinion had not changed.

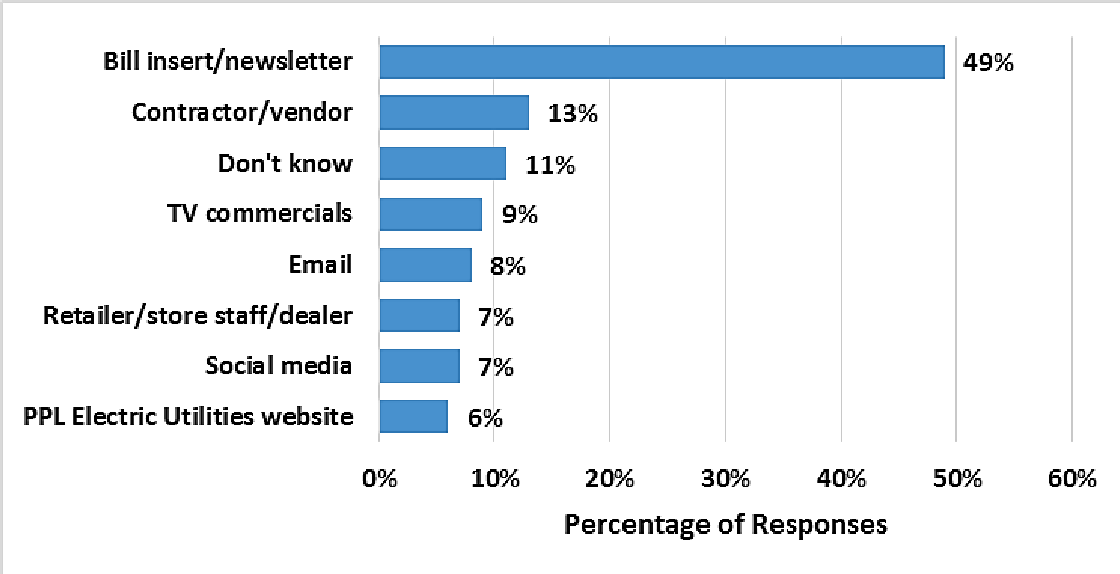
In PY7, 48% of respondents (137 of 286) said they recommended the program to someone else, and 36% (103 of 286) said their opinion of PPL Electric Utilities had improved *somewhat* or *significantly* since participating in the program.

### 7.4.8 Awareness

In PY7, 68% (153 of 224) of respondents heard about Residential Home Comfort Program through a contractor or vendor, while 19% (43 of 224) heard about the program through a retailer.

Respondents were asked about the best way for PPL Electric Utilities to inform the public about energy efficiency programs. Forty-nine percent (109 of 224) thought bill inserts and newsletters were the best way to reach customers, followed by contractors and vendors (13%, 30 of 224), television commercials (9%, 21 of 224), and e-mail (8%, 18 of 224). Figure 7-4 shows these results.

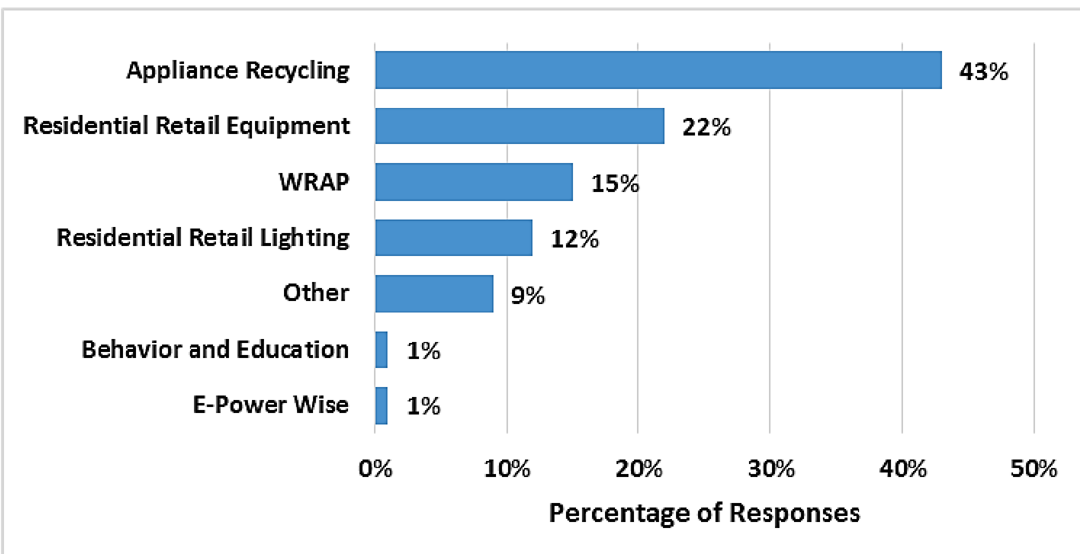
**Figure 7-4: Best Way for PPL Electric Utilities to Market Programs**




Source: PY7 participant survey question D2, "How satisfied are you with …" (n=224). Multiple responses allowed.

To gain insights into customer awareness of other PPL Electric Utilities programs, respondents were asked if they knew about other energy-saving rebates or programs offered by PPL Electric Utilities. Twenty-four percent (68 of 286) were aware of other PPL Electric Utilities offerings, 73% were not aware of other offerings, and 3% did not know. Of those who were aware, 43% (29 of 68) were aware of the Appliance Recycling Program, 22% (15 of 68) were aware of the Residential Retail Equipment Program, and 15% (10 of 68) were aware of the Winter Relief Assistance Program (WRAP). Figure 7-5 shows these results.

**Figure 7-5: PPL Electric Utilities Programs that Residential Home Comfort Participants Are Aware Of**




Source: PY7 participant survey question J1, "Aside from the Residential Home Comfort Program, what other energy saving rebates or programs have you heard about that PPL Electric Utilities offers?" (n=68). Multiple responses allowed. *Other* responses included commercial program offerings and program descriptions that do match any program that PPL Electric Utilities offers.

Cadmus compared awareness across product type, shown in Table 7-23. Weatherization participants were the least aware of other PPL Electric Utilities programs (15%, 2 of 13), while pool pump participants were the most aware of other PPL Electric Utilities programs (46%, 6 of 13).

**Table 7-23: Awareness of other PPL Electric Utilities Programs by Product Type**

| Product Type | Percentage of Respondents Aware of Other Programs | Number of Respondents Aware of Other Programs |
|---|---|---|
| Weatherization | 15% | 2 of 13 |
| Central air conditioner | 19% | 13 of 70 |
| Air source heat pump | 21% | 15 of 70 |
| Ductless heat pump | 24% | 17 of 71 |
| Audit | 29% | 14 of 49 |
| Pool pump | 46% | 6 of 13 |

### 7.4.9 Decision-Making

Survey respondents were asked to name the primary reason they purchased the rebated equipment. The most common response was to replace old or outdated equipment (53%, 119 of 224), followed by the product's specific features (24%, 53 of 224) and to reduce energy costs (17%, 39 of 224). Other reasons were to improve home comfort, the rebate amount, and part of a home remodel or new home build.

Survey respondents were then asked why they purchased the specific brand or model. Participants relied on recommendations, whether from friends, family, or online reviews, to determine which brand or model of equipment to purchase (62%, 138 of 224). Other reasons included the energy efficiency of the unit (14%, 31 of 224), price (12%, 27 of 224) and brand recognition (12%, 26 of 224).

### 7.4.10 Marketing and Outreach

The ICSP was responsible for most program marketing. It produced the marketing materials, which were reviewed by PPL Electric Utilities' marketing and communications staff. These marketing materials (which included cross-program messaging) were bill stuffers, trade ally newsletters, and trade show presentations. PPL Electric Utilities was responsible for program marketing through its website and social media accounts.

## 7.5 CONCLUSIONS AND RECOMMENDATIONS

Overall, PPL Electric Utilities' Residential Home Comfort Program exceeded its Phase II program targets for participation and its planned savings for energy and demand reduction.

Based on the findings, Cadmus offered these conclusions and recommendations.

**Conclusion**
Only 24% of PY7 participant survey respondents were aware of other PPL Electric Utilities programs (see Section 7.4.8). Responses varied across equipment type—46% (6 of 13) of pool pump respondents and 15% (2 of 13) weatherization respondents were aware of other programs. Notably, only 29% (14 of 49) of audit respondents, who have contractors come into their homes and suggest energy efficiency improvements, were aware of other PPL Electric Utilities programs.

**Recommendation**
Cadmus recommends that PPL Electric Utilities strengthen cross-program awareness initiatives in Phase III to garner awareness and participation from current participants. For Phase III paper rebate applications, PPL Electric Utilities could add eye-catching text on the first page encouraging participants to explore other energy-saving opportunities on PPL Electric Utilities' website. Each time a participant submits an online rebate form, the site could present a "Thank You" screen that includes a link to explore other PPL Electric Utilities offers.

Ensure that audit home energy reports and marketing materials include clear infographics explaining how customers can benefit from participating in other PPL Electric Utilities programs, including presenting the average savings in monetary terms.

Cadmus recommends PPL Electric Utilities and the ICSPs consider including a phone number, e-mail, and/or website address on rebate forms, audit home energy reports, and marketing materials so customers can ask questions and gather more information on other PPL Electric Utilities programs.

**Conclusion**
In PY7, Cadmus verified 14 of the 23 fuel-switching rebates that were submitted. Cadmus could not verify savings for the remaining nine records for which the existing heating equipment capacity was missing (see Section 7.2.5.1 for more details).

**Recommendation**
Equipment capacity is needed to determine savings. To gather capacity data, PPL Electric Utilities could consider requiring the AHRI certificate be submitted along with the rebate application. Additionally, PPL Electric Utilities should require the two heating capacity values (of the existing equipment and the new equipment) for rebate application acceptance. Both capacity values are listed as "variable" with a source of "EDC Data Gathering" in the 2014, 2015 and 2016 TRMs.

Four values are necessary to collect (either on the rebate form or in supporting documentation) to verify energy savings. Requiring the AHRI certificate of the new equipment would provide the information for requirements 3 and 4:

1. Equipment type of the replaced equipment
2. Capacity of the replaced equipment
3. Equipment type of the new equipment, specifically, whether the unit is a furnace or a boiler
4. Capacity of the new equipment

**Conclusion**
In PY7, some participants had difficulty filling out PPL Electric Utilities rebate forms (see Section 7.4.7.1). Half of the participants who were not satisfied with the program's various components said the rebate forms were too complicated or they had to resubmit the forms multiple times before approval. Cadmus recognized this issue during its records reviews; in Cadmus' review sample, the ICSP had returned 24% of application forms because they were missing necessary information. When asked about their general satisfaction with the program, participants said the top ways to improve the program were to provide clearer rebate information and improve the rebate process.

**Recommendation**
Cadmus recommends that PPL Electric Utilities consider adding instructions on rebate forms to assist participants in filling them out. Add text explaining where participants can find the information that PPL Electric Utilities, the ICSP, and the EM&V CSP need to verify participation and savings. For example, PPL Electric Utilities could recommend that fuel-switching rebate participants enter the AFUE rating from their product's user manual.

For Phase III paper rebate applications, PPL Electric Utilities could consider adding a section that directs customers to instructional videos and guides on the PPL Electric Utilities website. When a participant fills out an online rebate form, include icons that direct participants to more information about each entry's requirements and where to find the information on their equipment or in their user manual.

**Conclusion**
PPL Electric Utilities did not meet its internal key performance indicator for no customer complaints (discussed in Section 7.4.5.1). Toward the end of PY7, PPL Electric Utilities received several complaints because customers mailed rebate applications after the deadline, and the ICSP rejected them. PPL Electric Utilities rectified all of the complaints by honoring the rebates. In Phase III, PPL Electric Utilities is taking steps to manage this issue by clearly stating eligibility requirements on the rebate forms—the "Eligibility" section states the promotional dates and that "requests must be post-marked within 90 days from date of installation."

**Conclusion**
The manufactured home component continued to generate little interest in PY7 (see Section 7.4.5). The ICSP noted difficulties promoting the manufactured homes component to manufacturers and salespeople. PPL Electric Utilities believed that the rebate amount may not have been enough to entice manufactured homes buyers. In addition, in PY6, the four manufacturers Cadmus interviewed said that a very low percentage of these homes used electric space heat.

**Recommendation**
Consider exploring opportunities to involve manufactured homes dealers in the program. In Phase III, PPL Electric Utilities is considering trade ally SPIFs, which could be offered as incentives to dealers for each qualifying manufactured home sold.

Consider further study of other manufactured homes programs to determine if their delivery and incentive structures are more successful in garnering participation.

Additionally, consider further study to assess the potential market for electrically heated manufactured homes. Because very few all-electric manufactured homes are being built, PPL Electric Utilities may not need to offer incentives for air source heat pump and ductless heat pump installed in manufactured homes.

### 7.5.1 Status of Recommendations for Program

Table 7-24 contains the status of each PY7 process recommendation made to PPL Electric Utilities.

**Table 7-24: Residential Home Comfort Program Status Report on Process and Impact Recommendations**

| Recommendations | EDC Status Report for Process Evaluations (Implemented, Being Considered, Rejected AND Explanation of Action Taken by EDC |
|---|---|
| **Residential Home Comfort** | |
| Require the AHRI certificate and the two heating capacity values of the existing equipment and the new equipment for fuel-switching rebate forms. | Being considered and will likely be implemented. |
| Strengthen cross-program awareness initiatives in Phase III, such as adding banners to rebate forms, clear infographics to program materials, and PPL Electric Utilities' contact information to program materials. | Implemented. |
| Add instructions and helpful information on rebate forms to assist participants in filling them out. | Implemented and will be continually improved further. |
| Explore opportunities to involve manufactured homes dealers in the program, such as offering incentives for each qualifying manufactured home sold. | Being considered. |
| Consider further study of other manufactured homes programs to determine if other program delivery and incentive structures are successful in realizing participation. | Being considered. |
| Consider further study to assess the potential market for electrically heated manufactured homes. | Being considered. |

## 7.6 FINANCIAL REPORTING

A breakdown of the Residential Home Comfort Program finances is presented in Table 7-25.

**Table 7-25: Summary of Residential Home Comfort Program Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs[6] ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs (Sum of rows 2 to 4) | $16,774 | $21,978 |
| 2 | EDC Incentives to Participants | $4,842 | $5,619 |
| 3 | EDC Incentives to Trade Allies | - | - |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $11,932 | $16,360 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6, 7, 8, 9, 10 ) | $2,039 | $3,544 |
| 6 | Design & Development | $0 | $0 |
| 7 | Administration, Management, and Technical Assistance[1] | $2,039 | $3,544 |
| 8 | Marketing[2] | $0 | $0 |
| 9 | EDC Evaluation Costs | $0 | $0 |
| 10 | SWE Audit Costs | $0 | $0 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | $164 | $367 |
| | | | |
| 12 | Total TRC Costs[3] (Sum of rows 1, 5 and 11) | $18,977 | $25,890 |
| 13 | Total NPV Lifetime Energy Benefits | $11,000 | $14,724 |
| 14 | Total NPV Lifetime Capacity Benefits | $1,432 | $2,344 |
| 15 | Total NPV O&M Saving Benefits | $40 | $94 |
| 16 | Total NPV TRC Benefits[4] | $12,473 | $17,162 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | 0.66 | 0.66 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.
[2] Includes the marketing CSP and marketing costs by program CSPs.
[3] Total TRC Costs includes Total EDC Costs and Participant Costs.
[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.
[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[6] Phase II Costs in this table are discounted back to PY5, thus will not match cumulative costs reported in the PY7 Q4 quarterly report.

# ADDENDUM A. PARTICIPANT SURVEY METHODOLOGY

### 7.6.1 Dialing Instructions

PPL Electric Utilities provided dialing instructions for conducting surveys. Customers cannot be contacted within three months of the last time they completed a survey (with PPL Electric Utilities or Cadmus).[86] Any customer who has requested to be removed from the sample frame for any survey cannot be contacted again. Telephone survey calls cannot take place on Sundays or national holidays.

Researchers called participants at different times of day and different days of the week to increase the probability of contact. Researchers attempted surveys with potential respondents up to five times each.

### 7.6.2 Sample Cleaning and Attrition

Cadmus coordinated with PPL Electric Utilities' survey vendor to screen the sample and remove customer records called in the past year (whether for a Cadmus survey or a PPL Electric Utilities survey) and those who requested they not be contacted again. Cadmus removed records with incomplete information, duplicate contact information, inactive customers, and customers selected for a different survey. For the participant survey, Cadmus selected a simple random sample, stratified by program and by product type.

This cleaning and survey sample preparation process reduced the available sample. Table 7-26 through Table 7-32 lists total number of records submitted to the survey subcontractor and the outcome (final disposition) of each record.

**Table 7-26: Cross-Program Survey Sample Attrition Table – Overall**

| Cross-Program Survey: Residential Home Comfort Participants | |
|---|---|
| **Description** | **Count** |
| **Total population** | **6,880** |
| **Random sample selection** | **4,341** |
| Removed incomplete or bad phone number, inactive customer, completed survey in past year, on "do not call" list, selected for a different survey, duplicate contact | 880 |
| **Sent to Survey Subcontractor** | **4,341** |
| **Records Not Attempted** [1] | **1,655** |
| **Records Attempted** | **2,686** |
| Nonworking number | 57 |
| Business/wrong number | 33 |
| Refusal | 345 |
| Language barrier | 2 |
| Ineligible; PPL or market research employment | 29 |
| Ineligible; did not participate in program | 0 |
| No answer/answering machine/phone busy | 1319 |
| Nonspecific or specific callback scheduled | 584 |
| Partially completed survey | 31 |
| **Completed Survey** | **286** |
| **Survey Target** | **349** |
| [1] These records were not needed because product-level survey targets were reached before they were attempted. | |

86 PPL Electric changed this policy in May 2016 from one year to three months.

**Table 7-27: Cross-Program Survey Sample Attrition Table – Air Source Heat Pump**

| Cross-Program Survey: Residential Home Comfort air source heat pump Participants | |
|---|---|
| **Description** | **Count** |
| **Total population** | **3,417** |
| **Random sample selection** | **1,400** |
| Removed incomplete or bad phone number, inactive customer, completed survey in past year, on "do not call" list, selected for a different survey, duplicate contact | 358 |
| **Sent to Survey Subcontractor** | **1,400** |
| **Records Not Attempted** [1] | **801** |
| **Records Attempted** | **599** |
| Nonworking number | 12 |
| Business/wrong number | 8 |
| Refusal | 69 |
| Language barrier | 2 |
| Ineligible; PPL or market research employment | 7 |
| Ineligible; did not participate in program | 0 |
| No answer/answering machine/phone busy | 309 |
| Nonspecific or specific callback scheduled | 115 |
| Partially completed survey | 7 |
| **Completed Survey** | **70** |
| **Survey Target** | **70** |
| [1] These records were not needed because the survey targets were reached before they were attempted. | |

**Table 7-28: Cross-Program Survey Sample Attrition Table – Audit and Weatherization**

| Cross-Program Survey: Residential Home Comfort Audit and Weatherization Participants | |
|---|---|
| **Description** | **Count** |
| **Total population** | **951** |
| **Random sample selection** | 647 |
| Removed incomplete or bad phone number, inactive customer, completed survey in past year, on "do not call" list, selected for a different survey, duplicate contact | **304** |
| **Sent to Survey Subcontractor** | **647** |
| **Records Not Attempted** [1] | **10** |
| **Records Attempted** | **637** |
| Nonworking number | 11 |
| Business/wrong number | 8 |
| Refusal | 61 |
| Language barrier | 0 |
| Ineligible; PPL or market research employment | 12 |
| Ineligible; did not participate in program | 0 |
| No answer/answering machine/phone busy | 346 |
| Nonspecific or specific callback scheduled | 133 |
| Partially completed survey | 4 |
| **Completed Survey** | **62** |
| **Survey Target** | **62** |
| [1] These records were not needed because the survey targets were reached before they were attempted. | |

### Table 7-29: Cross-Program Survey Sample Attrition Table – Central Air Conditioner

| Cross-Program Survey: Residential Home Comfort Central Air Conditioner Participants | |
|---|---|
| **Description** | **Count** |
| **Total population** | **923** |
| **Random sample selection** | **871** |
| Removed incomplete or bad phone number, inactive customer, completed survey in past year, on "do not call" list, selected for a different survey, duplicate contact | 52 |
| **Sent to Survey Subcontractor** | **871** |
| **Records Not Attempted [1]** | **242** |
| **Records Attempted** | **629** |
| Nonworking number | 19 |
| Business/wrong number | 9 |
| Refusal | 103 |
| Language barrier | 0 |
| Ineligible; PPL or market research employment | 5 |
| Ineligible; did not participate in program | 0 |
| No answer/answering machine/phone busy | 274 |
| Nonspecific or specific callback scheduled | 140 |
| Partially completed survey | 9 |
| **Completed Survey** | **70** |
| **Survey Target** | **70** |
| [1] These records were not needed because the survey targets were reached before they were attempted. | |

### Table 7-30: Cross-Program Survey Sample Attrition Table – Ductless Heat Pump

| Cross-Program Survey: Residential Home Comfort Ductless Heat Pump Participants | |
|---|---|
| **Description** | **Count** |
| **Total population** | **1,388** |
| **Random sample selection** | **1,230** |
| Removed incomplete or bad phone number, inactive customer, completed survey in past year, on "do not call" list, selected for a different survey, duplicate contact | 158 |
| **Sent to Survey Subcontractor** | **1,230** |
| **Records Not Attempted [1]** | **602** |
| **Records Attempted** | **628** |
| Nonworking number | 11 |
| Business/wrong number | 3 |
| Refusal | 89 |
| Language barrier | 0 |
| Ineligible; PPL or market research employment | 5 |
| Ineligible; did not participate in program | 0 |
| No answer/answering machine/phone busy | 302 |
| Nonspecific or specific callback scheduled | 138 |
| Partially completed survey | 9 |
| **Completed Survey** | **71** |
| **Survey Target** | **70** |
| [1] These records were not needed because the survey targets were reached before they were attempted. | |

**Table 7-31: Cross-Program Survey Sample Attrition Table – Pool Pump**

| Cross-Program Survey: Residential Home Comfort Pool Pump Participants | |
|---|---|
| **Description** | **Count** |
| **Total population** | **193** |
| **Random sample selection** | **186** |
| Removed incomplete or bad phone number, inactive customer, completed survey in past year, on "do not call" list, selected for a different survey, duplicate contact | 7 |
| **Sent to Survey Subcontractor** | **186** |
| **Records Not Attempted** | **0** |
| **Records Attempted** | **186** |
| Nonworking number | 4 |
| Business/wrong number | 4 |
| Refusal | 23 |
| Language barrier | 0 |
| Ineligible; PPL or market research employment | 0 |
| Ineligible; did not participate in program | 0 |
| No answer/answering machine/phone busy | 85 |
| Nonspecific or specific callback scheduled | 55 |
| Partially completed survey | 2 |
| **Completed Survey** | **13** |
| **Survey Target** | **70** |

**Table 7-32: Cross-Program Survey Sample Attrition Table – ECM Furnace Fan and Whole House Fan**

| Cross-Program Survey: Residential Home Comfort Fan Participants | |
|---|---|
| **Description** | **Count** |
| **Total population** | **8** |
| **Random sample selection** | **7** |
| Removed incomplete or bad phone number, inactive customer, completed survey in past year, on "do not call" list, selected for a different survey, duplicate contact | 1 |
| **Sent to Survey Subcontractor** | **7** |
| **Records Not Attempted** | **0** |
| **Records Attempted** | **7** |
| Nonworking number | 0 |
| Business/wrong number | 1 |
| Refusal | 0 |
| Language barrier | 0 |
| Ineligible; PPL or market research employment | 0 |
| Ineligible; did not participate in program | 0 |
| No answer/answering machine/phone busy | 3 |
| Nonspecific or specific callback scheduled | 3 |
| Partially completed survey | 0 |
| **Completed Survey** | **0** |
| **Survey Target** | **7** |

# ADDENDUM B. NET SAVINGS COMMON APPROACH

Cadmus used self-report surveys to assess net savings for the Residential Home Comfort Program, following the Evaluation Framework's recommended common method for assessing freeridership.[87] The SWE team reviewed and approved the survey prior to fielding.

The assessment includes two components of freeridership—*intention* to implement an energy-efficient project without a rebate and *influence* of the program in the decision to implement the energy-efficient project. When scored, each component has a value ranging from zero to 50 and a combined total freeridership score ranging from zero to 100.

## Intention

*Intention* was assessed through several brief questions to determine how the project likely would have differed if the respondent had not received the program assistance. If the customer received more than one rebate, these questions focused on the project with the largest energy savings.

### 7.6.2.1 Intention Survey Questions

A15. Which of the following would have happened if you had not received the [V_MEASURE] rebate from PPL Electric Utilities? [READ LIST AND SELECT ONE RESPONSE]

a) Canceled or postponed purchase at least one year
b) Repaired the old [V_MEASURE]
c) Purchased a less expensive [V_MEASURE]
d) Purchased a less efficient [V_MEASURE]
e) Purchased the same [V_MEASURE1] without the [V_REBATE] rebate?

*Don't know, Refused*

## Influence

*Influence* is assessed by asking about how much influence – from 1 (no influence) to 5 (extreme influence) – various program elements had on the decision to do the project the way it was done. The items selected for rating were specific components of the Residential Home Comfort Program.

### 7.6.2.2 Influence Survey Questions

A16. I'm going to read a list of items about the [PROGRAM] program. Please rate each item on how much influence it had on your decision to purchase the [V_MEASURE]. Please use a scale from 1 to 5, 1 meaning no influence, and 5 meaning the item was extremely influential in your decision. [RANDOMIZE STATEMENTS]

[87] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase II Energy Efficiency and Conservation Programs.* Prepared by GDS Associates, Inc., and Nexant. June 1, 2014.

| Item | No influence | | | | Extremely influential | Don't know | Not applicable |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 98 | 96 |
| A. The [V_REBATE] rebate | | | | | | | |
| B. PPL Electric Utilities' marketing | | | | | | | |
| C. PPL Electric Utilities' information about energy efficiency | | | | | | | |
| [ASK IF PROGRAM=RHC] D. Information about the program from your installer or contractor | | | | | | | |
| [ASK IF RES RETAIL HPWH] E. Information about saving energy from the salesperson | | | | | | | |
| [ASK IF RES RETAIL HPWH] F. Information about heat pump water heaters from a plumber or contractor | | | | | | | |

A17. What else, if anything, was highly influential in your decision to purchase the [V_MEASURE]
[RECORD RESPONSE]
*Nothing, Don't know, Refused*

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# 8 STUDENT & PARENT ENERGY-EFFICIENCY EDUCATION PROGRAM

The Student & Parent Energy-Efficiency Education Program has completed its third year as a program in Act 129 Phase II of the PPL Electric Utilities Energy Efficiency and Conservation Plan. PPL Electric Utilities provides school-based energy efficiency education through classroom presentations for students in various grade levels, training for teachers, and community workshops for parents in low-income neighborhoods. Participants in all program components receive education materials and an energy-savings kit of low-cost items they can install at home. The kits are tailored to each grade level participating in the program and includes items such as LED lamps, energy-efficient showerheads, faucet aerators, smart power strips, and electroluminescent nightlights.

National Energy Foundation, the program ICSP, correlates the program's classroom workshop curricula to Pennsylvania academic standards for the appropriate grade levels, which is endorsed by the Pennsylvania Department of Education. During the summer, the ICSP conducts teacher workshops designed to address sustainability according to the Pennsylvania academic standards supported by the Pennsylvania Department of Education. Teachers participating in the teacher workshops receive approximately seven hours of credit applicable to Act 48 requirements.

PPL Electric Utilities provides school-based energy efficiency education through these components:

- **Classroom Presentations.** Interactive classroom presentations for students and teachers in three student cohorts:
  - Bright Kids (primary grades, 2nd – 3rd)
  - Take Action (intermediate grades, 4th – 8th)
  - Innovation (secondary grades, 9th – 12th)
- **Teacher Workshop.** Professional development workshops for teachers focused on energy efficiency and sustainability topics.
- **Parent Workshop.** Community in Action workshops for parents in schools with a known low-income population; the workshops are a fundraising opportunity for schools and parent teacher organizations.[88, 89]

Program participants receive education materials and an energy-savings kit containing low-cost products they can install at home.

Table 8-1 lists the items in each kit that contribute energy savings to the program. Note that teachers who participated in the professional development training workshops received a smart strip, but PPL Electric Utilities did not report energy savings for this item; therefore, Cadmus did not reference this group in any of the tables showing information for the impact evaluation.

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88 The term "parent" also refers to a student's guardian.

89 Low-income customers are generally customers who are at or below 150% of the federal poverty income guideline. However, PPL Electric and the implementation conservation service provider (ICSP) do not know the income of participating households. To determine low-income participation in the Student and Parent Energy-Efficiency Education Program, Cadmus analyzed the Pennsylvania Department of Education's data documenting schools in PPL Electric's service territory that offer free lunches to children from households with income below 120% of the federal poverty level, which is more conservative than 150% of the federal poverty level. For more details, see Appendix C: Low-Income Participation in Non-Low-Income Programs.

**Table 8-1: Student & Parent Energy-Efficiency Education Program Kit Products**

| Program Component | Cohort | Kit Products | | | | | | | | Supplementary Items | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 11-Watt LED Bulbs (x3) | 11-Watt LED Bulbs (x2) | Electroluminescent Night Light | Showerhead | Bathroom Aerator | Kitchen Aerator | TrickleStar Smart Power Strip | Furnace Whistle | Turn It Off Stickers | Shower Timer | Flow Test Bag | Mirror Decal | Plumber's Tape |
| Classroom Presentations | Bright Kids | ✓ | | ✓ | | | | | | ✓ | | | | |
| | Take Action | ✓ | | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | | |
| | Innovation | ✓ | | | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Classroom Presentations | Classroom Teachers | | | | | | | ✓ | | | | | | |
| Teacher Workshop | Workshop Teachers | | | | | | | ✓ [1] | | | | | | |
| Parent Workshop | Workshop Parents | | ✓ | ✓ | | | | | | | | | | |

[1] PPL Electric Utilities did not report energy savings for the teachers attending the professional development training workshops.

Although the energy-savings kits and training included behaviorally based activities that could reduce energy use, PPL Electric Utilities did not report or claim such savings for this program. Therefore, Cadmus, as the EM&V CSP, did not evaluate savings from behaviorally based activities.

The Community in Action workshops provided through the school's parent teacher organization target low-income neighborhoods. These workshops are a fundraising opportunity for the school or parent teacher organization to earn an incentive for recruiting parents to attend an energy efficiency workshop at their school.

The ICSP undertook a broad spectrum of responsibilities including marketing to and recruiting potential schools, teachers, and parent teacher organizations; creating curriculum correlated to Pennsylvania academic standards; securing support of the program components by the Pennsylvania Department of Education; conducting the various energy efficiency presentations; and assembling and shipping the energy-savings kits for installation in participant homes.

PPL Electric Utilities collaborated with the ICSP on the program's strategic direction while maintaining overarching Act 129 administrative, program support, and evaluation and data management systems.

PPL Electric Utilities has these objectives for the Student & Parent Energy-Efficiency Education Program:[90]

- Expand and promote energy efficiency literacy through education outreach programs
- Provide energy efficiency education to students offered through school assemblies and classroom curriculum and presentations to parent groups
- Ensure energy efficiency education correlates to Pennsylvania education academic standards
- Build awareness of energy efficiency in targeted low-income neighborhoods

90 Program objectives are stipulated on PPL Electric Utilities' revised EE&C Plan (Docket No. M-2012-2334388), approved by the Pennsylvania PUC on June 5, 2015, p. 74.

- Provide students, parents, and teachers with an energy-savings kit of energy-efficient products they can install at home
- Provide teachers with energy efficiency information, lesson plans, activities, training, materials, and support for classroom use
- Obtain participation of approximately 70,000 students, parents, and teachers through 2016, with a total energy reduction of approximately 16,000 MWh/yr.[91]

Table 8-2 shows a summary of cumulative Phase II program metrics.

**Table 8-2: Phase II Student & Parent Energy-Efficiency Education Summary**

| Sector | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Net-to-Gross Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) | Program Acquisition Cost[1] ($/Annual kWh) | Cost of Conserved Energy[2] (TRC Costs/ Lifetime kWh, at Generation) | Phase II Participants |
|---|---|---|---|---|---|---|---|---|---|
| Student & Parent Education | 16,108 | 17,185 | 13,397 | 1.0 | 2.05 | $5,345 | $0.40 | $0.054 | 67,732 |
| **Total** | **16,108** | **17,185[3]** | **13,397[4]** | **1.0** | **2.05** | **$5,345** | **$0.40** | **$0.054** | **67,732** |

[1] Total EDC Costs divided by first year kWh savings.
[2] Total TRC Costs divided by levelized lifetime kWh savings.
[3] In PY7, the EM&V ICSP made adjustments to the energy savings calculations for PY5 and PY6, which resulted in adjusted *ex ante* energy savings of 7,575 MWh/yr for PY5 and 4,497 MWh/yr for PY6.
[4] In PY7, the EM&V ICSP made adjustments to the energy savings calculations for PY5 and PY6, which resulted in verified gross energy savings of 5,223 MWh/yr for PY5 and 4,121 MWh/yr for PY6.

## 8.1 PROGRAM UPDATES

In PY7, PPL Electric Utilities and the ICSP made these two changes to the program:

- Increased the number of Bright Kids and Community in Action workshop participants
- Launched a poster contest to get students and classrooms involved in extra-curricular activities pertaining to energy efficiency

### 8.1.1 Definition of Participant

For reporting purposes, PPL Electric Utilities defines the number of participants in the Student & Parent Energy-Efficiency Education Program as the total number of energy-savings kits handed out to each classroom. Each record in EEMIS, PPL Electric Utilities' program tracking database, represents one participating classroom or workshop, and the quantity reported is the total number of kits distributed. Each classroom reports the number of kits distributed to students and the number of returned home energy worksheets (HEWs). Participating Bright Kids and Take Action classroom teachers received a smart strip for participating in the program (Innovation teachers did not receive smart strips in PY7); EEMIS contains the total quantity of smart strips distributed by cohort.

[91] Participation and savings numbers from PPL Electric's EE&C plan approved by the Pennsylvania PUC on 06/05/2015.

## 8.2 IMPACT EVALUATION GROSS SAVINGS

### 8.2.1 Reported Gross Savings

Table 8-3 shows the Phase II cumulative reported results by sector.

**Table 8-3: Phase II Student & Parent Energy-Efficiency Education Program Reported Results by Customer Sector**

| Sector | Phase II Participants [1] | Phase II Reported Gross Energy Savings (MWh/yr) | Phase II Reported Gross Demand Reduction (MW) | Incentives Paid ($1,000) |
|---|---|---|---|---|
| Residential | 67,732 | 16,108 | 1.65 | - |
| Low-Income | - | - | - | - |
| Small C&I | - | - | - | - |
| Large C&I | - | - | - | - |
| Government/Nonprofit/Education | - | - | - | - |
| **Phase II Total** | **67,732** | **16,108** | **1.65** | **-** |

[1] Student & Parent Energy-Efficiency Education Program participants correspond to the total number of kits entered into EEMIS. This count includes the smart strips distributed to the participating classroom teachers.

### 8.2.2 Database Review

Cadmus conducted multiple reviews of the EEMIS and ICSP's databases as well as reviewing the sources for the recordsin the databases. It inspected the databases for accuracy and consistency of EEMIS records against the ICSP records and found minimal discrepancies. In discussions, the ICSP and PPL Electric Utilities were able to correct the discrepancies in both databases to reflect the correct counts of returned HEW surveys (Table 8-4).

**Table 8-4: Student & Parent Energy-Efficiency Education Program Process Evaluation Database Review**

| Stratum | Population Size | Assumed Levels of Confidence and Precision | Target Sample size | Achieved Sample Size (Returned HEWs) | Used For Evaluation Activities (Impact, Process, NTG) |
|---|---|---|---|---|---|
| Classroom - Bright Kids | 8,017 | N/A | All records | 6,954 | Database review, Impact, Process |
| Classroom -Take Action | 10,853 | N/A | All records | 8,562 | Database review, Impact, Process |
| Classroom - Innovation | 5,200 | N/A | All records | 3,733 | Database review, Impact, Process |
| Parent Workshop | 1,015 | N/A | All records | 1,015 | Database review, Process |
| **Program Total** | **25,085** | **N/A** | **All records** | **20,264** | **N/A** |

### 8.2.3 EM&V Sampling Approach

The sampling approach for the impact evaluation data collection is summarized below for the five participating cohorts (student cohorts, parent workshops, and participating classroom teachers).

**Student cohorts.** For the three participating student cohorts, Bright Kids (primary school students), Take Action (intermediate school students), and Innovation (secondary school students), Cadmus conducted these two activities:

- A review of the database to ensure the accuracy of EEMIS records compared to the ICSP's records.
- An analysis of all HEWs returned by students who received a kit. The HEWs provided inputs, such as in-service rates, for calculating energy savings. Although not all students elected to return the HEWs,

all that were returned were included in the analysis and provided data for both the process and impact evaluations.

**Parent workshop.** All participants filled out an HEW during the parent workshop to receive an energy-savings kit. This worksheet asked which products the participant intended to install. In PY7, Cadmus did not conduct a follow-up survey with workshop participants about which products in the kit they installed. Instead, it applied the installation rates collected from the PY6 follow-up surveys to the PY7 population and used these data to calculate savings in the impact evaluation.

**Participating classroom teachers.** All Bright Kids and Take Action classroom teachers who hosted a student presentation received a smart power strip. Cadmus included the smart strip savings in the PY7 totals. Since the Cadmus did not conduct a follow-up survey with teachers in PY7 to ask about where they used the smart strips, it applied the Bright Kids and Take Action smart strip installation information collected in PY6 to the PY7 population.

Table 8-5 lists the program sampling for the impact evaluation.

**Table 8-5: PY7 Student & Parent Energy-Efficiency Education Program Impact Sampling Strategy**

| Stratum | Population Size (Kits) | Target Levels of Confidence and Precision | Target Sample Size | Achieved Sample Size (Surveys) | Evaluation Activity |
|---|---|---|---|---|---|
| Bright Kids, Take Action, Innovation | 24,070[1] | N/A[2] | All Available | All Available [1] | Records Review |
| Bright Kids (Primary) | 8,017 | N/A[2] | All Available | 6,954 | HEW Survey |
| Take Action (Intermediate) | 10,853 | N/A[2] | All Available | 8,562 | HEW Survey |
| Innovation (Secondary) | 5,200 | N/A[2] | All Available | 3,733 | HEW Survey |
| Parent Workshop | 1,015 | N/A | All Available[3] | 53[3] | PY6 Phone and Online Survey[4] |
| Participating Classroom Teachers | 749[6] | N/A[2] | All Available | 134[5] | PY6 Online Survey |
| **Program Total** | **25,834** | **N/A[2]** | | **20,503** | |

[1] Not counted in the program total calculation; counting the population in the records review would double-count records.
[2] Because this program's evaluation did not include sampling, Cv and target precision are not meaningful.
[3] In PY6, the EM&V CSP attempted to conduct phone and online surveys with all parent workshop participants who opted in.
[4] The EM&V CSP used PY6 installation rates collected from the PY6 phone and online surveys with parent workshop participants and applied them to the PY7 population.
[5] In PY7, the EM&V CSP use the PY6 online survey data to evaluate the Bright Kids (n=67) and Take Action teachers (n=67) smart strip use. The total achieved sample combines the survey totals for PY6 Bright Kids and Take Action participating teachers. Innovation teachers did not receive smart strips in PY7.
[6] The teacher population size reflects only those who received energy saving smart strips (Bright Kids and Take Action teachers). Because Innovations teachers did not receive a smart strip, they are not recorded in EEMIS or in the population for impact analysis. A total of 872 teachers in all three cohorts participated in the classroom teacher component of the program.

#### 8.2.3.1 Survey Sample Sizes

Table 8-6 presents the delivery method, achieved sample size, and functions of each of the surveys used in the impact evaluation.

**Student cohort participants.** The HEWs collected the data necessary for Cadmus to complete engineering calculations and compute energy savings. In each energy-savings kit distributed to classroom participants, the ICSP included an HEW for students to take home and complete. The students then transferred their responses from the HEWs to a Scantron form (a form that can be scanned electronically once completed) in the classroom. The Innovations cohort also had the option of completing the HEW online.

The participating classroom teachers returned the Scantron forms to the ICSP shortly after the classroom presentations in October 2015. In January 2016, the ICSP provided the data collected from the returned Scantron forms to Cadmus.

**Parent workshop participants.** Parent workshop participants filled out HEWs at the end of the workshop before taking the kit home and installing the items. The worksheets provided information about the actions participants intended to take but not what they actually did. Cadmus did not conduct follow-up surveys with workshop participants in PY7. To evaluate savings, Cadmus applied the PY6 survey-verified installation information to the PY7 workshop data.

**Participating classroom teachers.** The Bright Kids and Take Action teachers received a smart strip for their participation. Cadmus applied the smart strip installation information gathered from its PY6 surveys to calculate the energy savings from the Bright Kids and Take Action teacher smart strips.

**Table 8-6: PY7 Student & Parent Energy-Efficiency Education Program Survey Data Collection to Determine Energy Impacts**

| Survey | Survey Delivery Method | Frequency | Surveys Returned | Planned Sample Size | Data Used For | |
|---|---|---|---|---|---|---|
| | | | | | Impact Evaluation | Process Evaluation |
| Bright Kids Participant HEW | Included in Kit | Annually, completed Q3 | 6,954 | All Available | Yes | Yes |
| Take Action Participant HEW | Included in Kit | Annually, completed Q3 | 8,562 | All Available | Yes | Yes |
| Innovation Participant HEW | Included in Kit | Annually, completed Q3 | 3,733 | All Available | Yes | Yes |
| Parent Workshop Participant Survey [1] | Online and phone after opt-in during the workshop | PY6 Q3 | 53[1] | 53[1] | Yes | No |
| Participating Teachers Survey[2] | Included in classroom materials; online | Annually, completed Q3 | 134 [2] | 134[2] | Yes | Yes |

[1] Cadmus applied the installation rates collected from the PY6 phone and online surveys with parent workshop participants to the PY7 population.
[2] In PY7, Cadmus used the PY6 online survey data to evaluate the Bright Kids (n=67) and Take Action teachers (n=67) smart strip use. The total achieved sample combines the survey totals for PY6 Bright Kids and Take Action participating teachers. Innovation teachers did not receive smart strips in PY7.

### 8.2.4 *Ex Ante* Savings Methodology and Findings

For some products, PPL Electric Utilities used a placeholder or fixed value to determine and report savings. Cadmus adjusted the reported *ex ante* savings from EEMIS to align with the assumptions specified in the TRM and the characteristics of the products in the kit. Cadmus made this adjustment to the population and accounted for differences between planning assumptions, TRM assumptions, and the products that were actually distributed to participants. The results of this adjustment, prior to any calculations of savings, are the adjusted *ex ante* savings, which Cadmus used in the equation to determine the program's realization rate.

Table 8-7 shows the results of the TRM-adjusted *ex ante* calculations by cohort for the products in each energy-savings kit.

**Table 8-7: Reported and Adjusted *Ex Ante* Savings by Technology and Kit Item**

| Kit Item<br>*Cohort* | Reported<br>*Ex Ante* Savings<br>(kWh/yr) | Adjusted<br>*Ex Ante* Savings<br>(kWh/yr) | Factors Included in TRM *Ex Ante* Adjustments |
|---|---|---|---|
| Furnace Whistle<br>*Take Action* | 59.00 | 58.80 | PPL Electric Utilities assumed EFLH hours for Harrisburg as a placeholder (TRM table 2-31). |
| Low Flow Showerhead<br>*Take Action* | 57.71 | 62.88 | ▪ PPL Electric Utilities assumes a weighted savings value by housing type saturation for 1.5 gpm (2015 TRM Table 2-65), 31% planning ISR, and 52% fuel saturation per its RASS study.<br>▪ Adjusted *ex ante* uses statewide unknown housing type, showerhead rating of 1.5 gpm, 31% ISR, and 52% fuel saturation per PPL Electric Utilities' RASS study. |
| Kitchen Faucet Aerator<br>*Take Action* | 34.79 | 35.53 | ▪ PPL Electric Utilities assumes a weighted savings value by housing type saturation, 1.5 gpm (2015 TRM Table 2-64), 35% planning ISR, and 52% fuel saturation per its RASS study.<br>▪ Adjusted *ex ante* uses statewide unknown housing type, aerator rating of 1.5 gpm, 35% ISR, and 52% fuel saturation per PPL Electric Utilities' RASS study. |
| Bathroom Faucet Aerator<br>*Innovation* | 4.36 | 4.54 | ▪ PPL Electric Utilities assumes a weighted savings value by housing type saturation, 1.5 gpm (2015 TRM Table 2-64), 36% planning ISR, and 52% fuel saturation per its RASS study.<br>▪ Adjusted *ex ante* uses statewide unknown housing type, aerator rating of 1.5 gpm, 36% ISR, and 52% fuel saturation per PPL Electric Utilities' RASS study. |
| Energy-Efficient Showerhead<br>*Innovation* | 63.31 | 68.97 | ▪ PPL Electric Utilities assumes a weighted savings value by housing type saturation for 1.5 gpm (2015 TRM Table 2-65), 34% planning ISR, and 52% fuel saturation per its RASS study.<br>▪ Adjusted *ex ante* uses statewide unknown housing type, 1.5gpm, 34% ISR and 52% fuel saturation per PPL Electric Utilities' RASS study. |
| Smart Strip<br>*Innovation* | 53.26 | 46.95 | ▪ PPL Electric Utilities assumes average of residential installation locations and 80% ISR.<br>▪ Adjusted *ex ante* uses unspecified installation location and 80% ISR. |
| LEDs (3 Bulbs)<br>*Bright Kids, Take Action, Innovation* | 89.46 | 89.46 | No adjustments made to the reported *ex ante*; uses 2015 TRM default ISR of 97% (2015 TRM Table 2-1). |
| LEDs (2 Bulbs)<br>*Parent Workshop* | 59.64 | 59.64 | No adjustments made to the reported *ex ante;* use PPL Electric Utilities planning ISR assumption of 90%. |
| Electroluminescent Nightlight<br>*Bright Kids, Take Action, Parent Workshop* | Bright Kids (26.36); Take Action (23.97); Parent Workshop (26.96) | Bright Kids (26.36); Take Action (23.97); Parent Workshop (26.96) | ▪ Reported and adjusted *ex ante* for Bright Kids uses planning ISR of 88%.<br>▪ Take Action uses planning assumption of 80%.<br>▪ Parent workshop uses planning ISR of 83%. |
| Smart Strip<br>*Participating Teachers* | 90.83 | 90.83 | ▪ No adjustments made to the reported *ex ante;* uses weighted average of residential and commercial smart strip installation with the PY5 survey verified installation rates.<br>▪ 2015 TRM Section 2.5.3 provides deemed per-unit savings for residential use. 2015 TRM Section 3.9.3 provides deemed per-unit savings for commercial use. |

### 8.2.5 *Ex Post* Savings Methodology and Findings

*Ex post* savings analyses can result in modifying the TRM-adjusted *ex ante* savings in these ways:

- Incorporate the results of quantity adjustments resulting from database review activities
- Reflect the installation rates determined through survey**s**, including the student's returned HEWs, the parent workshop PY6 phone and online survey, and PY6 online teacher survey

#### 8.2.5.1 Database Review

Cadmus compared participant records from EEMIS with enrollment data stored in the ICSP's electronic database to ensure that all records were traceable between databases. Through the database review, Cadmus found the following issues:

- Two datasets did not match the total number of kits distributed through the parent workshop. Follow-up discussion with the ICSP confirmed that the total kit counts in EEMIS were correct and the ICSP data were updated accordingly.
- The ICSP's database contained more teacher ID records for the Bright Kids cohort than EEMIS did. Through discussion with the ICSP and PPL Electric Utilities, Cadmus determined that before uploading the data to EEMIS, the ICSP removed principals and department heads who ordered kits but did not conduct a classroom presentation; therefore, the EEMIS data reflected the correct number of participating teachers at the teacher ID level.
- The Take Action cohort included one record in the ICSP's database that did not appear in EEMIS. The ICSP worked with the EEMIS database team to upload this additional record, which aligned the two datasets.
- One record in the Innovations cohort had the correct number of returned HEWs in the ICSP's database but not in the EEMIS database. The ICSP worked with the EEMIS database team to amend this data entry error, which aligned the two datasets.

Table 8-8 shows the level of accuracy between the PPL Electric Utilities' records (EEMIS) and the ICSP's database after making corrections noted in the Cadmus database review process.

**Table 8-8: Database Review Results for PY7 Student & Parent Energy-Efficiency Education Program**

| Cohort | HEWS in EEMIS Database | HEWs in ICSP Database | Database Accuracy |
|---|---|---|---|
| Bright Kids | 6,954 | 6,954 | 100% |
| Take Action | 8,562 | 8,562 | 100% |
| Innovation | 3,733 | 3,733 | 100% |
| Parent Workshop | 1,015 | 1,015 | 100% |

Cadmus obtained all of the HEWs for each participant group from the ICSP in mid-January 2016 and compared participant responses from the scanned HEWS to the database extracts. The initial comparison identified extract formatting discrepancies and instances of missing or incorrect data, which Cadmus discussed and resolved after receiving the corrected ICSP database extracts. Cadmus then used the corrected ICSP database extract files in the final program analysis.

#### 8.2.5.2 Surveys

Cadmus used data obtained from the HEWs completed by the three student cohorts to calculate installation rates and other actions taken as a result of the program and to determine the product-level, cohort-level, and program-level realization rates.

Cadmus did not conduct follow-up surveys with participants in the parent workshop or with participating teachers in PY7. Instead, to calculate PY7 cohort-level realization rates, it used the following information:

- The installation rates for parent workshop participants collected from the PY6 follow-up surveys
- The smart strip installation information (including proportion of smart strips used at home and in the classroom) collected from participating Bright Kids and Take Action teachers through online surveys in PY6.

Table 8-9 lists the PY7 kits and the number of survey responses by cohort.

**Table 8-9: PY7 Summary of Kits and Survey Responses by Cohort**

| Cohort | Kits in EEMIS | Survey Responses in EEMIS | Survey Responses (Analysis) | Classroom Teachers in EEMIS | Classrooms with Survey Responses |
|---|---|---|---|---|---|
| Bright Kids | 8,017 | 6,954 | 6,954 | 343 | 322 |
| Take Action | 10,853 | 8,562 | 8,562 | 406 | 36 |
| Innovation | 5,200 | 3,733 | 3,733 | 124 | 107 |
| Parent Workshop | 1,015 | --[1] | --[1] | 22 | --[1] |
| Participating Teachers | 749 | --[2] | -- [3] | 2[4] | -- [3] |
| **Program Total** | **25,834** | | | **895** | |

[1] Cadmus calculated PY7 installation rates and savings for parent workshop participants using the findings from its PY6 phone and online survey (n=52).
[2] No HEWs for participating teachers. Installation rates and savings calculated using the Cadmus-conducted survey in PY6.
[3] In PY7, Cadmus used PY6 online survey data to evaluate the Bright Kids (n=67) and Take Action teachers (n=67) smart strip use. The total achieved sample combines the survey totals for PY6 Bright Kids and Take Action participating teachers. Innovation teachers did not receive smart strips in PY7.
[4] All 749 participating teachers who received a smart strip are entered into EEMIS as two records.

### 8.2.5.3 Methodology to Compute Savings Using Survey Data

Cadmus calculated the TRM-adjusted *ex ante* savings for each student using the savings associated with each item included in the energy-savings kit and planning assumptions (such as installation rates and percentage of electric water heat saturation) used by PPL Electric Utilities. (Additional detail is provided in *Appendix H: Methodology for Determining Savings from Energy-Savings Kits*.)

Cadmus based each student's verified *ex post* savings on the survey responses indicating whether the respondent installed the products. It also used data from the HEWs about fuel types for water and space heating to determine the *ex post* savings.

Cadmus totaled the student-level *ex post* and *ex ante* savings for each class (corresponding to a unique teacher ID) to estimate a realization rate, total *ex post* savings, and the standard error at the classroom level.

Assuming the survey responses represented a simple random sample of students in each class, Cadmus applied sampling weights based on the student population (the total number of kits distributed) and the sample size (the total number of surveys returned) to estimate the total savings and its standard error within each class.

Cadmus combined the class-level savings to estimate the population total within each cohort, assuming classes that returned surveys represented a simple random sample of classes from the cohort. It applied additional sampling weights according to class population (total number of classes in the cohort that participated in the program) and class sample size (total number of classes that returned surveys) to estimate the cohort population savings and the standard error at the cohort level. This approach to estimation is consistent with two-stage cluster sampling methods where the sampling weights and standard error calculation at each stage account for sampling uncertainty at both the class level and the cohort level.

Finally, Cadmus combined the cohort totals to estimate the program total savings, standard error, and precision.

#### 8.2.5.4 Summary of Survey Findings

Program participants returned 20,264 HEWs. Table 8-10 shows the PY7 in-service rate (ISR) and survey verified savings for each of the items in the energy-savings kit and for the participating classroom teacher smart strips. In-service rates represent the percentage of participants who verified they installed the product—that is, this percentage is specific to the product and derived from the participants who answered the product-specific question and not from the total number of people receiving or returning surveys. The installation rates for products are useful for program planning purposes.

As shown in Table 8-10, Cadmus calculated the water products' installation rates by dividing those who installed the product in an electric water heat home by the respondents who answered the question and have electric water heat. It also calculated the furnace whistle installation rate in a similar way, by dividing those who installed the product in an electric space heat home by the respondents who answered the question and have electric space heat or central air-conditioning in the home.

For LED bulbs in PY7, Cadmus based the ISR on an installation rate "trajectory" to include savings for all program bulbs assumed to be installed over time. For these, it incorporated the recommendations of the Uniform Methods Project (UMP) Residential Lighting Evaluation Protocol.[92]

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[92] National Renewable Energy Laboratory. *Uniform Methods Project.* Chapter 21: Residential Lighting Evaluation Protocol. Prepared by Apex Analytics, LLC. November 2014. Available online: http://www.nrel.gov/extranet/ump/pdfs/ump-res-lighting-clean.pdf

The UMP uses the findings from the 2014 California Upstream and Residential Lighting Impact Evaluation, which suggested that bulb installation rates could be as high as 97% within 4 years of purchase. Discounting the future savings back to the current program year reduces the ISR from 97%. This evaluation used a weighted average nominal discount rate of 8.14% for all electric distribution companies (EDCs).

**Table 8-10: Student & Parent Energy-Efficiency Education Program Product Savings per Distributed Unit in PY7**

| Product Installed | Valid Survey Responses | In-Service Rate | Survey Verified Per-Unit Savings (kWh/yr) |
|---|---|---|---|
| LED (3 bulbs) Bright Kids[1] | 6,954 | 90% combined for 3 bulbs[1] | 83.3[7] |
| LED (3 bulbs) Take Action[2] | 8,562 | 89% combined for 3 bulbs[2] | 82.2[8] |
| LED (3 bulbs) Innovations[3] | 3,733 | 89% combined for 3 bulbs[3] | 82.4[9] |
| LED (2 bulbs) Parent Workshop[4] | 50[5] | 82% combined for 2 bulbs[4] | 57.1 |
| Nightlight Bright Kids | 6,895 | 86% | 25.9 |
| Nightlight Take Action | 8,409 | 73% | 22.1 |
| Nightlight Parent Workshop | 51[5] | 80%[5] | 25.8 |
| Showerhead Take Action | 8,439 | 25% | 44.7 |
| Showerhead Innovation | 3,699 | 31% | 59.1 |
| Kitchen Aerator Take Action | 8,391 | 32% | 30.0 |
| Bathroom Aerator Innovation | 3,699 | 27% | 3.6 |
| Furnace Whistle Take Action | 8,318 | 13% | 6.6 |
| Smart Strip Innovation | 3,728 | 74% | 48.43 |
| Smart Strip Participating Teachers | 145[6] | 94%[6] | 86.0 |

[1] Individual Trajectory PY7 LED ISR for Bright Kids – LED1 92%, LED2 90%, LED3- 89% (Reported ISRs were LED1 57%, LED2 44%, LED3- 36%)

[2] Individual Trajectory PY7 LED ISR for Take Action – LED1 91%, LED2 89%, LED3 88%. (Reported ISRs were LED1 50%, LED2 35%, LED3 27%).

[3] Individual Trajectory PY7 LED ISR for Innovation – LED1 91%, LED2 89%, LED3 88%. (Reported ISRs were LED1 52%, LED2 37%, LED3 29%.)

[4] Individual PY7 LED ISR for Parent Workshop – LED1 88%, LED2 82%.

[5] Cadmus used PY6 installation rates collected from the PY6 phone and online surveys with parent workshop participants and applied them to the PY7 population.

[6] Cadmus applied the Bright Kids and Take Action smart strip installation information and ISRs collected in PY6 to the PY7 population.

[7] Individual PY7 LED per unit savings for Bright Kids—LED1 28.2, LED2 27.7, LED3 27.3.

[8] Individual PY7 LED per unit savings for Take Action—LED1 27.9, LED2 27.3, LED3 27.0.

[9] Individual PY7 LED per unit savings for Innovation— LED1 28.0, LED2 27.4, LED3 27.0.

### 8.2.6 Summary of Evaluation Results

Cadmus estimated savings for product installations using 2015 TRM algorithms for each item in the kit. It derived data inputs for in-service rates from the classroom and parent workshops HEWs, using all questions in the HEWs applicable to EDC-gathered variables in the TRM algorithms. It used manufacturer's data (for example, aerator and showerhead flow rates) in the algorithms to calculate verified savings for each product.

Cadmus calculated the realization rate as the ratio of *ex post* verified gross savings to *ex ante* adjusted savings.

Table 8-11 and Table 8-12 present the program saving results.

**Table 8-11: PY7 Student & Parent Energy-Efficiency Education Program Summary of Evaluation Results for Energy [1]**

| Stratum | PYTD Reported Gross Impact (MWh/yr) | PYTD Adjusted *Ex Ante* Energy Savings (MWh/yr) | Energy Realization Rate (%) | PYTD Verified Gross Energy Savings (MWh/yr)[2] | Sample CV, Error Ratio (ER), or Proportion | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Bright Kids | 929 | 929 | 94% | 875 | 0.0116 | 0.09% |
| Take Action | 2,875 | 2,937 | 69% | 2,023 | 0.2061 | 1.55% |
| Innovations | 1,094 | 1,092 | 92% | 1,006 | 0.1483 | 2.08% |
| Parent Workshop | 88 | 88 | 96% | 84 | 0.0038 | 0.12% |
| Participating Teachers | 68 | 68 | 95% | 64 | 0.1730 | 2.08% |
| **Program Total** | **5,054** | **5,113** | **79%** | **4,053** | **N/A** | **0.93%** |

[1] Values in this table refer to savings at the point of consumption. (Savings targets for MWh refer to values at the point of consumption.) Due to line losses, savings at the point of generation are systematically larger.
[2] Adjusted *ex ante* multiplied by the realization rate will not equal verified gross energy savings due to rounding

**Table 8-12: PY7 Student & Parent Energy-Efficiency Education Program Summary of Evaluation Results for Demand**

| Stratum | Reported Gross Demand Savings[1] (MW) | Adjusted *Ex Ante* Demand Savings[2] (MW) | Demand Realization Rate (%) | Verified Gross Demand Savings[2], [3] (MW) | Observed Coefficient of Variation (Cv) or Error Ratio in Sample | Demand Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Bright Kids | 0.077 | 0.083 | 92% | 0.076 | 0.0053 | 0.04% |
| Take Action | 0.456 | 0.498 | 45% | 0.225 | 0.2139 | 1.61% |
| Innovation | 0.117 | 0.126 | 88% | 0.111 | 0.1235 | 1.73% |
| Parent Workshop | 0.006 | 0.007 | 97% | 0.007 | 0.0053 | 0.17% |
| Participating Teachers | 0.007 | 0.007 | 116% | 0.008 | 0.1548 | 1.86% |
| **Program Total** | **0.663** | **0.722** | **59%** | **0.428** | **N/A** | **0.96%** |

[1] Reported gross demand reductions do not include the gross-up to reflect T&D losses.
[2] Adjusted *ex ante* and verified gross demand reductions include T&D losses.
[3] Adjusted *ex ante* multiplied by the realization rate will not equal verified gross demand savings due to rounding.

## 8.3 IMPACT EVALUATION NET SAVINGS

The Student & Parent Energy-Efficiency Education Program provides classroom training and energy-conservation kits at no cost to teachers, classroom, and workshop participants. Teachers do not purchase the training materials or the energy-conservation kits for their students. Students do not request or pay for the kits. Teachers send the kits home with children as part of the school's curriculum and households are not offered a choice to participate in this program.

In this program, a free rider would be a teacher who purchased the kits for their students in the absence of the program. Cadmus assumes that teachers and students would not purchase the same energy conservation kits of their own accord in the absence of the program. Therefore, and in keeping with the discussion in the SWE-approved EM&V plan, there were no free riders among this program's population. Likewise, according to the EM&V plan, Cadmus did not conduct follow-up process evaluation surveys in PY7 and assumed there was no spillover. The Student & Parent Energy-Efficiency Education Program has an NTG ratio of 1.0.

**Table 8-13: PY7 Student & Parent Energy-Efficiency Education Program Sampling Strategy for NTG Research**

| Stratum | Stratum Boundaries | Population Size (Number of Energy-Savings Kits) | Assumed CV or Proportion in Sample Design | Assumed Levels of Confidence & Precision | Target Sample size | Achieved Sample Size | Percentage of Sample Frame Contacted to Achieve Sample[1] |
|---|---|---|---|---|---|---|---|
| Student & Parent Program | Program | 25,085 | N/A | N/A | N/A | N/A | N/A |

[1] The sample frame is a list of contacts who may be selected into the sample. The percentage of sample frame contacted means the percentage of the population contacted to complete surveys.

**Table 8-14: PY7 Student & Parent Energy-Efficiency Education Program Summary of Evaluation Results for NTG Research**

| Target Group or Stratum (if appropriate) | Estimated Freeridership | Estimated Participant Spillover | NTG Ratio | Observed CV or Proportion | Relative Precision |
|---|---|---|---|---|---|
| Student & Parent Program | N/A | N/A | 1.0 | N/A | N/A |

## 8.4 PROCESS EVALUATION

### 8.4.1 Research Objectives

The evaluation of the Student & Parent Energy-Efficiency Education Program involves these research objectives:

- Collect demographic data to determine characteristics of participating households
- Collect and analyze feedback from participants to gather insights into program design, delivery, and satisfaction

### 8.4.2 Evaluation Activities

In PY7, which ended May 31, 2016, Cadmus conducted these process evaluation activities for the Student & Parent Energy-Efficiency Education Program, which were consistent with the PY7 evaluation plan:

- Interviewed program staff and implementer (n=2)
- Analyzed returned ICSP-administered HEWs (n= 19,249). All students received an HEW with their kit. Participating teachers encouraged students to complete the HEW at home and bring it back to their classroom where they transferred their answers to Scantron forms, which the teachers then returned to the ICSP. The Innovations cohort also had the option of completing the HEW online. The HEWs asked questions to provide data for the impact evaluation as well as the process evaluation.
  - Bright Kids returned HEWs (n=6,954)
  - Take Action returned HEWs (n=8,562)
  - Innovation returned HEWs (n=3,733)
- Analyzed parent workshop (Community in Action) HEWs (n=1,015). All parent workshop participants filled out an HEW during the parent workshop to receive a kit with energy-efficient products. Because the parent workshop HEWs asked questions about what the participant planned to do, Cadmus did not use these data to determine the in-service rates. However, it used these data in the process evaluation.
- Analyzed returned ICSP-administered parent surveys (n=2,229). The ICSP included these postage-paid postcard surveys in all of the Bright Kids, Take Action, and Innovation kits and in the parents'

energy-savings kits. The postcards asked parents about their experience with the kit items and whether they would like to see the program continued in local schools.

  - Bright Kids (n=1,531)
  - Take Action (n=587)
  - Innovation (n=111)
- Analyzed open-ended responses from ICSP-administered classroom teacher, teacher workshop, and parent workshop evaluation surveys (n=1,918 total). Classroom teachers received the evaluation as part of their Teacher Materials Folder. They completed and returned the evaluation surveys along with their students' HEWs using a postage-paid envelope provided by the ICSP. Parent and teacher workshop participants completed evaluation forms at the end of each workshop.
  - Bright Kids teachers (n=227)
  - Take Action teachers (n=326)
  - Innovation teachers (n=54)
  - Teacher workshop (n=148)
  - Parent workshop (n=1,163)
- Conducted database and quality assurance/quality control review of records

### 8.4.3 Methodology

This section summarizes the process evaluation activities and methodology.

#### 8.4.3.1 Program Staff and Implementer Interviews

Cadmus conducted interviews with PPL Electric Utilities' program manager and the ICSP's program manager in February 2016. The interviews focused on the objectives, goals, key performance indicators, program processes, marketing, and data tracking and assessed what worked well and areas where challenges existed in PY7.

#### 8.4.3.2 Participant Surveys

Cadmus did not conduct surveys with classroom teachers, teacher workshop participants, or parent workshop participants in PY7. Instead, it analyzed all available parent postcard surveys and the participating classroom teacher evaluation forms returned to the ICSP to obtain comments about the program.

Potential sources of bias in the surveys include nonresponse, recall, and social desirability biases. The ICSP addressed these potential sources of bias by applying survey design and survey data collection best practices. To ensure high response rates, the ICSP offered mini-grants as incentives to schools for returning the HEWs and encouraged teachers to give grades or extra credit for students who completed the worksheets. Since the overall HEW response rate of 81% is quite high (20,264 HEWs were returned out of 25,085 kits distributed), Cadmus assumed that any possible bias will have minimal impact.

Table 8-15 summarizes the survey sampling strategy for the cohort HEWs, the parent postcards, and the participating teacher evaluation forms.

#### 8.4.3.3 Analysis of ICSP-Administered Surveys

Cadmus analyzed the ICSP's survey data to determine installation rates, establish the demographic profile of participants, and gather qualitative program insights. It analyzed all HEWs from the student cohorts and parent workshops (n=20,264), all postcard surveys (n=2,229), and all open-ended responses from the program evaluation surveys received by the ICSP (n=1,918).

**Table 8-15: Student & Parent Energy-Efficiency Education Program Process Evaluation Sampling Strategy for PY7**

| Stratum | Stratum Boundaries | Population Size | Assumed Proportion or CV in Sample Design | Assumed Levels of Confidence and Precision | Target Sample Size | Achieved Sample Size | Percentage of Sample Contacted to Achieve Sample[1] | Used for Evaluation Activities |
|---|---|---|---|---|---|---|---|---|
| PPL Electric Utilities Program and ICSP Staff | Staff | 2 | N/A | N/A | 2 | 2 | 100% | Process, program staff interview |
| Home Energy Worksheets (included in kits) | Bright Kids, Take Action, Innovation, Parent Workshop | 25,085 | N/A | N/A | All records | 20,264 | 100% | Impact, process |
| Postcards (Included in Kits) | Bright Kids, Take Action, Innovation | 24,070 | N/A | N/A | All records | 2,229 | 100% | Process, qualitative analysis |
| Program Evaluation Surveys | Classroom Teachers, Teacher Workshop, Parent Workshop | 2,037 | N/A | N/A | All records | 1,918 | 100% | Process, qualitative analysis |
| **Program Total[2]** | **N/A** | **51,194** | **N/A** | **N/A** | **N/A** | **24,413** | **N/A** | **N/A** |

[1] The sample frame is a list of contacts that may be selected into the sample. The percentage contacted means the percentage of the sample frame contacted to complete surveys.
[2] Because the program participants gave responses across various data collection activities (home energy worksheets, postcards, and surveys), the program total row may double-count participants.

### 8.4.4 Achievements Against Plan

In PY7, the Student & Parent Energy-Efficiency Education Program achieved 85% of its planned MWh/yr savings,[93] 70% of its planned MW savings, and 108% of its annual participation (Table 8-16).

The program did not meet its Phase II planned MWh/yr savings, demand savings, or participation. For Phase II, the program achieved:

- 86% of its 15,628 MWh/yr three-year planned savings
- 59% of its 2.02 MW three-year planned demand reduction
- 97% of its three-year planned participation of approximately 70,000 kits

**Table 8-16: Student & Parent Energy-Efficiency Education Program Savings**

| Unit | PY5 Verified | PY6 Verified | PY7 | | | PY5–PY7 | | |
|---|---|---|---|---|---|---|---|---|
| | | | Planned | Verified | Percentage of Planned | Planned | Verified | Percentage of Planned |
| MWh/yr | 5,223[2] | 4,121[2] | 4,746 | 4,053 | 85% | 15,628 | 13,397 | 86% |
| MW | 0.30 | 0.50 | 0.61 | 0.43 | 70% | 2.02 | 1.20 | 59% |
| Participants [1] | 21,036 | 21,611 | 23,200 | 25,085 | 108% | 70,000 | 67,732 | 97% |

[1] Beginning in PY6 Q3, the methodology for counting participants for the Student & Parent Energy-Efficiency Education Program changed. The participant count is now based on the number of kits distributed instead of the previously reported number of classrooms. Cadmus applied this change to all of Phase II counts in this table.
[2] In PY7, Cadmus made adjustments to the energy savings calculations for PY5 and PY6, which resulted in verified gross energy savings of 5,223 MWh/yr for PY5 and 4,121 MWh/yr for PY6.

The following list includes several possible reasons why the program did not meet its planned savings or participation for Phase II:

- In PY6, LED bulbs and furnace whistles had fixed installation rates per the 2014 TRM algorithms. In the 2015 TRM (used for PY7 savings calculations), all products in the kits used EDC data gathering to determine the installation rates.
- Consistent with prior years, ISRs were low for showerheads, faucet aerators, and furnace whistles.
- Although the program exceeded its PY7 participation targets, it did not meet its Phase II participation targets by 2,268 participants, thus reducing the program's potential for savings.
- PPL increased planned participation and savings in the final EE&C plan filing.

### 8.4.5 Program Delivery

According to PPL Electric Utilities and the ICSP, the Student & Parent Energy-Efficiency Education Program ran very smoothly in PY7; they did not report any challenges or issues with the program. PPL Electric Utilities and the ICSP reported a smooth program delivery in PY6, which provided a solid foundation for PY7.

93 Planned savings are based on PPL Electric's revised EE&C Plan (Docket No. M-2012-2334388) filed with the Pennsylvania PUC on June 5, 2015, Table H5, p. 72.

#### 8.4.5.1 Key Performance Indicators

In addition to energy savings and participation, PPL Electric Utilities and the ICSP identified four key performance indicators that measure how the program is performing. The ICSP monitors these metrics to assess its own performance. Table 8-17 shows these key performance indicators with their PY7 results.

**Table 8-17: Student & Parent Energy-Efficiency Education Program Key Performance Indicators**

| Key Performance Indicator | Metric | Goal | PY7 Result |
|---|---|---|---|
| Program Enrollment | Number of schools enrolled for the program | Be fully enrolled by the start of summer | Reached full enrollment by summer and also increased enrollment to accommodate demand |
| New School Enrollment | Number of new schools enrolled for the program | 30% of program enrollment to come from new schools | Met goal |
| Teacher Workshop Participation | Number of teacher workshop participants | 150 teachers | Met goal with 150 teachers |
| Classroom and Parent Workshop Participation | Number of HEWs returned | Meet or exceed PY6's HEW return rate of 72% | Exceeded goal with 81% HEW return rate |

The key performance indicators reveal that the program did very well in program enrollment, new school enrollment, and teacher workshop participation. The program exceeded PY6's HEW return rate of 72% (81% in PY7). In addition, out of the 72% HEW return rate for the Innovations cohort, participants returned 40% through the new online option.

### 8.4.6 Program Updates and Outcomes

For PY7, the program implemented minor changes to program design and delivery from PY6. Cadmus made recommendations in PY6 and followed up with PPL Electric Utilities and the ICSP to determine if these recommendations were implemented in PY7. PPL Electric Utilities and the ICSP implemented the recommendation to include an online HEW completion process for Innovation students. The ICSP found that about 40% of the Innovation students who completed an HEW used the online return option. Overall, the HEW return rate increased for all cohorts, compared to PY6, with a program-level return rate of 81% in PY7.

In PY7, the updates to the EE&C plan required the program to enlist more schools for the Bright Kids cohort and the parent workshops. The ICSP exceeded the enrollment target for the Bright Kids cohort and met the target for the parent workshops. Both PPL Electric Utilities and the ICSP credit an increase in outreach to different types of schools, such as private and charter schools, to meet the planned enrollment in the program. PPL Electric Utilities and the ICSP also launched a poster contest to get students and classrooms involved in extra-curricular activities pertaining to energy efficiency.

In PY6, Cadmus recommended that the teacher workshop curriculum be modified so that teachers could attend the workshop again this year if they attended last year and still receive continuing education credit. However, the ICSP did not change the teacher workshop curriculum in PY7, so all participating teachers had to be new to the program.

Recommendations from the PY6 report to change the HEW survey questions (adding more details on heating and cooling equipment for furnace whistle calculations) were implemented in PY7 and allowed Cadmus to more accurately calculate savings for the furnace whistle.

### 8.4.7 Participant Profile

Participants in the Student & Parent Energy-Efficiency Education Program consisted of four groups representing the program components:

- Classroom teachers
- Workshop teachers
- Classroom parents
- Workshop parents

#### 8.4.7.1 Classroom Teachers

A total of 872 teachers from 218 schools participated in the classroom presentation component of the program, an increase from PY6 when 703 teachers from 191 schools participated. The largest classroom teacher participation came from Take Action (n=405, 92 schools), followed by Bright Kids (n=343, 89 schools) and Innovation (n=124, 37 schools).

#### 8.4.7.2 Workshop Teachers

The program achieved the planned number of teacher workshop participants, with exactly 150 teachers participating in the professional development workshop component of the program. Of these, 37% of workshop teachers represented primary grades (kindergarten – 5th grade), 32% represented intermediate grades (6th – 8th grade), and 32% represented secondary grades (9th – 12th grade).

#### 8.4.7.3 Classroom Parents

The parents of students who received the classroom-distributed kits (24,070 kits distributed in PY7) returned 19,249 HEWs (an increase from the 14,778 parents who returned HEWs in PY6).[94] The largest classroom parent participation was in the Take Action cohort (n=8,562), followed by Bright Kids (n=6,954) and Innovation (n=3,733). This distribution of classroom participation by cohort is consistent with past years. The ICSP gathered demographic data through the HEWs for Take Action and Innovation cohorts but did not ask demographic questions on the Bright Kids HEW.

Based on the demographic responses indicated in the HEWs, the majority of Take Action and Innovation classroom parents reported these characteristics:

- Live in a single-family home (80%)
- Have a household size of four members (33%)
- Use electricity as their main source of heat (41%)
- Heat their water with electricity (41%)
- Use central heat to heat their homes (38%)
- Use central air conditioning to cool their homes (43%)

#### 8.4.7.4 Workshop Parents

During PY7, PPL Electric Utilities and the ICSP held 22 Community in Action parent workshops in 22 schools. The workshop attendees returned 1,015 HEWs and reported these characteristics:

- Live in a single-family home (82%) that is 31 years or older (49%)
- Have a household size of four members (30%)
- Use electricity as their main source of heat (33%)

94 The number of classroom parents is not tracked. Instead, the number of HEWs returned is used to gauge classroom parent participation. HEWs are also used to gauge parent participation in the Community in Action (parent) workshops.

- Heat their water with electricity (55%)
- Have a central air conditioner (43%)

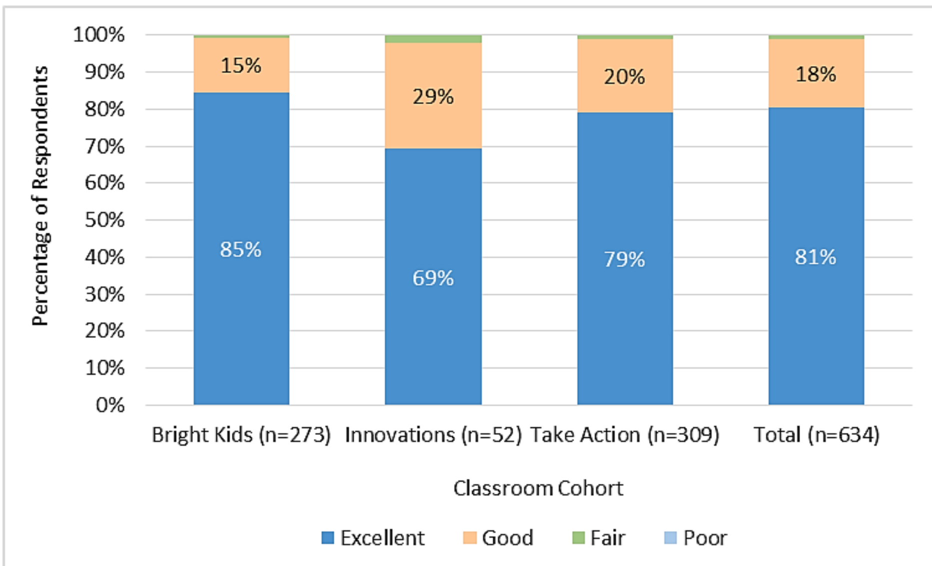
### 8.4.8 Satisfaction

Teacher and parent participants reported positive experiences with the program.

#### 8.4.8.1 Classroom Teachers

Overall, the participating classroom teachers in all cohorts reported high satisfaction with the program, with 81% (511 of the 634 classroom teachers who answered the question) stating their overall impression of the program was *excellent*. Participating Bright Kids teachers reported the highest satisfaction with the program (85%, 231 of 273, stated their overall impression was *excellent)*, followed by Take Action (79%; 244 of 309) and Innovations (69%, 36 of 52) teachers. Figure 8-1 shows the breakdown of responses by classroom cohort.

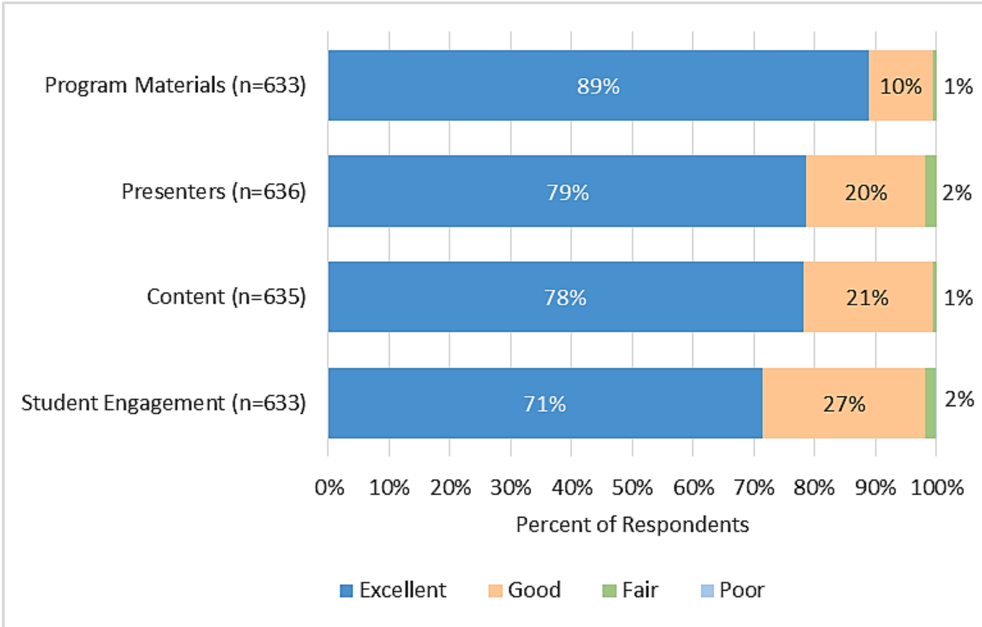
**Figure 8-1: Teacher Impressions of the Program Overall by Classroom Cohort**




Source. ICSP-administered teacher evaluation survey, "Please share your impressions of the Think! Energy Program: program overall."

Teachers also indicated positive impressions of program components, with the majority of respondents rating their experience with each program component as *excellent.* Teachers provided the highest rating of program materials (89%, 563 of 633, said the program materials were *excellent*) and the lowest rating of student engagement (71%, 452 of 633, said student engagement with the program was *excellent*), as shown in Figure 8-2.

**Figure 8-2: Classroom Teacher Impressions of Program Components**



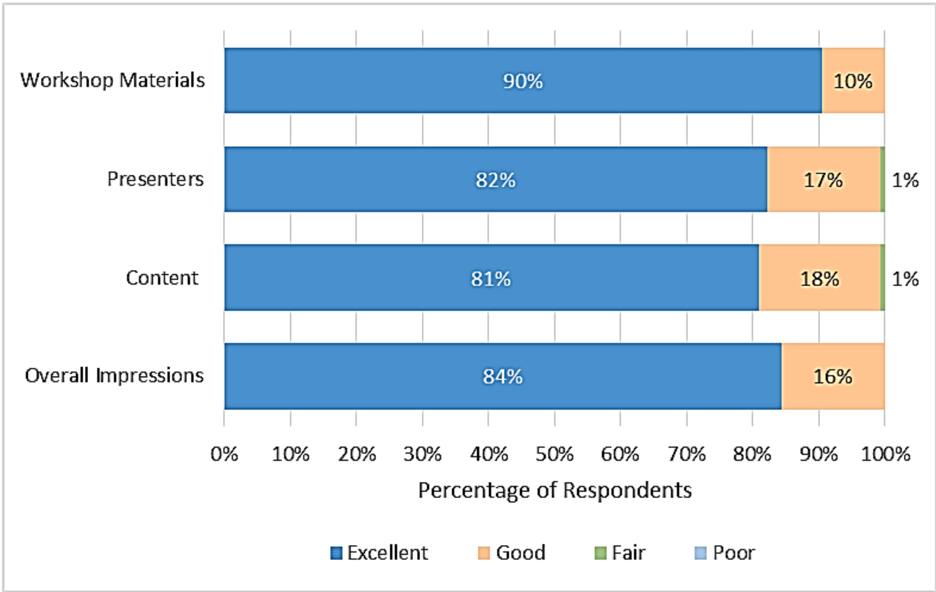

Source. ICSP-administered teacher evaluation survey, "Please share your impressions of the Think! Energy Program: Materials, student engagement, content, presenters."

### 8.4.8.2 Workshop Teachers

In the summer, the program offers teachers professional development workshops focused on energy efficiency and sustainability topics. Participating workshop teachers provided positive feedback about their impressions of the workshop. Of those who responded to the ICSP-administered survey, 84% (124 of 147) rated their overall impressions of the workshop as *excellent* (Figure 8-3).

Ninety percent of respondents rated the workshop materials as *excellent*, and they all said they intend to use the education materials from the workshop. Teachers provided slightly lower ratings of the presenters and workshop content; however, the majority of respondents still rated these workshop components as *excellent* (82% for presenters and 81% for workshop content).

**Figure 8-3: Workshop Teacher Impressions of the Workshop and Workshop Attributes**




Source: ICSP-administered teacher workshop evaluation survey, "Please rate the presentation by the following attributes: Materials, presenters, content, overall workshop" (n=147)

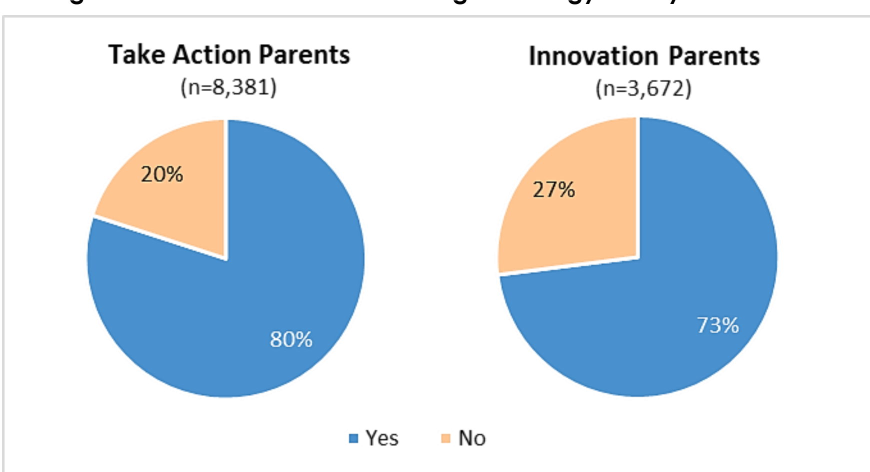
#### 8.4.8.3 Classroom Parents

Classroom parents provided very positive feedback about the program. Almost all classroom parents gave these responses on the ICSP-administered parent feedback postcards:

- The kit and products were easy for them and their child to install and use (100%; n=2,197)
- They would continue to use the kit items after completion of the program (99%; n=2,192)
- They would like to see the program continued in local schools (100%; n=2,195)

Since participating in the program, the majority of parents reported a behavior change toward energy efficiency. As Figure 8-4 shows, 80% of Take Action parents (6,679 of 8,381) and nearly three-quarters of Innovation parents (2,682 of 3,672) indicated that they had changed the way they used energy in their home since participating in the program.

**Figure 8-4: Classroom Parent Change in Energy Use by Classroom Cohort**

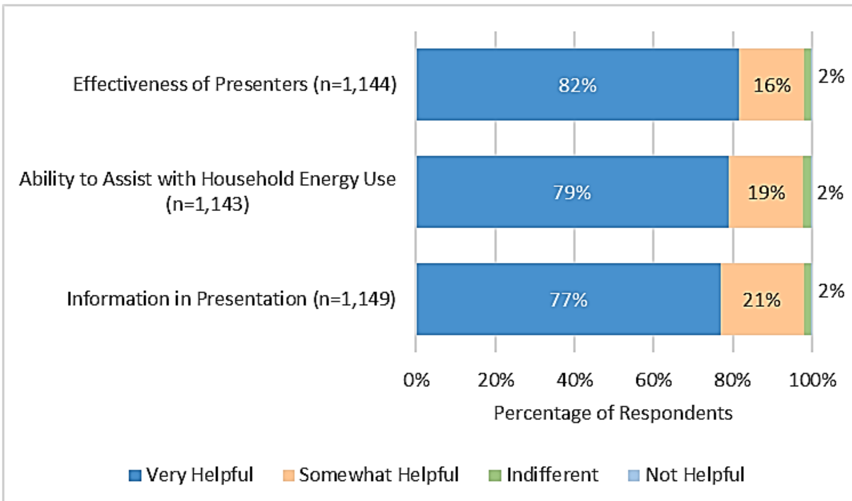



Source: ICSP HEW, Question 24, "Has participation in THINK! ENERGY changed the way you use energy in your home?"

#### 8.4.8.4 Workshop PareHnts

The program also delivers workshops for parents, targeting low-income neighborhoods to provide energy education and energy savings kits. After attending the workshop, the ICSP asked parent workshop participants to complete an evaluation survey and rate the helpfulness of the workshop. As Figure 8-5 shows, most respondents believed the workshop and workshop components were helpful. They provided the highest rating with the effectiveness of the presenters in communicating the information concerning the HEW and kit contents (82%, 934 of 1,144, said it was very *helpful)*, followed by the workshop's ability to assist their household in energy use (79%; 903 of 1,143), and the information in the presentation (77%; 883 of 1,149).

**Figure 8-5: Workshop Parent Rating of Helpfulness of Workshop**




Source: ICSP-administered workshop evaluation survey, Question 1, "How would you rate the information in the presentation?" Question 2, "How effective were the presenters in communicating information concerning the Home Energy Worksheet and kit contents?" Question 3, "How would you rate the overall Community in Action forum in its ability to assist your household with its energy use?"

### 8.4.9 Aspects Working Well and Areas of Improvement

Table 8-18 provides a high-level summary of the responses participating teachers and parents gave about aspects of the program that are working well and areas that can be improved. Responses came from open-ended survey questions from the ICSP-administered evaluation surveys (n=1,918).

### 8.4.10 Marketing and Outreach

The ICSP continued to use a targeted marketing and personalized outreach approach to recruit schools and educators into the program. The marketing placed a priority on recruiting new participant schools, while the outreach efforts focused on making direct communication (via phone and e-mail) to educators at schools with a low-income population. The ICSP made sure to contact and invite all qualified schools in PPL Electric Utilities' service territory that had not participated in the past.

To market the teacher workshop, the ICSP sent e-mail blasts to educators, posted on social media (Facebook), and featured an article in PPL Electric Utilities' Connect newsletter. To market the Community in Action parent workshop, the ICSP directly phoned and e-mailed all parent teacher organizations on the qualified schools' list, targeting the schools identified as low-income first.

**Table 8-18: Teacher and Parent Feedback on Program Components**

| Program Component | Aspect Working Well | Area For Improvement |
|---|---|---|
| Classroom – Bright Kids<br><br>Primary<br>(2nd – 3rd) | ▪ Program's ability to engage students and inform them about energy efficiency<br>▪ Posters, energy stick, and activity sheets from the Teacher Guide, particularly the renewable and nonrenewable resources activity<br>▪ Mini-grants<br>▪ Works well with science curriculum | ▪ Provide more student interaction opportunities such as hands-on activities<br>▪ Have more enthusiastic presenters<br>▪ Reduce paperwork of HEWs<br>▪ Provide longer, less condensed presentations |
| Classroom – Take Action<br>Intermediate (4th – 8th) | ▪ Posters, energy stick, and activity sheets from the Teacher Guide, particularly the pass-the-sack activity, lesson on fossil fuels, and Energy for Electricity activity<br>▪ Program's ability to engage students and inform them about energy efficiency<br>▪ Materials and resources are useful | ▪ Provide more student interaction opportunities such as follow-up visits, hands-on activities, and longer presentations<br>▪ Provide prizes for Lingo activity<br>▪ Offer more convenient scheduling<br>▪ Reduce paperwork of HEWs |
| Classroom – Innovation<br>Secondary<br>(9th – 12th) | ▪ Electricity-related activities (Kill-A-Watt and school lighting audit), as well as the Cost of Looking Your Best activity from the Teacher Guide<br>▪ Program's ability to engage and inform students about energy efficiency<br>▪ Materials and resources are useful | ▪ Provide more student interaction opportunities such as hands-on activities<br>▪ Improve the PowerPoint presentations and videos<br>▪ Provide longer, more in-depth presentations<br>▪ Reduce paperwork of HEWs |
| Teacher Workshop | ▪ Workshop is very interactive and informative<br>▪ Hands-on activities<br>▪ Free goodies | ▪ Provide more time for activities |
| Parent Workshop | ▪ Information was useful, especially about smart power strips, LEDs, phantom loads, and the cookie demonstration<br>▪ Great program overall | ▪ Improve the presentation such as improving the sound on the video and reducing the noise in the workshop environment |
| Source: ICSP classroom teacher evaluation surveys; teacher workshop evaluation survey; parent workshop evaluation survey; energy savings kit evaluation survey (Parent Postcard). | | |

Near the starting date, PPL Electric Utilities advertised the classroom presentations via social media and in the Connect newsletter. The ICSP also commented on the status of the classroom presentations via social media in conjunction with PPL Electric Utilities' outreach activities. In addition, the program received media attention about its energy efficiency poster contest activities, and some participating teachers wrote articles in local newspapers about the classroom presentations PPL Electric Utilities described in its marketing activities.

These marketing and outreach efforts successfully increased participation. The program enlisted participants in all components of the program and either met or exceeded the planned enrollment for PY7.

## 8.5 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings, Cadmus drew conclusions and suggests that PPL Electric Utilities consider these recommendations in PY7.

**Conclusion**

Survey reported light bulb installation rates decreased from PY5 to PY7. The HEWs completed by classroom cohort participants provided data to determine the installation rates each year (see Section 8.2.5.4 Summary of Survey Findings). The wording of the question about light bulb installation changed slightly between PY6 and PY7, which may account for some reporting differences. In PY5 and PY6, the HEW survey asked participants to identify the wattage of the bulb they replaced with the first, second, and third LED or CFL from their kit, with *did not install* as the last option. In PY7, the HEW survey asked respondents more directly *"did you install the LED from your kit"* for each of the three bulbs. The more direct question may lead to answers that are more accurate.

**Recommendation**
Monitor LED bulb installation rates in PY8. Consider reducing the number of LEDs included in the kits in PY9 if in-service rates continue to decrease.

**Recommendation**
Review student guides and education and installation materials to assess opportunities to further highlight LED benefits (compared to both incandescent and CFLs) and encourage installation.

**Conclusion**
Installation rates for most items stayed relatively consistent from PY5 to PY7. Participants continued to use the plugged-in products (e.g., LED bulbs, smart power strips, and night lights) more than the furnace whistle or the water saving products (see Section 8.2.5.4 Summary of Survey Findings).

**Recommendation**
Consider increasing the grade-appropriate classroom instructions and discussion about the furnace whistle, showerhead, and faucet aerator items to encourage installation.

**Recommendation**
In the PY5 evaluation, participants commonly said they did not install a particular product because they had already installed one.[95] Although PPL Electric Utilities and the ICSP carefully track kit distribution to avoid repeat distributions to the same participants, rotating the kits or products every other year may offer an easier way to boost installation rates. When kit products remain the same from year to year, saturation makes it less likely participants will install the products, if the kits are distributed to the same homes. Alternatively, as proposed in PY6,[96] explore new ideas to increase installation rates, other than changing the products in the kit. For example, encourage product trade-ins or donate unused products to organizations that will use them.

**Conclusion**
The ICSP's targeted marketing and personalized outreach efforts that focused on recruiting new participants, making one-on-one calls, and sending personalized e-mails to schools with a low-income population galvanized program awareness and helped to increase participation across all cohorts and workshops. In PY7, the ICSP distributed more kits (25,085) than in PY6 (21,611) and PY5 (21,036) (see Section 8.4.10, Market and Outreach and Section 8.4.4, Achievements Against Plan).

**Conclusion**
The PY7 program met all of its key performance indicators for program enrollment, new school enrollment, and teacher workshop participation. The PY7 program exceeded its key performance

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95 PPL Electric Process Evaluation Report: *Program Year Five.* Student Parent Energy-Efficiency Education Program. Prepared by The Cadmus Group. November 2014. Available online: https://www.pplelectric.com/~/media/pplelectric/save%20energy%20and%20money/docs/act129_phase2/pplpy5processevaluation212015.pdf?la=en

96 PPL Electric Utilities Annual Reports to the PA PUC: *Program Year Six.* Chapter 7: Student Parent Energy-Efficiency Education Program. Prepared by The Cadmus Group. November 2015. Available online: https://www.pplelectric.com/~/media/pplelectric/save%20energy%20and%20money/docs/act129_phase2/py6annualreport20151115.pdf?la=en

indicator for workshop and classroom participation as measured by the number of HEWs returned. PY7 achieved a HEW return rate of 81%, an increase from the PY6 HEW return rate of 72% and the PY5 return rate of 79%. Efforts to increase HEW return rates were successful (see Section 8.4.5.1, Key Performance Indicators).

PPL Electric Utilities and the ICSP implemented the recommendation from PY6 to include an online HEW completion process for Innovation students. Out of the 72% HEW return rate for the Innovations cohort, 40% came from the new online return option. Offering this online completion option probably contributed to the increase in returned Innovations HEWs from 59% in PY6 to 72% in PY7. Teacher responses from all three cohorts from the ICSP-administered program evaluation forms suggest that the paperwork involved with completing and submitting HEWs remains a barrier. (See Section 8.4.9, Aspects Working Well and Areas of Improvement)

**Recommendation**
Consider a streamlined HEW data collection process where all student cohorts can input the data online instead of filling out a Scantron form in Phase III. Students would still complete the paper HEW at home, but would enter the data online through an identical-looking form. Teachers can then review the collected data and submit all data online, reducing the amount of paperwork for both students and teachers.

### 8.5.1 Status of Recommendations for Program

Table 8-19 contains the status of each PY7 process recommendation made to PPL Electric Utilities.

**Table 8-19: Student & Parent Energy-Efficiency Education Status Report on Process and Impact Recommendations**

| Recommendations | EDC Status of Recommendation (Implemented, Being Considered, Rejected AND Explanation of Action Taken by EDC) |
|---|---|
| **Student & Parent Energy-Efficiency Education Program** | |
| Monitor LED bulb installation rates in PY8 and consider reducing the number of LEDs included in the kits in PY9 if ISRs continue to decrease. | Being considered. PPL will certainly monitor the PY8 LED bulb installation rate and determine if program changes are required (reduce the number of bulbs or improve messaging to encourage a higher installation rate.) |
| Review student guides and education and installation materials to assess opportunities to further highlight LED benefits (compared to both incandescent and CFLs) and encourage installation. | Being considered. PPL will certainly monitor the PY8 LED bulb installation rate and determine if program changes are required (reduce the number of bulbs or improve messaging to encourage a higher installation rate.) |
| Consider increasing the grade-appropriate classroom instructions and discussion about the furnace whistle, showerhead, and faucet aerator items to encourage installation. Consider other ideas to increase installation rates, other than, or in addition to, changing the products in the kit. | Will be implemented. Since the program is well underway for PY8, any changes will likely be for PY9. |
| Consider a streamlined HEW data collection process where all student cohorts can input the data online instead of filling out a Scantron form. | Being considered. Since the program is well underway for PY8, any changes will likely be for PY9. |

## 8.6 FINANCIAL REPORTING

Table 8-20 shows a breakdown of the Student & Parent Energy-Efficiency Education Program finances.

**Table 8-20: Summary of Student & Parent Energy-Efficiency Education Program Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs [6] ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs | $0 | $0 |
| 2 | EDC Incentives to Participants | $0 | $0 |
| 3 | EDC Incentives to Trade Allies | - | - |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $0 | $0 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6, 7, 8, 9, 10 ) | $2,216 | $4,875 |
| 6 | Design & Development | $0 | $0 |
| 7 | Administration, Management, and Technical Assistance[1] | $2,216 | $4,875 |
| 8 | Marketing[2] | $0 | $0 |
| 9 | EDC Evaluation Costs | $0 | $0 |
| 10 | SWE Audit Costs | $0 | $0 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | $0 | $0 |
| | | | |
| 12 | Total TRC Costs [3] (Sum of rows 1, 5 and 11) | $2,216 | $4,875 |
| 13 | Total NPV Lifetime Energy Benefits | $2,810 | $8,442 |
| 14 | Total NPV Lifetime Capacity Benefits | $157 | $428 |
| 15 | Total NPV O&M Saving Benefits | $498 | $1,117 |
| 16 | Total NPV TRC Benefits[4] | $3,465 | $9,988 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | 1.56 | 2.05 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.
[2] Includes the marketing CSP and marketing costs by program CSPs.
[3] Total TRC Costs includes Total EDC Costs and Participant Costs.
[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.
[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[6] Phase II Costs in this table are discounted back to PY5, thus will not match cumulative costs reported in the PY7 Q4 quarterly report

# 9 LOW-INCOME WINTER RELIEF ASSISTANCE PROGRAM (WRAP)

The Act 129 Low-Income Winter Relief Assistance Program (Act 129 WRAP) supplements and operates in tandem with PPL Electric Utilities' Universal Services Program (USP) WRAP. Both programs are designed to reduce electric consumption and improve living comfort for income-qualified customers.

USP WRAP targets residential customers whose income is at or below 200% of the federal poverty guidelines. Act 129 WRAP operates in largely the same manner but targets customers whose income is at or below 150% the federal poverty guidelines. Both programs seek to reach these three groups:

- New participants
- PPL Electric Utilities customers who have received WRAP assistance in the past and may be in need of further WRAP services
- Customers who may not have been eligible for low-income assistance in the past because of eligibility rules such as the requirement to have at least one year of pre-participation kWh usage data

USP WRAP and Act 129 WRAP are available to customers in existing single-family homes and multifamily housing (three or more dwelling units) where 50% or more of the tenants are income-qualified.

PPL Electric Utilities designed USP WRAP and Act 129 WRAP to operate seamlessly so that customers are not aware from which program they are receiving services. It funds both programs through tariffed electric bill surcharges but tracks each program's funding sources, budgets, and expenditures separately. The same PPL Electric Utilities program manager manages both programs.

Income-eligible customers receive a free energy audit where technicians evaluate their home for eligible energy-saving products. The audit refers to a preapproved list of appliances and large equipment along with other criteria to determine if any of these can be replaced cost-effectively. In the unlikely event a structure requires minor health and safety repairs before services can be provided, contractors make the repairs so that the agencies implementing the program do not have to deny services altogether.

PPL Electric Utilities works with community-based organizations to implement the program. These organizations either use in-house contractors or outsource the installation of energy-saving products and replacement of outdated and inefficient equipment with program-qualifying energy-efficient equipment.

WRAP provides low-income customers with three types of service, also known as "jobs"—baseload (customers without electric heat and without electric water heater), low-cost (customers without electric heat but with electric water heater), and full-cost (customers with electric heat and an electric water heater). PPL Electric Utilities provides all services and products to income-qualified customers at no cost. WRAP also offers energy education to encourage customers to conserve energy.

Baseload products include these:

- Energy education
- Installation of efficient lighting (such as LEDs)
- Refrigerator replacement
- Air conditioner replacement
- Dehumidifier replacement
- Changing or cleaning of heating and cooling filters
- Dryer venting (electric dryer)
- Power strips and smart plugs

Low-cost products include all baseload products as well as water-heating products such as these:

- Water heater replacement
- Water heater pipe wrap
- Faucet aerators
- Efficient showerheads

Full-cost products and services include all baseload and low-cost products and adds treatment of the building shell:

- Insulation (e.g., attic, floor, wall)
- Infiltration (e.g., caulking, weatherstripping, blower door testing)
- HVAC repair and replacement
- Duct insulation and repair
- Window repair and replacement

In addition, PPL Electric Utilities offers a heat pump water heater at no cost to qualified low-income customers with electric water heating.

The Act 129 WRAP included one new component in PY7, referred to as the De Facto Heating Pilot.

***De Facto Heating Pilot.*** The De Facto Heating Pilot targeted WRAP-eligible customers who use an inefficient or unsafe electric heat source, such as portable electric space heaters or an electric stove, in place of their inoperable oil heating system. PPL Electric Utilities installed high-efficiency heat pump systems in 11 homes to provide these customers a safer, more efficient heating source. PPL Electric Utilities also installed heat pump water heaters in two of these homes and WRAP services in 10 of these homes and one home, which was later ineligible for the De Facto Heating Pilot's heating system. Results of this effort are discussed in Section 9.7.4.4 Achievements Against Plan.

The objectives of the Act 129 WRAP are these:[97]

- Provide low-income customers with education and measures to help reduce their energy costs and increase their energy efficiency
- Maintain partnerships with local community-based organizations and contractors to ensure that customers receive maximum and timely customer assistance
- Promote other PPL Electric Utilities energy efficiency programs
- Install WRAP measures in approximately 10,000 low-income customer homes through 2016 with a total approximate reduction in energy use of 10,400 MWh/yr[98]

In addition to the first three objectives listed above, the De Facto Heating Pilot included the objective to install high-efficiency heat pump systems in 20 low-income customers' homes through 2016 with a total approximate reduction in energy use of 69 MWh/yr. The primary objectives of this pilot are described in Section 9.7.

A summary of cumulative Phase II program metrics is shown in Table 9-1.

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97 Program objectives are stipulated on PPL Electric Utilities' revised EE&C Plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, p.82.

98 Low-income is defined at 150% of the federal poverty level or below.

**Table 9-1: Phase II Act 129 WRAP Summary[1]**

| Program | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Net-to-Gross Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) [1] | Program Acquisition Cost ($/Annual kWh) | Cost of Conserved Energy (TRC Costs/ Lifetime kWh, at Generation) | Phase II Participants |
|---|---|---|---|---|---|---|---|---|---|
| Low-Income WRAP | 12,074 | 12,074 | 11,788 | 1.0 | 0.76 | $16,312 | $1.38 | $0.139 | 10,261 |
| **Total** | **12,074** | **12,074** | **11,788** | **1.0** | **0.76** | **$16,312** | **$1.38** | **$0.139** | **10,261** |

[1] This table does not include the De Facto Heating Pilot.

## 9.1 PROGRAM UPDATES

In PY7, PPL Electric Utilities introduced one new WRAP component. The De Facto Heating component targeted income-qualified participants with inoperable heating systems. No other changes were introduced to WRAP in PY7. PPL Electric Utilities continued to offer baseload, low-cost, and full-cost job types, as well as heat pump water heaters.

### 9.1.1 Definition of Participant

An Act 129 WRAP participant is defined as an income-eligible household, and each household is identified in THE EEMIS database with a unique customer Job ID. Participants can receive a WRAP job, a heat pump water heater, or both within the same Job ID. Customers receiving both a WRAP job and a heat pump water heater contribute only once to the participant counts.

In PY7, a participant can also be defined as a customer who participated in the De Facto Heating component (discussed in 9.7.1.1 Definition of Participant).

## 9.2 IMPACT EVALUATION GROSS SAVINGS

Table 9-2 shows cumulative Phase II program metrics by customer sector. In Phase II, Act 129 WRAP reported energy savings of 12,074 MWh/yr, adjusted *ex ante* energy savings of 12,074 MWh/yr, and verified gross energy savings of 11,788 MWh/yr.

**Table 9-2: Phase II Act 129 WRAP Executive Summary by Customer Sector**

| Sector | Phase II Reported Energy Savings (MWh/yr) [1] | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) [1] | Phase II Verified Gross Energy Savings (MWh/yr) [1] | Phase II Net-to-Gross Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) [1] | Program Acquisition Cost ($/Annual kWh) [1] | Cost of Conserved Energy (TRC Costs/Lifetime kWh, at Generation) | Phase II Participants [1] |
|---|---|---|---|---|---|---|---|---|---|
| Residential | - | - | - | - | N/A | - | N/A | N/A | - |
| Low-Income | 12,074 | 12,074 | 11,788 | 1.0 | 0.76 | $16,312 | $1.38 | $0.139 | 10,261 |
| Small C&I | - | - | - | - | N/A | - | N/A | N/A | - |
| Large C&I | - | - | - | - | N/A | - | N/A | N/A | - |
| Government/ Nonprofit/Education | - | - | - | - | N/A | - | N/A | N/A | - |
| **Total** | **12,074** | **12,074** | **11,788** | **1.0** | **0.76** | **$16,312** | **$1.38** | **$0.139** | **10,261** |

[1] This does not include De Facto Heating Pilot.

### 9.2.1 Reported Gross Savings

For Act 129 WRAP, *ex ante* reported energy savings and demand reduction for WRAP jobs are deemed by job type rather than by the TRM algorithm for each product installed. In Phase II, PPL Electric Utilities and Cadmus used energy savings estimates by job type derived from a customer usage analysis of the previous years' Act 129 WRAP participants, in compliance with the Evaluation Framework and the PA Mass Market Protocol.[99, 100] Table 9-3 shows the annual reported savings by job type.

**Table 9-3: Reported Annual Savings by Job Type**

| Job Type | Annual Savings by Job Type (kWh/yr) |
|---|---|
| Baseload Service Package Installed in PY6 | 988 |
| Baseload Service Package Installed in PY7 | 1,200 |
| Low-Cost Service Package Installed in PY6 | 1,057 |
| Low-Cost Service Package Installed in PY7 | 1,228 |
| Full-Cost Service Package Installed in PY6 | 1,360 |
| Full-Cost Service Package Installed in PY7 | 1,476 |
| Heat Pump Water Heaters Installed in PY6 | 1,776 |
| Heat Pump Water Heaters Installed in PY7 | 1,723 |

### 9.2.2 Database Review

For both the impact and process evaluations, Cadmus reviewed the tracking database extracts for the sample of records selected of PY7 projects and WRAP components. The QAQC review assessed the completeness of fields necessary to conduct the participant telephone surveys and verify that measures recorded in EEMIS for each job sampled matched the measures installed from the Low-Income Energy Assistance Program (LEAP) records.[101]

### 9.2.3 EM&V Sampling Approach

In PY7, Cadmus performed these impact evaluation activities:

- Database and records quality control review
- Records review
- Billing analysis

Table 9-4 lists the approaches used to evaluate savings for each program stratum.

99 Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase II Energy Efficiency and Conservation Programs.* Pp. 50-52. Prepared by GDS Associates, Inc., and Nexant. June 1, 2014.

100 Navigant Consulting, Inc., et al. *PA Mass Market Protocol: Savings Verification Methodology for Whole-Building Retrofit Measures in Low-Income Programs*. August 9, 2013.

101 LEAP is an electronic tracking system used by PPL Electric Utiliites to track WRAP data. LEAP was implemented by PPL Electric Utiliites in PY6.

**Table 9-4: PY7 Act 129 WRAP Impact Evaluation Sampling Strategy**

| Stratum | Population (Job Type) | Target Levels of Confidence & Precision | Target Sample Size | Achieved Sample Size | Evaluation Activity |
|---|---|---|---|---|---|
| Baseload | 2,476 | N/A | 30 | 30 | Database and Records Quality Control Review; Records Review; Billing Analysis |
| Low-Cost | 570 | N/A | 30 | 34 | Database and Records Quality Control Review; Records Review; Billing Analysis |
| Full-Cost | 359 | N/A | 30 | 46 | Database and Records Quality Control Review; Records Review; Billing Analysis |
| Heat Pump Water Heater | 180 | N/A | 30 | 61 | Database and Records Quality Control Review; Records Review |
| **Program Total [1]** | **3,585** | **85/15** | **120** | **171** | |

[1] In PY7, 3,405 unique participants received a baseload, low-cost, or full-cost job. Of these, 170 also received a heat pump water heater. Another 10 participants received only a heat pump water heater, for a total of 3,415 unique participants.

### 9.2.4 *Ex Ante* Adjustment Methodology and Findings

Because *ex ante* savings for baseload, low-cost, and full-cost jobs are based on a billing analysis, Cadmus did not make any *ex ante* adjustments to the reported gross savings for these job types. The heat pump water measure *ex ante* savings were based on TRM algorithms; however, no *ex ante* adjustments were necessary for heat pump water heater jobs.

### 9.2.5 *Ex Post* Methodology and Findings

#### 9.2.5.1 Records Review

For all quarters of PY7, data were available from PPL Electric Utilities' new LEAP tracking system (used for USP WRAP and Act 129 WRAP tracking). LEAP incorporates electronic data entry so there were no paper documents to review; the PY7 records review activities involved comparing LEAP and EEMIS electronic data.

Cadmus conducted a records review of a sample of baseload, low-cost, full-cost, and heat pump water heater jobs. Because the type of job depended on the type of measures installed, the purpose of the records review was to verify that the job type recorded for the customer corresponded to the equipment installed. Full-cost jobs included at least one space-heating measure (e.g., shell or furnace measure), low-cost jobs excluded space-heating measures but included at least one water-heating measure (e.g., low-flow showerheads or aerators), and baseload jobs excluded both space-heating and water-heating measures. Heat pump water heater jobs referred to the installation of this equipment.

The impact evaluation review focused on the completeness and accuracy of parameters such as energy savings, demand reduction, and algorithm input parameters. The records review exceeded the sample designed to meet levels of 85% confidence and 15% precision by program.

Cadmus made *ex post* adjustments to six WRAP jobs for which savings were double-counted because of database tracking errors. Cadmus determined that for six individual participant sites, savings were reported for two jobs (excluding heat pump water heaters) at each site. The multiple records were because measure installations occurred on different dates for the same participant site or because the same participant received two different audits. Cadmus verified savings for the job type most representative of the measures received by the participant and assigned an *ex post* value of zero savings for the other job to avoid double-counting of savings at the same participant site.

#### 9.2.5.2 WRAP Jobs - Installation Dates in PY6

To estimate the *ex post* evaluated savings per job for jobs completed in PY6 but reported in PY7, Cadmus conducted a customer usage analysis of PY3 and PY4 participants (Phases I and II), which resulted in these savings:

- 988 kWh/yr in savings per baseload job
- 1,057 kWh/yr in savings per low-cost job
- 1,360 kWh/yr in savings per full-cost job

More detailed information about the billing analysis for PY6 estimates is available in *Appendix J: Act 129 WRAP Billing Analysis* of the PPL Electric Utilities' Final Annual Report for PY6.[102]

PPL Electric Utilities applied the PY6 savings per job prospectively, so the reported gross energy savings and the verified gross energy savings per job would be the same. For jobs completed in PY6, Cadmus calculated the *ex post* demand reduction by multiplying the per-unit energy savings by the coincidence factor of 0.00011797. In 2014, Cadmus updated this coincidence factor for WRAP jobs from 0.00011381 to comply with the Phase II Evaluation Framework's peak demand window definition of 2:00 p.m. to 6:00 p.m. on non-holiday weekdays during June, July, and August (replacing the previously defined "top 100 hours").[103]

Additionally, Cadmus used a different load shape—Residential Single-Family Miscellaneous load shape—to calculate the updated coincidence factor because it is more representative of the whole house weatherization approach used in Act 129 WRAP. The prior coincidence factor of 0.00011381 was effective in Phase I and calculated using PPL Electric's Low-Income Heating load shape. The per-unit demand savings are provided in Table 9-5.

**Table 9-5: Act 129 WRAP Phase II per Unit Demand Values per Job with Installation Date in PY6**

| Job Type | Reported Gross Demand Savings (kW per Unit) | Adjusted *Ex Ante* Demand Savings (kW per Unit) | Verified Gross Demand Savings (kW per Unit) |
|---|---|---|---|
| Baseload | 0.12 | 0.12 | 0.12 |
| Low-Cost | 0.11 | 0.11 | 0.11 |
| Full-Cost | 0.15 | 0.15 | 0.16 |

[102] PPL Electric Utilities. *Final Annual Report to the Pennsylvania Public Utility Commission For the Period June 2013 through May 2014 Program Year 6*. Prepared by Cadmus. November 16, 2015. Appendix J: Act 129 WRAP Billing Analysis.

[103] Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase II Energy Efficiency and Conservation Programs.* Prepared by GDS Associates, Inc., and Nexant. June 1, 2014.

#### 9.2.5.3 WRAP Jobs - Installation Dates in PY7

To estimate the per-job *ex post* evaluated savings for jobs completed and reported in PY7, Cadmus conducted a customer energy usage analysis of PY4 and PY5 participants.[104] This analysis resulted in these values:

- 1,200 kWh/yr in savings per baseload job
- 1,228 kWh/yr in savings per low-cost job
- 1,476 kWh/yr in savings per full-cost job

PPL Electric Utilities applied the PY7 savings per job prospectively, so the reported *ex ante* gross energy savings and the verified gross energy savings per job are the same. More detailed information about the billing analysis for PY7 estimates is available in the *Appendix J: Act 129 WRAP Billing Analysis*.

For jobs completed in PY7, Cadmus calculated demand savings by multiplying the per-unit energy savings by the updated coincidence factor of 0.00011797 described in Section 9.2.5.2. The per-unit demand savings are provided in Table 9-6.

**Table 9-6: Act 129 WRAP Phase II per Unit Demand Values per Job with Installation Date in PY7**

| Job Type | Reported Gross Demand Savings (kW per Unit) | Adjusted *Ex Ante* Demand Savings (kW per Unit) | Verified Gross Demand Savings (kW per Unit) |
|---|---|---|---|
| Baseload | 0.14 | 0.14 | 0.14 |
| Low-Cost | 0.14 | 0.14 | 0.14 |
| Full-Cost | 0.17 | 0.17 | 0.17 |

#### 9.2.5.4 Heat Pump Water Heaters - Installation Dates in PY6

The 2014 TRM provides a savings algorithm for calculation of the energy savings and demand reductions from heat pump water heaters.[105] Cadmus calculated verified gross energy savings using the 2014 TRM algorithm and the data requested as part of the records review.

Cadmus requested these parameters from PPL Electric Utilities for the sample of heat pump water heaters installed in PY6:

- Existing water heater tank size (informs EFbase)
- Installed tank size of the new heat pump water heater
- Actual energy factor of the installed heat pump water heater ($EF_{ee}$)

Cadmus requested and reviewed copies of LEAP audit documentation for a sample of heat pump water heater installations in Q1 through Q3.

104 Only baseload jobs were installed in PY5; therefore, the low-cost and full-cost savings per job were based on customer usage analysis of only PY4 participants because there was no PY5 data for these jobs. The full-cost job savings estimate was based on usage from more than 500 PY4 homes, consistent with the Phase II Evaluation Framework guidance. The low-cost job savings estimate was based on PY4 usage data from 411 homes; however, the resulting savings per job were not statistically different from the low-cost job savings estimate calculated by Cadmus for use in PY8 based on PY4 and PY6 usage data (complete PY6 usage data was not available when PY7 *ex ante* estimates were developed). Therefore, Cadmus retained the low-cost savings estimate based on PY4 usage data for *ex post* estimates for PY7, consistent with the PA Mass Market Protocol.

105 Pennsylvania Public Utility Commission. *Technical Reference Manual*. June 2014. Available online: http://www.puc.pa.gov/pcdocs/1265230.docx

The savings algorithm uses the difference between the inverse of the existing and efficient energy factors. Larger existing water heater tanks have a lower baseline energy factor; the inverse of this lower baseline energy factor is a higher baseline energy use. PPL Electric Utilities assumes an existing tank size of 50 gallons and an $EF_{base}$ of 0.9040 to calculate the reported gross energy savings for heat pump water heaters. Of the sampled heat pump water heaters that were installed in PY6 but reported in PY7, all (n=35) had existing tank sizes of 50 gallons, resulting in a baseline efficiency equal to that assumed by PPL Electric Utilities.

Of the newly installed sampled heat pump water heaters, actual energy factors ranged from 2.3 to 2.9. Of these, 86% (30; n=35) had a higher energy factor than the required minimum energy factor of 2.3, as shown in Table 9-7.

**Table 9-7: Energy Factors of Efficient Heat Pump Water Heater Sample**

| Energy Factor | Number of Installations | Percent of Installations |
|---|---|---|
| 2.3 | 5 | 14% |
| 2.35 | 5 | 14% |
| 2.4 | 19 | 54% |
| 2.9 | 6 | 17% |
| **PY6 Total** | **35** | **100%** |

Savings calculated with the observed existing tank sizes and actual installed energy factors were approximately 6% higher than the *ex ante* energy savings per heat pump water heater.

The 2014 TRM stipulates a 0.00008294 coincidence factor for heat pump water heaters installed in PY6. The reported gross demand savings, *ex ante* demand savings, and verified gross demand savings per-unit estimates all employed this coincidence factor in their calculations. Therefore, the verified demand savings of heat pump water heaters installed in PY6 differed from the reported savings only for units where the existing tank size or efficient energy factor differed from the default assumptions.

#### 9.2.5.5 Heat Pump Water Heaters - Installation Dates in PY7

For heat pump water heaters with installation dates in PY7, the 2015 TRM provides a savings algorithm for calculation of energy savings and demand reductions.[106] Cadmus calculated verified gross energy savings using the 2015 TRM algorithm and data requested as part of the records review.

Cadmus requested these parameters from PPL Electric Utilities for the sample of heat pump water heaters installed and reported in PY7:

- Existing water heater tank size (informs EFbase)
- Installed tank size of the new heat pump water heater
- Actual energy factor of the installed heat pump water heater ($EF_{ee}$)

Cadmus requested and reviewed copies of LEAP audit documentation for the parameters listed above for a sample of heat pump water heater installations in Q1 through Q3 of PY7.

The savings algorithm uses the difference between the inverse of the existing and efficient energy factors. Larger existing tanks have a lower baseline energy factor; the inverse of this lower baseline energy factor

106 Pennsylvania Public Utility Commission. Technical Reference Manual. June 2015. Available online: http://www.puc.state.pa.us/Electric/pdf/Act129/Act129_TRM-2015_Redlined_v2.pdf

is a higher baseline energy use. PPL Electric Utilities assumes an existing tank size of 50 gallons and an $EF_{base}$ of 0.9040 to calculate the reported gross energy savings for heat pump water heaters. Of the sampled heat pump water heaters that were installed in PY7, all (n=58) had existing tank sizes of 50 gallons, resulting in a baseline efficiency equal to that assumed by PPL Electric Utilities.

Of the sampled heat pump water heaters installed and reported in PY7, actual energy factors ranged from 2.3 to 3.39. Of these, 88% (51; n=58) had a higher energy factor than the required minimum energy factor of 2.3, as shown in Table 9-8.

**Table 9-8: Energy Factors of Efficient Heat Pump Water Heater Sample**

| Energy Factor | Number of Installations | Percent of Installations |
|---|---|---|
| 2.3 | 7 | 12% |
| 2.34 | 6 | 10% |
| 2.35 | 2 | 3% |
| 2.4 | 38 | 66% |
| 2.9 | 4 | 7% |
| 3.39 | 1 | 2% |
| **PY7 Total** | **58** | **100%** |

Savings calculated with the observed existing tank sizes and actual installed energy factors were approximately 4% higher than the *ex ante* energy savings per heat pump water heater.

The 2015 TRM stipulates a 0.00008294 coincidence factor for heat pump water heaters installed in PY7. The reported gross demand savings, adjusted *ex ante* demand savings, and verified gross demand savings per-unit estimates all employed this value in their calculations. The verified demand savings for heat pump water heaters installed in PY7 differed from the reported demand savings only for units where the existing tank size or efficient energy factor differed from the default assumptions.

The final realization rate for heat pump water heaters combines the PY6 installations (reported in PY7, and for which the realization rate is 106%) and the PY7 installations (for which the realization rate is 104%) for a final overall realization rate of 105%.

#### 9.2.5.6 Site Inspections Summary

Cadmus does not conduct verification site visits for this program. All full-cost jobs and heat pump water heater installations are slated for verification site visits conducted by PPL Electric Utilities and its trade allies. Although PPL Electric Utilities' goal is to conduct site visits at all full-cost jobs and heat pump water heater installations, this goal is not reachable because participants may not keep an appointment for a site inspection, or are otherwise unreachable. If PPL Electric Utilities' inspectors fail a WRAP job, the case goes to remediation, and the contractor corrects the job. No projects are final nor are they uploaded into EEMIS until corrections are made. Therefore, it is unlikely that the inspected jobs reported in EEMIS include any products that are not installed.

Table 9-9 summarizes the results of the site inspections conducted by PPL Electric Utilities.

**Table 9-9: PY7 Act 129 WRAP On-Site Inspection Summary**

| Stratum | On-site Inspection Goal – EE&C Plan[1] | On-Site Inspection Goal – PY7 EM&V Plan | On-Site Inspection Goal – PPL Electric Utilities | On-Site Inspections Completed | Number of Jobs Failed by PPL Inspectors | Type of Discrepancies | Resolution of Discrepancies[1] | Number of Jobs with Missed Opportunities Identified and Resolved |
|---|---|---|---|---|---|---|---|---|
| Baseload | 0 | 0 | 0 | 0 | N/A | N/A | N/A | |
| Low-Cost | 0 | 0 | 0 | 0 | N/A | N/A | N/A | |
| Full-Cost | 0 | 0 | 390 | 288 | 29 | No CO detector | CO detector installed | 23 |
| | | | | | | Condensate pump not installed | Billing (credit) adjustment | |
| | | | | | | Dryer vent not vented or stuck | Replaced dryer vent | |
| | | | | | | Products invoiced but not installed | Billing (credit) adjustment | |
| | | | | | | No water heater drain pipe | Drain pipe installed | |
| | | | | | | Windows unrepaired | Windows repaired | |
| | | | | | | Damaged freezer or refrigerator | Freezer or refrigerator replaced | |
| | | | | | | Weather-stripping needed | Weather-stripping installed | |
| | | | | | | Bathroom fan not vented | Bathroom fan vented | |
| Heat Pump Water Heater | 0 | 0 | 109 | 93 | 3 | Heat pump water heater not heating enough water | Contractor contacted GE for repairs | 3 |
| | | | | | | Heat pump water heater fault code on heat pump water heater screen | Contractor cleaned condensate port | |
| **Program Total** | **0** | **0** | **499** | **381** | **32** | | | **26** |

[1] *PPL Electric Utilities Corporation Energy Efficiency and Conservation Plan Act 129 Phase II*. Docket No. M-2012-2334388. Compliance Filing dated June 5, 2015.

### 9.2.6 Summary of Evaluation Results

In Phase II, Act 129 WRAP reported energy savings of 12,074 MWh/yr and demand reduction of 1.28 MW in the low-income sector, as shown in Table 9-10. No incentives are listed because WRAP products and services are offered at no cost to participants, therefore no incentives are paid to participants.

**Table 9-10: Phase II Act 129 WRAP Reported Results by Customer Sector**

| Sector | Phase II Participants [1] | Phase II Reported Gross Energy Savings (MWh/yr) [1] | Phase II Reported Gross Demand Reduction (MW) [1] | Incentives Paid ($1,000) |
|---|---|---|---|---|
| Residential | - | - | - | - |
| Low-Income | 10,261 | 12,074 | 1.28 | - |
| Small C&I | - | - | - | - |
| Large C&I | - | - | - | - |
| Government/Nonprofit/Education | - | - | - | - |
| **Phase II Total** | **10,261** | **12,074** | **1.28** | **-** |

[1] This does not include the De Facto Heating Pilot.

In PY7, Act 129 WRAP reported energy savings of 4,448 MWh/yr, adjusted *ex ante* energy savings of 4,448 MWh/yr, verified gross energy savings of 4,454 MWh/yr, and a realization rate of 100% for installations in both PY6 and PY7. Table 9-11 lists reported, adjusted, and verified energy savings, realization rates, and relative precision by stratum for WRAP in PY7.

**Table 9-11: PY7 Act 129 WRAP Summary of Evaluation Results for Energy**

| Stratum | PYTD Reported Gross Energy Savings (MWh/yr) [1] | PYTD Adjusted *Ex Ante* Energy Savings (MWh/yr) [1] | Energy Realization Rate (%) [1] | PYTD Verified Gross Energy Savings (MWh/yr) [1] [2] | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion [1] [3] | Relative Precision at 85% C.L. [1] |
|---|---|---|---|---|---|---|
| Baseload | 2,922 | 2,922 | 100% | 2,916 | 0.04 | 5.67% |
| Low-Cost | 690 | 690 | 100% | 690 | 0.10 | 14.78% |
| Full-Cost | 523 | 523 | 99% | 520 | 0.06 | 9.15% |
| Heat Pump Water Heater | 313 | 313 | 105% | 328 | 0.76 | 0.61% |
| **Program Total** | **4,448** | **4,448** | **100%** | **4,453** | **N/A** | **2.29%** |

[1] This does not include the De Facto Heating Pilot. This table refers to savings at the point of consumption.
[2] Adjusted *ex ante* multiplied by the realization rate will not equal verified gross energy savings due to rounding
[3] Sample Cv and relative precision based on (a) billing analysis regression for baseload, full-cost, and low-cost strata, and (b) ratio estimation for heat pump water heater and energy education stratum.

In PY7, Act 129 WRAP reported demand savings of 0.504 MW, adjusted *ex ante* demand savings of 0.547 MW, verified gross demand savings of 0.555 MW and a realization rate of 102%. Table 9-12 provides the summaries of demand savings, realization rates, and relative precision by stratum for PY7.

**Table 9-12: PY7 Act 129 WRAP Summary of Evaluation Results for Demand**

| Stratum | PYTD Reported Gross Demand Savings [1] [2] (MW) | PYTD Adjusted *Ex Ante* Demand Savings [1] [3] (MW) | Demand Realization Rate [1] | PYTD Verified Gross Demand Savings [3] (MW) | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion [3] [4] | Relative Precision at 85% C.L. [1] |
|---|---|---|---|---|---|---|
| Baseload | 0.341 | 0.370 | 101% | 0.373 | 0.04 | 5.67% |
| Low-Cost | 0.078 | 0.084 | 103% | 0.087 | 0.10 | 14.78% |
| Full-Cost | 0.060 | 0.065 | 103% | 0.066 | 0.06 | 9.15% |
| Heat Pump Water Heater | 0.025 | 0.028 | 105% | 0.029 | 0.77 | 0.61% |
| **Program Total** | **0.504** | **0.546** | **102%** | **0.555** | **N/A** | **4.59%** |

[1] This does not include the De Facto Heating Pilot.
[2] Reported gross demand reductions do not include the gross-up to reflect transmission and distribution (T&D) losses.
[3] Adjusted *ex ante* and verified gross demand reductions include T&D losses.
[4] Sample Cv and relative precision based on billing analysis regression for baseload, full-cost, and low-cost strata; based on ratio estimation for heat pump water heater and energy education stratum.

## 9.3 IMPACT EVALUATION NET SAVINGS

WRAP targets the low-income community, and only income-verified customers participate. These customers seek assistance from community based organizations and from PPL Electric Utilities and receive free weatherization tailored to the needs of their homes. Technicians conduct energy audits at no cost to the customer and determine the type of weatherization assistance the customer needs. Products are installed at no cost to income-eligible customers. Cadmus is of the opinion that the low-income participants would not pay for an audit, nor purchase and install weatherization in the absence of the program. Therefore, and in keeping with the discussion in the evaluation plan approved by the SWE, Cadmus did not allocate time or budget to conduct surveys to estimate freeridership and spillover. Shown in Table 9-13 and Table 9-14, Cadmus assumes there is no freeridership and spillover among the income-qualified WRAP participants.

**Table 9-13: PY7 Act 129 WRAP Sampling Strategy for NTG Research**

| Stratum | Stratum Boundaries | Population Size (number of Unique Households) [1] | Assumed CV or Proportion in Sample Design | Assumed Levels of Confidence & Precision | Target Sample size | Achieved Sample Size | Percent of Sample Frame Contacted |
|---|---|---|---|---|---|---|---|
| **WRAP** | Program | 3,415 | N/A | N/A | N/A | N/A | N/A |

[1] During PY7, there were 3,415 confirmed unique individuals who participated in Act 129 WRAP. The total number of participants reported in PY7 was 3,422. Seven of the 3,422 participants were duplicates in which two jobs were reported with separate job identification numbers for the same customer. Six of the seven cases involved two WRAP jobs being reported for the same customer. In these six cases, Cadmus assigned *ex post* savings of zero to one of the two WRAP jobs to prevent double-counting. In one of these seven cases, the participant received one WRAP job and one heat pump water heater job. In this case, Cadmus verified *ex post* savings for both jobs.

**Table 9-14: PY7 Act 129 WRAP Summary of Evaluation Results for NTG Research**

| Target Group or Stratum (if appropriate) | Estimated Freeridership | Estimated Participant Spillover | NTG Ratio | Observed Coefficient of Variation or Proportion | Relative Precision |
|---|---|---|---|---|---|
| **WRAP** | N/A | N/A | 1.0 | N/A | N/A |

## 9.4 PROCESS EVALUATION

### 9.4.1 Research Objectives

Cadmus conducted the PY7 process evaluation to realize the following research objectives:

- Document the changes in the Act 129 program from previous program years through a program staff interview
- Assess customer satisfaction with program services and contractors through participant telephone surveys
- Ensure appropriate data are collected to inform the evaluation through a program database review

### 9.4.2 Evaluation Activities

For WRAP, Cadmus conducted the following research activities in PY7:

- Program staff and implementer interviews (n=1)
- Participant surveys (n=141)
- Database and quality assurance/quality control (QA/QC) review (n=203)

The activities were consistent with the evaluation plan except in one way. Cadmus initially planned to conduct surveys of 70 baseload job participants, but it increased the number of target surveys to include low-cost and full-cost job participants for a comprehensive evaluation of the multiple WRAP job types. In prior years, PPL Electric Utilities conducted surveys with participants receiving these jobs.

### 9.4.3 Methodology

Table 9-15 summarizes the process evaluation's sampling plan for the PY7 WRAP baseload, low-cost, and full-cost job participants. See *Addendum A* for more details about the participant survey.

#### 9.4.3.1 Program Staff and Implementer Interviews

Cadmus conducted one program staff interview by telephone with the PPL Electric Utilities program manager.

#### 9.4.3.2 Participant Surveys

Cadmus conducted a telephone survey with a sample of baseload, low-cost, and full-cost job participants during March and April 2016. The purpose of the survey was to assess satisfaction with WRAP. The survey sample frame included all PY7 Q1 and Q2 WRAP participants who received a baseload, low-cost, or full-cost job, from which Cadmus selected a stratified random sample. Participant data from Q3 and Q4 were not available at the time the survey sample was drawn. Because there was no meaningful difference in the types of participants recruited and measures installed during the first two quarters compared to the last two quarters of PY7, Q1 and Q2 participants are considered representative of all PY7 participants.

Potential sources of bias in the surveys include nonresponse, recall, and social desirability biases. Cadmus attempted to mitigate these sources of bias by applying random sampling whenever possible and using survey design and survey data collection best practices. It designed surveys to include questions that were not leading or ambiguous, were not double-barreled, and provided clear interviewing and programming instructions so that the questions could be implemented consistently across interviewers and surveys. Cadmus also attempted to reach respondents up to five times over several days at different times of the day and scheduled callbacks whenever possible.

**Table 9-15: PY7 WRAP Process Evaluation Survey Sampling Strategy**

| Stratum | Stratum Boundaries | Population Size (Q1-Q2) | Assumed Proportion or $C_V$ in Sample Design | Assumed Levels of Confidence & Precision | Target Sample Size | Number of Records Selected for Sample Frame | Achieved Sample Size | Percentage of Sample Frame Contacted [1] | Evaluation Activities |
|---|---|---|---|---|---|---|---|---|---|
| Baseload, Participants | Participants that received baseload jobs in Q1 and Q2 | 1,790 | 0.5 | 90/10 | 70 | 1,395 | 70 | 22% | Process, Telephone survey, Simple Random Sample |
| Low-Cost Participants | Participants that received baseload jobs in Q1 and Q2 | 397 | 0.5 | 90/10 | 53 | 352 | 54 | 47% | Process, Telephone survey, Simple Random Sample |
| Full-Cost Participants | Participants that received baseload jobs in Q1 and Q2 | 136 | 0.5 | 90/10 | 17 | 109 | 17 | 80% | Process, Telephone survey, Simple Random Sample |
| **Program Total** | | **2,323** | **0.5** | **90/10** | **140** | **1,856** | **141** | **30%** | |

[1] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means the percentage of the sample frame called to complete surveys.

### 9.4.4 Achievements Against Plan

Table 9-16 contains the program's energy savings and incentive plans and progress through PY7. Act 129 WRAP exceeded its energy savings and demand reduction plans for PY7 and Phase II.

**Table 9-16: WRAP Savings [1] [2]**

| | PY5 Verified | PY6 Verified | PY7 | | | Phase II: PY5-PY7 | | |
|---|---|---|---|---|---|---|---|---|
| | | | Planned | Verified | Percentage of Planned | Planned [1] | Verified | Percentage of Planned |
| MWh/yr | 2,810 | 4,525 | 3,598 | 4,454 | 124% | 10,411 | 11,788 | 113% |
| MW | 0.33 | 0.56 | 0.45 | 0.56 | 124% | 1.33 | 1.44 | 109% |
| Participation | 2,791 | 4,048 | 3,462 | 3,415 [3] | 99% | 10,200 | 10,261 | 100% |

[1] Planned savings are based on PPL Electric Utilities' revised EE&C plan (Docket No. M-2012-2334388) filed with the Pennsylvania PUC on June 5, 2015, Table J6, pp. 89.
[2] Does not include De Facto Heating Pilot savings.
[3] The total number of reported participants for PY7 was 3,422. The impact evaluation determined that seven of the 3,422 participants were duplicates in which two jobs were reported with separate job identification numbers for the same customer.

### 9.4.5 Program Delivery

The most significant change in PY7 was the addition of a new program component: the De Facto Heating Pilot. The De Facto Heating Pilot component targeted homes with inoperable heating systems. Evaluation results for these components are discussed in Section 9.7.

The key performance indicators in PY7 for Act 129 WRAP were energy savings and participation, which are tracked in EEMIS, the program tracking database. The current key performance indicators revealed that the program did very well in achieving the participation and energy savings targets, surpassing its savings targets by the close of Q3 2016. PPL Electric Utilities has not identified other key performance indicators to measure program performance besides energy savings and participation.

#### 9.4.5.1 Program Updates and Outcomes

***De Facto Heating Pilot.*** PPL Electric Utilities launched the De Facto Heating Pilot through Act 129 WRAP in January 2016. This program component targeted WRAP eligible customers who use an inefficient or unsafe electric heat source, such as portable electric space heaters or an electric stove, in place of their inoperable oil heating system. PPL Electric Utilities installed high efficiency heat pump systems in 11 homes to provide these customers a safer, more efficient heating source. PPL Electric also installed heat pump water heaters in two of these homes and WRAP measures in 11 homes (10 of which also received heat pumps). Results of this effort are discussed in Section 9.7.4.4.

***LEAP tracking system.*** In Q4 of PY6, PPL Electric Utilities introduced a new Low-Income Energy Assistance Program (LEAP) tracking system.[107] Data for Act 129 WRAP participants were uploaded from the LEAP system to EEMIS, the Act 129 participant tracking database. PPL Electric Utilities' program staff continued to be very satisfied with LEAP in PY7. The database enabled it to quickly review program statistics and performance metrics, including number of jobs completed by contractor and job type, and to easily access job information, including inspection status and measures installed.

[107] The costs for developing the LEAP tracking system were shared equally by Act 129 WRAP and USP WRAP.

### 9.4.6 Participant Profile

During PY7, Cadmus verified there were 3,415 unique individuals (households) that participated in Act 129 WRAP. Of these, 3,235 received a WRAP job only, 170 received a heat pump water heater and a WRAP job, and 10 received only a heat pump water heater. In PY7, there were 16% fewer jobs than PY6 and 16% more jobs than PY5. Table 9-17 shows the number of participants who received a WRAP job, a heat pump water heater, or both in PY5, PY6, and PY7.

**Table 9-17: Phase II Act 129 WRAP Distribution of Measures Provided**

| Job Type | PY5 | PY6 | PY7 |
|---|---|---|---|
| WRAP Only Jobs | 2,773 | 3,752 | 3,235 |
| Heat Pump Water Heater & WRAP Job | 0 | 239 | 170 |
| Heat Pump Water Heater Only Jobs | 167 | 57 | 10 |
| **Program Total** | **2,940** | **4,048** | **3,415** |

Of the 3,405 participants who received a WRAP job,[108] 2,481 received a baseload job, 570 received a low-cost job, and 360 received a full-cost job. A random sample of the WRAP participants who received baseload, low-cost, or full-cost jobs were selected for a participant survey.

### 9.4.7 Participant Satisfaction

#### 9.4.7.1 Program Satisfaction

Cadmus assessed participants' satisfaction with Act 129 WRAP using responses to the telephone survey of all job type recipients (n=141), which included baseload job recipients (n=70), low-cost job recipients (n=54), and full-cost job recipients (n=17). Figure 9-1 shows the responses to the question *"How satisfied are you with the WRAP program?"* The survey uses a scale of 5 to 1, with 5 being *very satisfied* and 1 being *very dissatisfied.*

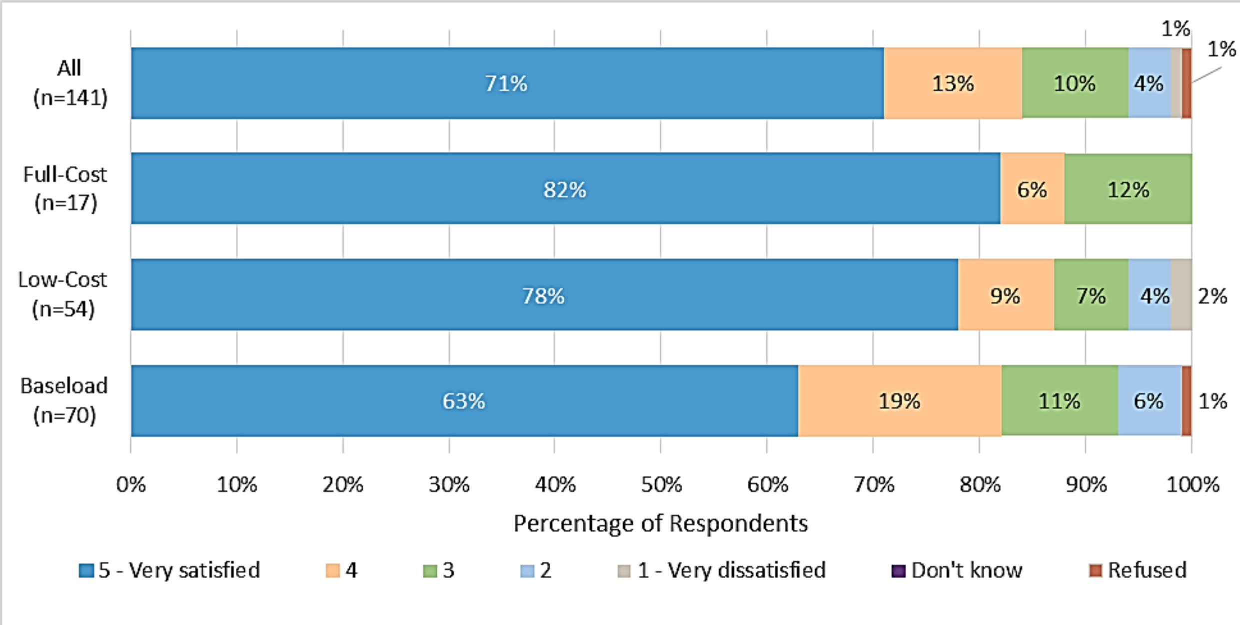
Seventy-one percent of all survey respondents (n=141) said they were *very satisfied* (rating their satisfaction as a 5 on a 1 to 5 scale [109]) with the WRAP. An additional 13% rated their satisfaction as a 4, and another 10% rated their satisfaction as a 3. Only 4% rated their satisfaction as a 2, and only 1% rated their satisfaction as *very dissatisfied,* or a 1.

Eighty-two percent of full-cost participants were *very satisfied* (n=17), followed by 78% of low-cost participants (n=54). For baseload participants, 63% were *very satisfied,* which is a 4% increase from PY6 baseload job survey respondents (59% of whom were *very satisfied*). The difference in satisfaction between PY6 and PY7 baseload respondents is not statistically significant, nor was the difference in satisfaction between job types in PY7.

[108] The 3,405 figure includes both the 3,235 participants who received a WRAP job only as well as the 170 participants who received both a WRAP job and a heat pump water heater.

[109] Question, "On a scale of 1 to 5, with "5" being very satisfied and "1" being very dissatisfied, and using any number in between, how satisfied are you with the WRAP program?"

**Figure 9-1: Participant Satisfaction with WRAP**



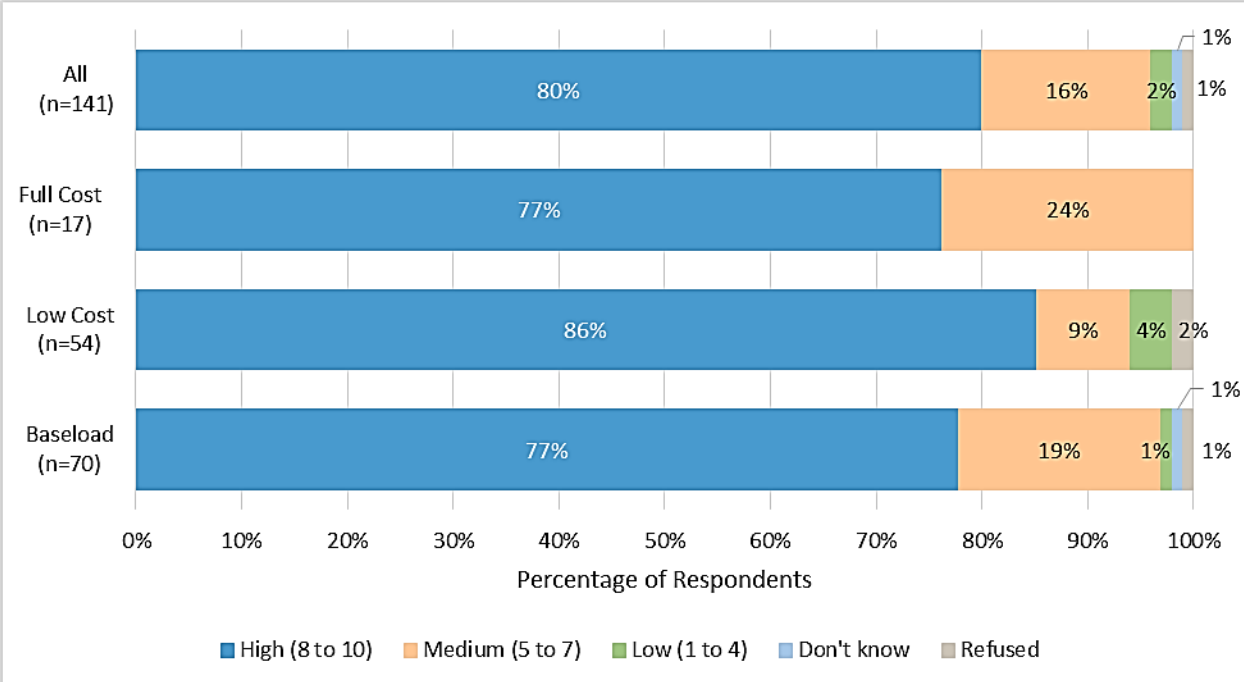

Question E1. “How satisfied are you with the WRAP program?”

Thirty-four respondents of all job types rating their satisfaction as other than *very satisfied* gave different reasons for their level of satisfaction and about how to increase that satisfaction. The most frequent response concerned improving the contractor experience. Fourteen of 34 respondents reported being dissatisfied with their contractor experience; of these, nine said the contractor did not do the work as stated. To increase satisfaction, a few respondents expressed interest in receiving additional measures.

### 9.4.7.2 Satisfaction with PPL Electric

Cadmus asked survey respondents of all job types (n=141) about their satisfaction with PPL Electric Utilities as a service provider (using a rating scale from 1 to 10 where 1 means *unacceptable* and 10 means *outstanding)*. Eighty percent gave a rating of 8 or greater, as shown in Figure 9-2.

**Figure 9-2: Participant Satisfaction with PPL Electric as a Service Provider**



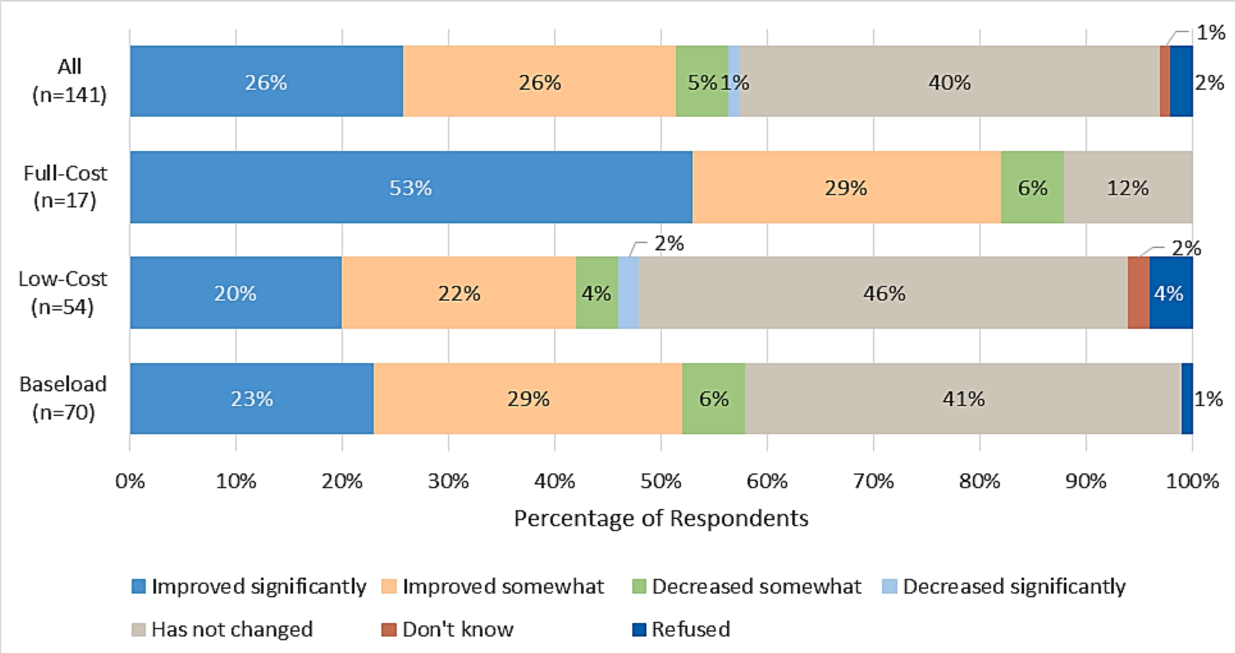

Question F1. "How do you rate PPL Electric overall as a provider of electric service to your home?

Forty-five percent of all job type respondents rated PPL Electric Utilities *outstanding* (10) as a service provider and an additional 35% rated their satisfaction as an 8 or 9. Only 2% gave a low rating of less than 5. Low-cost participants were the most satisfied out of all job type respondents (50% gave a rating of 10; n=54), followed by 47% full-cost respondents (n=17). For baseload respondents, 41% gave a rating of 10 (n=70), which is consistent with PY6 baseload job survey responses. There were no statistically significant differences in satisfaction with PPL Electric Utilities between job types in PY7.

Sixty-five percent of survey respondents (n=141) have recommended WRAP to friends, relatives, or colleagues since participating in WRAP.

As shown in Figure 9-3, over half (53%; n=141) of survey respondents of all job types reported their opinion of PPL Electric Utilities as a service provider has *improved* since participating in WRAP. Another 41% of respondents said their opinion of PPL Electric Utilities as a service provider has *not changed* since receiving WRAP services, and 5% of respondents reported their opinion of PPL Electric Utilities *decreased somewhat*. Only 1% of all respondents said their opinion of PPL Electric Utilities as a service provider has *decreased significantly* since receiving WRAP services.

**Figure 9-3: Change in Opinion of PPL Electric**




Question F2. "After participating in the WRAP program, has your opinion of PPL Electric…"

## 9.4.8 Marketing and Outreach

The only targeted marketing strategy continued in PY7 from PY6 was mail-in postcards, though the PPL Electric Utilities program manager indicated that the program had less success with postcard responses in PY7 than in PY6. In PY6, PPL Electric Utilities implemented an online website where customers could apply for WRAP. The online web application has contributed to customer participation in PY7, and the toll-free WRAP phone number has also been successful in bringing in program participants.

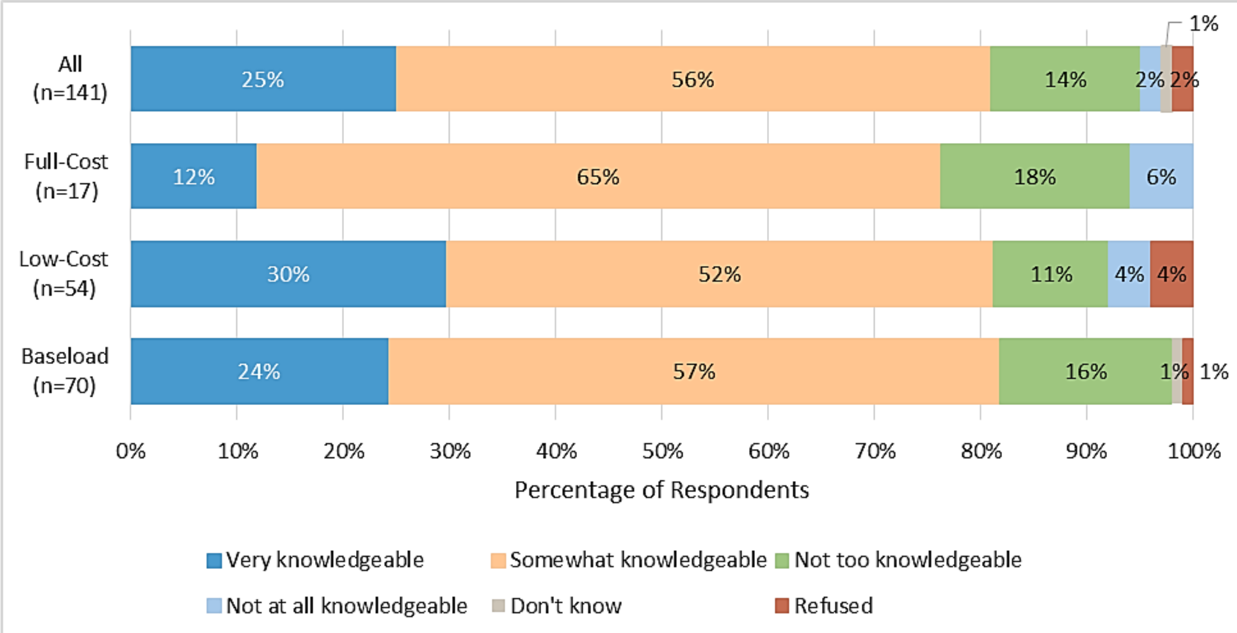
Additionally, PPL Electric Utilities' Customer Assistance Program (CAP) helps customers seek electric bill assistance and has provided customers with details of WRAP and encouraged them to apply. In PY7, CAP enrollment increased by 25%, from approximately 30,000 to 40,000 customers, which likely translated to an increase in applications for, and participation in, WRAP from the previous program year.

## 9.4.9 Energy Efficiency Knowledge, Challenges, and Actions

### 9.4.9.1 Knowledge About Ways to Save Energy

Survey respondents of all job types (n=141) answered questions about their knowledge of ways to save energy in their home. As shown in Figure 9-4, the majority (81%) of survey participants said they were knowledgeable about ways to save energy in their home prior to participating in WRAP. Twenty-five percent (n=141) said they were *very knowledgeable* and 56% said they were *somewhat knowledgeable*. Fourteen percent reported they were *not too knowledgeable*, and two percent reported *not at all knowledgeable*. Of baseload respondents, 24% believed they were *very knowledgeable* of ways to save energy, a 6% decrease from PY6 baseload respondents.

**Figure 9-4: Energy Efficiency Knowledge Prior to WRAP Participation**

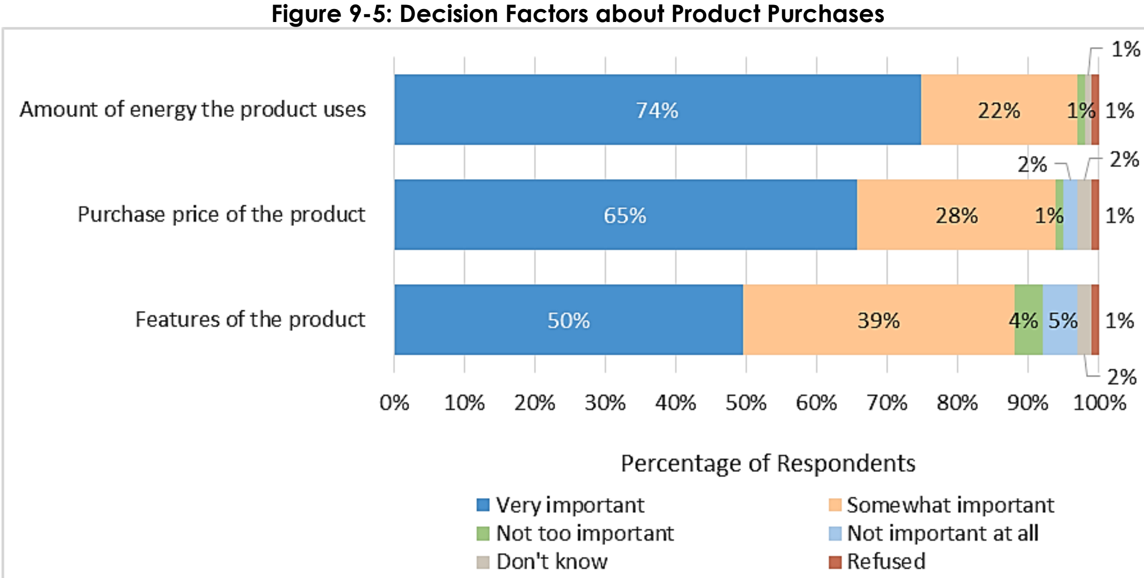



Question D1. "Before you participated in the WRAP program, how knowledgeable were you about ways to save energy in your home?"

### 9.4.9.2 Challenges

Cadmus asked survey respondents of all job types to think about different features they might consider when shopping for products or appliances that use energy in the home. Respondents then rated the importance of each of these features on their decision to purchase or not purchase the product, shown in Figure 9-5.

**Figure 9-5: Decision Factors about Product Purchases**




Question D5. "When shopping for products or appliances that use energy in your home, how would you rate the importance of each of the following…?" (n=141)

WRAP participants indicated the strongest concern was for the amount of energy used by the product or appliance. Nearly all (96%; n=141) survey respondents rated energy use as either a *very* or *somewhat important* consideration, with 74% rating energy use as a *very important* consideration. Only two respondents indicated that the energy use of a product or appliance is *not important* to their purchase decision.

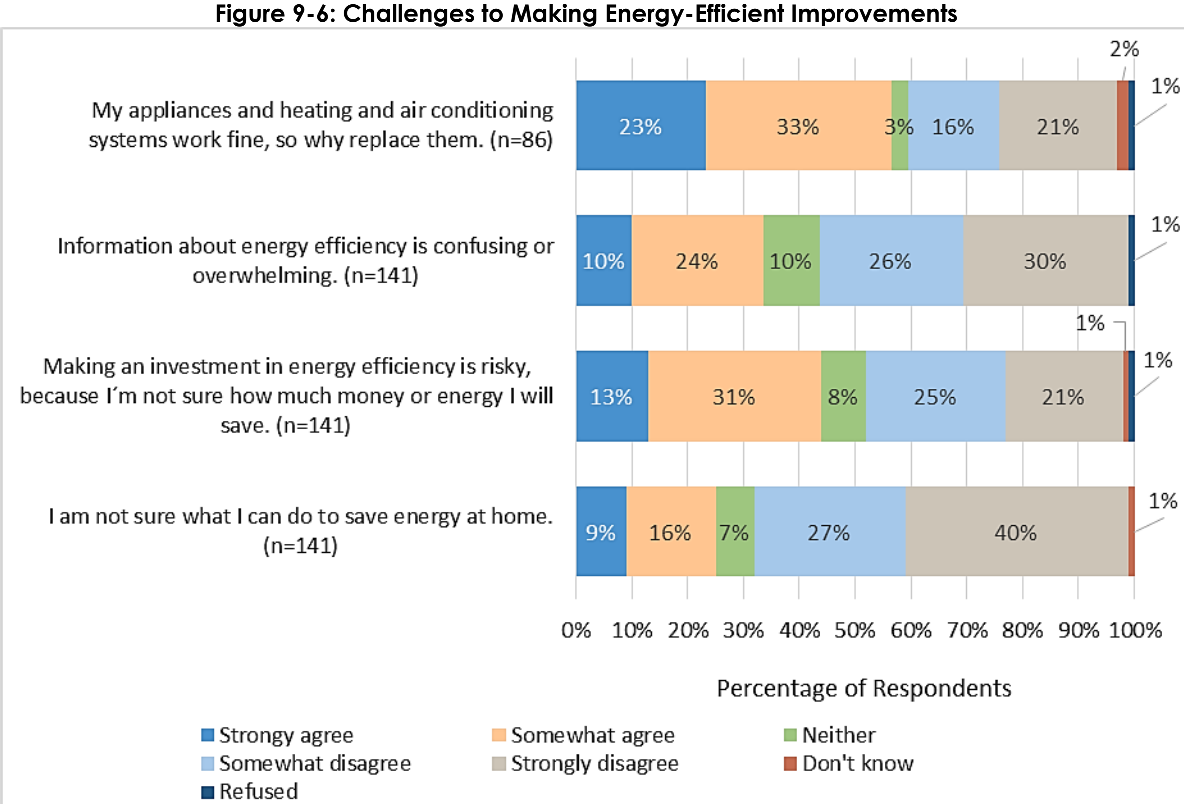
Because WRAP participants have incomes at or below 150% of the federal poverty level, it is not surprising that nearly all respondents (93%; n=141) reported that price is an important consideration when deciding to purchase a particular product. Over two-thirds of respondents (65%) rated price as a *very important* consideration when purchasing an energy-using product, while another 28% rated price as *somewhat important*. Only 3% of WRAP participants indicated that price is not an important consideration.

The survey also asked respondents about the importance of product features on their purchase decisions. The responses listed in Figure 9-5 indicated that the majority of respondents (89%; n=141) believe product features are an important consideration, but fewer (50%) indicated they are *very important* to their purchase decision.

Compared to participants who thought price (3%) and energy use (1%) were not important considerations, more respondents (9%; n=141) said product features were not an important consideration when purchasing a product or appliance.

Respondents next answered questions about four scenarios that people might face when purchasing new appliances or considering energy-efficient improvements to their home. Respondents rated their level of agreement or disagreement with each statement (Figure 9-6).

**Figure 9-6: Challenges to Making Energy-Efficient Improvements**




Question D8. "Do you face these scenarios when purchasing new appliances or considering energy-efficient improvements to your home?"

These are the findings about the four scenarios:

- *"My appliances and heating and air conditioning systems work fine, so why replace them."* The 61% of survey respondents (n=141) who said they own their home were asked to rate their agreement or disagreement with this statement. More homeowners agreed (56%) than disagreed (37%) about replacing working appliances; 3% took no position. Two percent stated they did not know whether they agreed or disagreed.
- *"Making an investment in energy efficiency is risky, because I am not sure how much money or energy I will save."* As shown in Figure 9-6, nearly as many respondents (44%; n=141) said they do not consider investments in energy efficiency to be risky as agreed (46%) that such investments are risky. Eight percent took no position on the statement, and 1% said they did not know.
- *"Information about energy efficiency is confusing or overwhelming."* WRAP participants were confident in their ability to understand information about energy efficiency. The majority (56%; n=141) do not believe this statement. A little over one-third (34%) either *somewhat* or *strongly agreed* with the statement.
- *"I am not sure what I can do to save energy at home."* WRAP participants were even more certain about their ability to save energy at home. As shown in Figure 9-6, nearly two-thirds (67%; n=141) of respondents indicated they were sure they knew what to do to save energy in their home, and approximately 40% were very sure.

### 9.4.9.3 Steps to Saving Energy

During the survey, WRAP participants of all job types answered questions about the energy-saving ideas that the energy educator provided during the in-home energy audit. Eighty-three percent (n=105) were able to recall examples. Table 9-18 shows the energy-saving ideas the respondents recalled, along with the percentage of each.

**Table 9-18: Energy-saving Ideas Provided to WRAP Participants**

| Energy Savings Ideas | Percentage of Respondents |
|---|---|
| Use efficient lighting | 36% |
| Turn off lights | 30% |
| Limit hot water usage | 25% |
| Unplug devices when not in use | 25% |
| Adjust thermostats | 20% |
| Information on using appliances | 18% |
| Information about weatherization or infiltration | 12% |
| Power strip | 6% |
| Other | 22% |
| Source: Question C4. "Can you list some of the ideas that were provided to you during the visit?" (n=105) | |

Information on using appliances, the sixth category in Table 9-18, included keeping the refrigerator or freezer full, operating appliances at optimal times, running clothes washers, dryers, and dishwashers with larger loads, washing in cold water, and putting a *"tennis ball in the dryer."* The *Other* category included installing products such as LEDs and low-flow showerheads, using "*blinds during the day,*" and "*testing the water heater*."

Later in the call, participants answered questions about whether they took steps to save energy at home and, if so, what steps they take. Nearly all WRAP participants (94%; n=141) said they take such steps. Table

9-19 shows actions respondents reported, along with the percentage of respondents providing the response.

**Table 9-19: Energy Savings Steps Taken by WRAP Participants**

| Energy Saving Steps | Percentage Providing Response |
|---|---|
| Turn off lights | 76% |
| Unplug devices when not in use | 30% |
| Adjust thermostats | 22% |
| Wash clothes in cold water | 18% |
| Take fewer or shorter showers | 13% |
| Turn down water heater temperature | 4% |
| Hang clothes on clothesline | 6% |
| Other | 25% |
| Source: Question D4. “What steps do you take?” (n=132) | |

The most popular energy-saving step was turning off the lights, followed by unplugging devices when not in use, adjusting the thermostat, washing clothes in cold water, and taking fewer or shorter showers. Steps mentioned in the *Other* category were using less water, turning off the TV, reducing the number of wash loads, using nightlights, using space heaters less, closing windows during the day in the summer, and closing the blinds.

These steps track closely with the ideas participants remembered from the energy educator’s visit, which indicates that energy education is effective. Participants are listening and implementing the ideas provided by the educator.

## 9.5 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings,Cadmus suggest PPL Electric Utilities consider the following recommendations in PY7.

Overall, PPL Electric Utilities’ Act 129 program offers a comprehensive and customized weatherization service to its low-income customers, improving the comfort and safety of these homes while helping to reduce customer energy bills. Customers are satisfied with the program and they are acting on energy-saving strategies recommended by the program’s energy educators. The program ramped down some of its marketing efforts in PY7 but was still able to meet its energy and demand goals.

**Conclusion**
The PPL Electric Utilities program manager indicated that CAP enrollment increased 25% in PY7 and referrals through CAP were a strong contributor to PY7 WRAP participation. Therefore, the CAP enrollment process and associated referrals to WRAP appears to be an effective channel for garnering WRAP participation. Between PY6 and PY7, PPL Electric Utilities used fewer WRAP marketing strategies, retaining only the mail-in postcards, which reportedly was less effective in PY7 than PY6. Despite this, the program still met 99% of its PY7 participation target. For more details, see Section 9.4.8.

**Conclusion**
WRAP is a successful program among participants. Participants were satisfied with the measures products and services provided by PPL Electric Utilities through the program. Of the 141 WRAP participants surveyed, 71% rated WRAP 5 on a 1-to-5 scale, with 5 representing *very satisfied* and 1 representing *very dissatisfied*. Another 13% of the surveyed participants rated WRAP a 4. For more details, see Section 9.4.7.1. Participant satisfaction will be an important program performance metric in Phase III.

**Conclusion**
In some cases, it appears that WRAP contractors can improve communication with customers about the products that will be installed after the audit. Fourteen of 34 respondents reported being dissatisfied with their contractor experience; nine of these respondents said the contractor did not do what was said would be done. For more details, see Section 9.4.7.1.

**Recommendation**
Consider emphasizing to contractors the importance of managing customer expectations by clearly explaining to customers which products and services will be installed or conducted after the audit takes place and when installations will occur. Contractors may also want to clarify at the beginning of the audit that only recommended measures will be installed, depending on the audit findings. Additionally, contractors should provide an explanation that if any installation plans changed after the audit, it would result in participants not receiving the products discussed at the time of the audit. This may help mitigate customer dissatisfaction regarding contractors not doing what they say will be done.

**Recommendation**
Consider asking contractors to keep multiple easy-to-install items in their trucks at all times to ensure these products are on-hand during the audit. This will minimize the number of products a contractor must install, and may accidentally overlook, during a follow-up visit.

**Conclusion**
There is still an opportunity for increasing energy awareness among participants. One quarter of WRAP survey respondents (n=141) agreed or somewhat agreed that they are *"not sure what [they] can do to save energy at home."* Additionally, 35% of the WRAP survey respondents (n=141) agreed or somewhat agreed that *"information about energy efficiency is confusing or overwhelming."* For more details, see Section 9.4.9.

**Recommendation**
Consider emphasizing the energy education portion of the audit by taking time to explain ways to save energy and encouraging customers to take action on their energy usage. By emphasizing the energy education component during WRAP home audits, PPL Electric Utilities may be able to help customers take ownership of their energy usage through increased knowledge and understanding of energy efficiency.

### 9.5.1 Status of Recommendations for Program

Table 9-20 contains the status of each PY7 process recommendation made to PPL Electric Utilities.

**Table 9-20: Low-Income WRAP Status Report on Process and Impact Recommendations**

| Recommendations | EDC Status of Recommendation (Implemented, Being Considered, Rejected AND Explanation of Action Taken by EDC) |
|---|---|
| **Winter Relief Assistance Program (WRAP)** | |
| Consider emphasizing to contractors the importance of clearly explaining to customers which products and services will be installed or conducted after the audit takes place and when installations will occur | Implemented. |
| Consider emphasizing the energy education portion of the audit, and take time to explain ways to save energy | Implemented. |

## 9.6 FINANCIAL REPORTING

A breakdown of the Low-Income WRAP finances is presented in Table 9-21.

**Table 9-21: Summary of Low-Income WRAP Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs[6] ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs (Sum of rows 2 to 4) | $0 | $0 |
| 2 | EDC Incentives to Participants | $0 | $0 |
| 3 | EDC Incentives to Trade Allies | $0 | $0 |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $0 | $0 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6, 7, 8, 9, 10 ) | $6,445 | $14,894 |
| 6 | Design & Development | $0 | $0 |
| 7 | Administration [7], Management, and Technical Assistance[1] | $6,445 | $14,894 |
| 8 | Marketing[2] | $0 | $0 |
| 9 | EDC Evaluation Costs | $0 | $0 |
| 10 | SWE Audit Costs | $0 | $0 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | $0 | $0 |
| | | | |
| 12 | Total TRC Costs[3] (Sum of rows 1, 5 and 11) | $6,445 | $14,894 |
| 13 | Total NPV Lifetime Energy Benefits | $4,563 | $10,722 |
| 14 | Total NPV Lifetime Capacity Benefits | $273 | $626 |
| 15 | Total NPV O&M Saving Benefits | $0 | $0 |
| 16 | Total NPV TRC Benefits[4] | $4,836 | $11,348 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | 0.75 | 0.76 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.

[2] Includes the marketing CSP and marketing costs by program CSPs.

[3] Total TRC Costs includes Total EDC Costs and Participant Costs.

[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.

[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.

[6] Phase II Costs in this table are discounted back to PY5, thus will not match cumulative costs reported in the PY7 Q4 quarterly report.

[7] Includes the cost (labor and materials) of direct-install energy efficiency measures provided to customer at no cost.

# ADDENDUM A. PARTICIPANT SURVEY METHODOLOGY - WRAP

## Dialing Instructions

PPL Electric Utilities provided dialing instructions for conducting surveys. Customers cannot be contacted for a survey if they have completed a survey in the twelve months prior to survey data collection or if they opted out of a survey. Telephone survey calls cannot take place on Sundays or national holidays.

Researchers called participants at different times of day and different days of the week to increase the probability of contact. Researchers attempted surveys with potential respondents up to five times each.

## Sample Cleaning and Attrition

Cadmus coordinated with PPL Electric Utilities' survey contractor to screen the sample and remove the records of any customers called in the past year (whether for a Cadmus survey or a PPL Electric survey) and any who requested not to be contacted again. Cadmus also removed records with incomplete information. This cleaning and survey sample preparation process reduced the available sample.

Cadmus selected a random sample of all remaining records and sent them to the survey subcontractor. The survey subcontractor attempted each record up to four times. Table 9-22 lists total number of records submitted to the survey subcontractor and the outcome (final disposition) of each record.

**Table 9-22: Survey Sample Attrition Table**

| Description of Call Outcomes | Number of Records |
|---|---|
| **Population (number of Q1-Q2 jobs)** | **2,323** |
| **Random Sample Selection** | **2,113** |
| Removed incomplete or bad phone number | 27 |
| Removed inactive customer or nonresidential customer | 134 |
| Removed completed survey in past year | 50 |
| Removed because on do not call list | 25 |
| Removed because selected for other survey | 1 |
| Removed because duplicate | 20 |
| **Survey Sample Frame (sent to survey subcontractor)** | **1,856** |
| **Not Attempted [1]** | **1,162** |
| **Records Attempted** | **694** |
| Non-working number | 51 |
| Wrong number, business | 15 |
| Call privacy | 0 |
| Language barrier | 16 |
| PPL Electric or market research employee | 37 |
| Do not know if product was installed | 0 |
| Refusal | 55 |
| No answer/answering machine/phone busy | 243 |
| Non-specific or specific callback scheduled | 122 |
| Partial complete | 14 |
| **Completed Survey** | **141** |

[1] These records were not needed because the survey target was reached before they were attempted.

## 9.7 DE FACTO HEATING PILOT

The De Facto Heating Pilot targets low-income households that use an inefficient or unsafe electric heat source, such as portable electric space heaters or an electric stove, in place of their inoperable fossil fuel heating system. Through the pilot, PPL Electric Utilities replaced the inoperable heating system of participants with an efficient heat pump system. Some participants were also eligible to receive a heat pump water heater and full-cost products and services through the Winter Relief Assistance Program (WRAP).

The objectives of the De Facto Heating Pilot were the following:

- Provide low-income customers with education and energy efficiency products and services to help reduce their energy consumption and costs
- Identify the costs and savings associated with providing this service to customers and any operational issues that may exist
- Determine if De Facto Heating is scalable and if this measure should be offered in Phase III
- Determine the ease of implementation and identify challenges that may exist
- Maintain partnerships with local community-based organizations and contractors to ensure that customers receive maximum and timely customer assistance
- Promote other PPL Electric Utilities energy efficiency programs
- Install high-efficiency heat pump systems in up to 20 low-income customers' homes through 2016

PPL Electric Utilities implemented the pilot from January to May 2016. It spent considerable time and resources identifying and selecting participants who met the pilot's criteria. PPL Electric Utilities selected participants from an initial group of more than 2,000 eligible participants. It contacted 300 customers and 57 were included in the final screening process. Nineteen customers received in-home audits to determine eligibility. Of these, two received heat pumps, WRAP full-cost products and services, and heat pump water heaters, eight received both heat pumps and WRAP full-cost products and services, one received only a heat pump system, and one received only WRAP full-cost products and services.[110]

A summary of pilot metrics can be found in Table 9-23.

**Table 9-23: WRAP De Facto Heating Pilot Summary**

| Program | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Net-to-Gross Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) [1] | Program Acquisition Cost [1], [2] ($/Annual kWh) | Cost of Conserved Energy[3] (TRC $/kWh) | Phase II Participants |
|---|---|---|---|---|---|---|---|---|---|
| De Facto Heating Pilot | 61 | 44 | 44 | 1.0 | 0.21 | $226 | $5.03 | $0.517 | 12 |
| **Total** | **61** | **44** | **44** | **1.0** | **0.21** | **$226** | **$5.03** | **$0.517** | **12** |

[1] Expenditures are tracked at the program level, not by component.
[2] Total EDC Costs divided by kWh savings.
[3] Total TRC Costs divided by levelized lifetime kWh savings.

110 This customer was scheduled to receive a heat pump, however the job was cancelled because the working environment was unsafe.

PPL Electric Utilities reported savings of 61 MWh/yr and 0.004 MW. Cadmus verified savings of 44 MWh/yr and −0.004 MW/yr in demand reduction.

### 9.7.1 Program Updates

The De Facto Heating Pilot was new in PY7. PPL Electric Utilities' initial savings estimates assumed that up to 20 homes would receive a ductless heat pump system, full-cost WRAP jobs , and a heat pump water heater. However, many homes were larger than the planning assumptions had anticipated and these homes required more expensive systems. To remain within the pilot's budget, PPL Electric Utilities installed 11 heat pump systems.

PPL Electric Utilities made two adjustments during the pilot. Initially, it assumed each home would receive a ductless mini-split heat pump. One participant's home already had ducts, so this participant was given an air source heat pump, as it was a more cost-effective solution. PPL Electric Utilities subsequently revised the pilot plan from the installation of a high-efficiency ductless heat pump to the installation of a high-efficiency heat pump system. PPL Electric Utilities also allowed a customer who used kerosene, an electric stove, and electric space heater to participate in the pilot. PPL Electric Utilities allowed this customer to participate because of health and safety concerns and using an electric stove to heat a residence is an inefficient electric heating source.

To plan the pilot within the allotted budget, PPL Electric Utilities made assumptions about the home type of each home, the numbers of homes that could participate, the equipment that could be installed, and the anticipated savings from the installed equipment. However, actual conditions in the population and the selected homes varied from the planning assumptions in a number of ways. Table 9-24 shows the assumptions and the actual field conditions.

**Table 9-24. Assumptions in the EM&V Plan Versus Actual Fielded Results**

| Assumption | Actual |
|---|---|
| Each home would receive a ductless mini-split heat pump. | One participant already had ducts, so an air source heat pump was installed. |
| Each home would receive a two-zone ductless mini-split heating unit. | Participating homes were larger than originally estimated, with an average of 4.9 zones. |
| Each home would receive a heat pump water heater. | Heat pump water heaters were installed in homes where they could be installed. There were technological feasibility issues preventing installation in every home. |
| PPL budgeted $7,000 per heat pump system (two zone) and an average total cost for all measures per home of $12,000 (assuming 20 homes). | The installed heat pump systems cost an average $13,660 per home. On average, the total cost for all measures was $18,546 per home. |
| Each home would be a ranch-style home. | Homes were mostly row-style homes with multiple stories or heating zones. |

#### 9.7.1.1 Definition of Participant

A De Facto Heating Pilot participant was defined as a PPL Electric Utilities customer who received an efficient heat pump system. Each participating household contributed once to the participant counts. Participants were required to meet these four criteria:

- Qualify for Act 129 WRAP
- Own their home
- Have an inoperable oil heating system without access to natural gas
- Use electric space heaters as their primary heat source

Table 9-25 summarizes the equipment installed in the De Facto Heating Pilot.

**Table 9-25. Summary of Equipment Installed in De Facto Heating Pilot**

| Equipment Combination | Customers | Notes |
|---|---|---|
| Heat Pumps, Heat Pump Water Heaters, and Full-Cost Job | 2 | - |
| Heat Pumps and Full-Cost Job | 8 | - |
| Heat Pump Only | 1 | This customer already received full-cost equipment under WRAP |
| WRAP Full-Cost Job Only | 1 | A heat pump was planned for this home but the environment was unsafe and the heat pump job was cancelled; a WRAP full-cost job was completed |

## 9.7.2 Impact Evaluation Gross Savings

### 9.7.2.1 Reported Gross Savings

PPL Electric Utilities planned to calculate savings for all equipment installed within this pilot. It reported *ex ante* savings only for the installation of ductless heat pumps in the participants' homes. The reported *ex ante* savings did not capture savings from the installation of heat pump water heaters and full-cost WRAP products and services. Table 9-26 lists the reported savings by customer sector.

**Table 9-26: Phase II De Facto Heating Pilot Reported Results by Customer Sector[1]**

| Sector | Participants | Reported Gross Energy Savings (MWh/yr) | Reported Gross Demand Reduction (MW) | Incentives Paid ($1,000) |
|---|---|---|---|---|
| Residential | - | - | - | - |
| Low-Income | 12 | 61 | 0.004 | N/A |
| Small Commercial and Industrial | - | - | - | - |
| Large Commercial and Industrial | - | - | - | - |
| Government/Nonprofit/Education | - | - | - | - |
| **Phase II Total** | **12** | **61** | **0.004** | **N/A** |
| [1] Savings may not add up due to rounding. | | | | |

### 9.7.2.2 EM&V Sampling Approach

Cadmus included all participants in the savings verification. Table 9-27 shows the sampling strategy.

**Table 9-27: De Facto Heating Pilot Sampling Strategy for PY7**

| Stratum | Population Size | Target Levels of Confidence & Precision | Target Sample Size | Achieved Sample Size | Evaluation Activity |
|---|---|---|---|---|---|
| De Facto Heating Pilot Participants | 12 | N/A | 12 | 12 | Record Review, impact evaluation |

### 9.7.2.3 *Ex Ante* Savings Methodology and Findings

PPL Electric Utilities reported *ex ante* savings, calculating savings for ductless heat pumps. *Ex ante* savings excluded savings from the heat pump water heaters and full-cost WRAP products and services.

Cadmus found that the calculations for ductless heat pump savings and for air source heat pump savings did not align with the 2016 TRM methodologies in sections 2.2.3 and 2.2.1, respectively.[111] The reported *ex ante* savings were based on outdoor units and assumed that all heat pumps installed through the pilot were ductless heat pumps. Cadmus adjusted the *ex ante* savings using the correct algorithms for ductless heat pumps and the correct algorithm for the one case of an air source heat pump.

Cadmus also adjusted the *ex ante* savings and included savings for the full-cost WRAP job components and to the heat pump water heater equipment installed through the pilot.

### 9.7.2.4 *Ex Post* Savings Methodology and Findings

#### *Efficient Heat Pumps*

Cadmus examined the contractor's notes and verified that the gas or oil heating system was broken beyond repair and verified that the specifications of the installed heat pumps, the number of electric space heaters and room air conditioners, and the number of heating and cooling zones were correct.

To calculate the *ex post* savings for ductless heat pumps, Cadmus had to assume the location of electric space heaters and room air conditioners because the contractor did not provide these data. This assumption influenced savings because primary and secondary zones have different effective full load heating and cooling hours. Cadmus assumed the inefficient equipment occupied the primary zones first and the secondary zones second (depending on how many zones were in the home) because baseline heating and cooling equipment are placed in the most-used locations (the primary zones). Cadmus also assumed the inefficient equipment was stationary (i.e., did not change zones).[112]

Cadmus found that the number of zones where new equipment was installed did not match the number of electric space heaters and room air conditioners in most cases. There was an average of 4.9 zones installed and an average of 3.3 electric space heaters and 3.1 room air conditioners. Thus, on average, there were almost two ductless indoor units with no baseline.

Section 2.2.3 of the 2016 TRM addresses the scenario where a zone has no baseline.[113] In that scenario, it assigns a standard ductless heat pump as a heating baseline and a central air conditioner or room air conditioner as a cooling baseline (depending on the zone type). This baseline assignment by the TRM implies that a customer installing a high efficiency ductless heat pump unit in a heating zone with no previous equipment would have simply installed the minimum efficiency level of equipment (if not for a

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111 The 2016 TRM was used instead of the 2015 TRM (although the 2015 TRM corresponds to PY7) because the 2016 TRM has a baseline in the ductless heat pump and air source heat pump calculations that is specific to de facto space heaters. Pennsylvania Public Utility Commission. *2016 Technical Reference Manual.* Section 2.2.1 and Section 2.2.3June 2016. Available online: http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

112 This assumption is most likely true for the room air conditioners (which are cumbersome to move) but probably not as true for electric space heaters (which are portable). Nevertheless, savings cannot be estimated if the electric space heater moves from room to room.

113 Pennsylvania Public Utility Commission. *2016 Technical Reference Manual.* Section 2.3.2. June 2016. Available online: http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

rebate or incentive).[114] However, since the De Facto Heating Pilot was a low-income, direct install program, Cadmus assumed that these customers would not have installed any equipment in that space—especially considering that customers qualified for this pilot because they possessed inoperable oil heating and were primarily using space heaters to heat their homes. Because of this assumption, units installed in zones with no baseline contributed to negative savings.[115] Cadmus believes this captures the most likely scenario, given the program design and implementation.

The methodology to determine demand savings of the ductless heat pumps used the same assumptions as were used to determine energy savings (number of cooling and heating zones, electric space heaters, etc.) The demand savings for heat pumps were negative, for two primary reasons—there were no demand savings for heating (which provided the majority of the energy savings) and there was an average of 4.9 zones with equipment installed and an average of 3.1 room air conditioners in the homes (resulting in a demand increase).

The calculation of air source heat pump savings did not require these assumptions (as air source heat pump savings algorithms are not dependent on heating zones). Cadmus followed the 2016 TRM to calculate savings (the de facto heating baseline was not present in the 2015 TRM). Cadmus verified both ductless and air source heat pump savings using the contractor's data for heating and cooling zones, model numbers of indoor units (for the ductless heat pumps), and manufacturer's specifications (to calculate verified savings for the indoor units).

The installation contractor provided the wattage of the space heaters (needed to estimate the oversize factor for energy savings calculations). However, the reported wattage for every space heater in every home was 1,500 watts. Cadmus discussed this finding with PPL Electric Utilities and the contractor and determined that, although the contractor collected the best data possible, it was unlikely that the space heaters in every home would have the same wattage.[116] Because of this, Cadmus used the default oversize factor value in section 2.2.3 of the 2016 TRM for de facto space heaters as opposed to calculating the oversize factor from the wattage of the space heaters.

#### *WRAP Full-Cost Jobs*

Cadmus used the average WRAP full-cost job savings determined through a billing analysis for each participant who received a full-cost job. (See *Appendix J: Act 129 WRAP Billing Analysis* or the Low-Income WRAP chapter for details.)

#### *Heat Pump Water Heaters*

The contractor did not provide data for the heat pump water heater, so Cadmus used the default value in section 2.3.2 of the 2015 TRM to estimate the energy and demand savings (again, the 2015 TRM corresponds to PY7).

#### *On-Site Inspections*

The ICSP, MT Heating and Cooling, conducted energy audits and on-site inspections for ten of the 11 participants receiving efficient heat pumps. All of these sites passed quality assurance inspections. PPL Electric Utilities performed an energy audit and on-site inspection for the remaining participant who

114 The vintage for the measure is replace on burnout.

115 In the algorithm to calculate savings, Cadmus zeroed out the baseline term.

116 Pennsylvania Public Utility Commission. *2016 Technical Reference Manual.* Section 2.3.2. June 2016. Available online: http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

received an efficient heat pump system. The ICSP performed an on-site inspection of the WRAP products and services installed.

#### 9.7.2.5 Summary of Evaluation Results

Cadmus stratified savings into the three types of equipment: ductless heat pumps, heat pump water heaters, and full-cost WRAP products and services. Cadmus reviewed and calculated savings for all projects within this pilot. Table 9-28 shows energy savings and Table 9-29 shows demand savings. Note that the coefficient of variation for energy and demand savings was not applicable because Cadmus verified all projects. Likewise, the relative precision at 85% confidence is 0% for energy and demand savings because Cadmus verified all projects.

**Table 9-28: PY7 De Facto Heating Pilot Summary of Evaluation Results for Energy[1]**

| Stratum | Reported Gross Energy Savings (MWh/yr) | Adjusted *Ex Ante* Energy Savings (MWh/yr) | Energy Realization Rate (%) | Verified Gross Energy Savings (MWh/yr) | Observed Coefficient of Variation (Cv) or Proportion in Sample Design | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Efficient Heat Pumps | 61 | 24 | 100% | 24 | N/A | 0% |
| Heat Pump Water Heaters | 0 | 3 | 100% | 3 | N/A | 0% |
| Full-cost WRAP Jobs | 0 | 17 | 100% | 17 | N/A | 0% |
| **Pilot Total** | **61** | **44** | **100%** | **44** | **N/A** | **0%** |
| [1] Savings may not add up due to rounding. All projects were included in the evaluation. | | | | | | |

**Table 9-29: PY7 De Facto Heating Pilot Summary of Evaluation Results for Demand[1]**

| Stratum | Reported Gross Demand Savings (MW) | Adjusted *Ex Ante* Demand Savings (MW) | Demand Realization Rate (%) | Verified Gross Demand Savings (MW) | Observed Coefficient of Variation (Cv) or Proportion in Sample Design | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Efficient Heat Pumps | 0.004 | (0.006) | 100% | (0.006) | N/A | 0% |
| Heat Pump Water Heaters | 0.0000 | 0.0002 | 100% | 0.0002 | N/A | 0% |
| Full-Cost WRAP Jobs | 0.0000 | 0.002 | 100% | 0.002 | N/A | 0% |
| **Pilot Total** | **0.004** | **(0.004)** | **100%** | **(0.004)** | **N/A** | **0%** |
| [1] Savings may not add up due to rounding. All projects were included in the evaluation. | | | | | | |

### 9.7.3 Impact Evaluation Net Savings

Cadmus did not assess freeridership or spillover for this pilot targeting the low-income population who were eligible for WRAP. Equipment was installed at no cost to income-eligible customers. The pilot offered equipment in homes that used electric space heaters because the fossil fuel heating system was broken beyond repair. At an average expenditure of $18,546 for each participating household, it is very unlikely that low-income participants would have installed the equipment in the absence of the pilot program. Therefore, Cadmus assumed an NTG ratio of 1.0 (Table 9-30).

**Table 9-30: PY7 De Facto Heating Pilot Summary of Evaluation Results for NTG Research**

| Target Group or Stratum (if appropriate) | Estimated Freeridership | Estimated Participant Spillover | NTG Ratio | Observed Coefficient of Variation or Proportion | Relative Precision |
|---|---|---|---|---|---|
| De Facto Heating Pilot | N/A | N/A | 1.0 | N/A | N/A |

## 9.7.4 Process Evaluation

### 9.7.4.1 Research Objectives

The purpose of the process evaluation was to assess the De Facto Heating Pilot's effectiveness in achieving its objectives and to make recommendations for improvements. These were the objectives of the process evaluation:

- Document pilot processes from the stakeholder's perspective
- Document pilot processes from the contractors' point of view
- Ask participants about pilot delivery
- Ask participants about their satisfaction with the installed equipment, contractors, and the installation process
- Assess areas where challenges exist

### 9.7.4.2 Evaluation Activities

The process evaluation activities were consistent with Cadmus' evaluation plan. They are listed here and discussed in the next section on methodology:

- PPL Electric Utilities program manager interview (n=1)
- Installation contractor interview (n=1)
- Participant surveys (n=3)

The sampling strategy for De Facto Heating Pilot is presented in Table 9-31.

**Table 9-31: De Facto Heating Pilot Sampling Strategy for PY7**

| Target Group or Stratum | Stratum Boundaries | Population Size | Assumed Proportion or CV in Sample Design | Assumed Levels of Confidence & Precision | Target Sample Size | Number of Records Selected for Sample Frame | Achieved Sample Size | Percent of Population Frame Contacted to Achieve Sample [1] | Used For Evaluation Activities (Impact, Process, NTG) |
|---|---|---|---|---|---|---|---|---|---|
| De Facto Heating Pilot Participants Survey | All participants | 12 | N/A | N/A | 11 [2] | 11 | 3 | 100% | Process |
| PPL Electric Utilities Program Manager | - | 1 | N/A | N/A | 1 | 1 | 1 | 100% | Process |
| Installation Contractor | - | 1 | N/A | N/A | 1 | 1 | 1 | 100% | Process |
| **Pilot Total** | **-** | **14** | **N/A** | **N/A** | **13** | **13** | **5** | **100%** | **Process** |

[1] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted is the percentage of the sample frame called to complete surveys.
[2] One customer was not included because they did not install a heat pump.

#### 9.7.4.3 Methodology

*Program Staff and ICSP Interviews*

Cadmus interviewed the PPL Electric Utilities program manager and the ICSP to gain a thorough understanding of the pilot's processes and to discuss their perspectives about things that worked well and areas that experienced challenges. Cadmus contacted the implementation contractor two times to complete the interview.

*Participant Surveys*

The primary purpose of the survey was to assess customer satisfaction, program effectiveness, and whether customers continued using their electric space heaters and room air conditioners after participating in the pilot.

Cadmus contacted all 11 of the pilot's participants who installed heat pumps and conducted surveys with three. Cadmus called every customer who received a heat pump and attempted to reach the respondents four times over several days at different times of the day and scheduled callbacks whenever possible.

Potential sources of bias in the surveys include nonresponse bias, recall, and social desirability biases. Cadmus attempted to mitigate response bias by using survey design and survey data collection best practices. Since there were few participants, and three completed surveys, nonresponse bias is plausible.

Surveys were designed to include questions that were not leading or ambiguous, were not double-barreled, and provided clear interviewing and programming instructions so that they could be implemented consistently across interviewers and surveys.

Cadmus fielded the participant surveys during July and August of 2016.

#### 9.7.4.4 Achievements Against Plan

Table 9-32 contains the De Facto Heating Pilot planned energy savings and incentives and the progress on these.

**Table 9-32: De Facto Heating Pilot Savings[1]**

| | PY7 | | |
|---|---|---|---|
| | Planned [1] | Verified | Percentage of Planned |
| MWh/yr | 147 | 44 | 30% |
| MW[2] | N/A | (0.004) | N/A |
| Participants | Up to 20 | 12 | 55% |

[1] Planned savings are based on PPL Electric's revised EE&C plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, Table E6, p.56.
[2] Planned and verified MW savings include line losses.

The De Facto Heating Pilot achieved 29% of its planned PY7 MWh/yr savings. The pilot did not have any MW savings goals, but Cadmus verified −0.004 MW of savings. The pilot achieved a per-participant savings of 3.5 MWh/yr, less than its planned per-participant savings of 7.4 MWh/yr, the pilot's budget was constrained and fewer participants could participate.

The primary reasons the *ex post* verified savings differed from the *ex ante* reported savings and PPL Electric Utilities did not achieve its planned savings were:

- Projects were larger and more expensive than PPL Electric Utilities had initially anticipated. It had assumed that each home would be a ranch style home with two heating zones, and would receive a two-zone ductless mini-split unit. However, the average number of heating zones per home (of the

10 homes that received ductless heat pumps) was 4.9. The average cost of each heat pump installation was $13,660 (compared to an estimated cost of $7,000 per heat pump installation). Moreover, for the 10 homes that received ductless heat pumps the number of space heaters and the number of room air conditioners did not match the number of indoor heat pump units installed. The average number of space heaters in each home was 3.3, and the average number of room air conditioners in each home was 3.1. Thus, using the 2016 TRM protocol (section 2.2.3), there was an average of 1.6 units installed that had no heating baseline and 1.8 units that had no cooling baseline. In those cases (and according to the assumption that these customers would not have installed any equipment in those zones if not for this direct install pilot), negative savings resulted. Note that this is not applicable for the home that received an air source heat pump.

- The *ex ante* reported savings calculations for heat pumps did not follow the TRM methodology correctly and, as a result, the *ex ante* savings were overestimated.
- One customer did not receive an efficient heat pump system (potentially, a twelfth participant) and received only full-cost WRAP products and services.

In total, the pilot installed 10 ductless heat pumps, one air source heat pump, two heat pump water heaters, and completed 11 WRAP full-cost jobs.

#### 9.7.4.5 Program Delivery

PPL Electric Utilities delivered the De Facto Heating Pilot from January to May 2016. The pilot anticipated serving up to 20 participants and estimated savings for 20. To remain within the pilot's budget, it served 12 participants (with 11 receiving heat pumps).

PPL Electric Utilities prescreened more than 2,000 income-eligible customers; however, selecting qualified participants and homes that fit the assumptions of the evaluation plan was difficult. The utility contacted 300 customers and 57 of these proceeded to the final screening. Of these 57, 19 received in-home audits. Eight customers were disqualified during the in-home audit for reasons such as an unsafe working environment, health and safety concerns, or a new HVAC system was not a good application for their home. After the final screening, 11 households received heat pumps.

Moreover, to complete the pilot in a short time, PPL Electric Utilities originally talked with three contractors. However, one contractor was unresponsive, and a second contractor's timelines to complete their project estimates did not coincide well with the pilot's timeframe. Therefore, PPL Electric Utilities contracted with one contractor to complete all of the jobs.

##### *Key Performance Indicators*

In addition to energy savings, PPL Electric Utilities identified four key performance indicators it tracked to measure how well the pilot performed. These were project costs, the continued use of portable space heaters and room air conditioners following the installation of an efficient heat pump, customer satisfaction with the products and services and with the comfort provide with the new systems, and participant awareness of other PPL Electric Utilities rebate programs.

The pilot had a fixed budget and originally planned to recruit up to 20 homes. However, the total project cost per home was more than anticipated (the evaluation plan assumed a cost of $12,000 per home, but the average cost of just the heat pumps was $13,660 and the average cost to treat the entire home was $18,546). To maintain the budget, the pilot installed 11 heat pumps and installed only two heat pump water heaters (as there were technical feasibility constraints in most of the participants' homes preventing them from receiving heat pump water heaters).

Discussion of the continued use of inefficient equipment and customer satisfaction can be found in Section 9.7.4.7 Satisfaction, and discussion of participants' awareness of other PPL rebate programs can be found in Section 9.7.4.9 Marketing and Outreach.

PPL Electric Utilities determined it would not continue the De Facto Heating Pilot in Phase III.

#### 9.7.4.6 Participant Profile

Participants of the De Facto Heating Pilot owned their own home and were income-qualified for services through the Act 129 WRAP. The homes had an inoperable oil heating system without access to natural gas and used electric space heaters as their primary heat source. Table 9-33 lists the inoperable fossil fuel heating systems for the 11 participants who received heat pumps. The pilot replaced eight oil boilers, two oil furnaces, and one kerosene heater.

**Table 9-33. Summary of Participants' Inoperable Heating System Type**

| Participant | Inoperable Heating Equipment |
|---|---|
| 1 | Oil furnace |
| 2 | Oil furnace |
| 3 | Oil boiler |
| 4 | Oil boiler |
| 5 | Oil boiler |
| 6 | Oil boiler |
| 7 | Oil boiler |
| 8 | Oil boiler |
| 9 | Oil boiler |
| 10 | Kerosene heater and electric oven/range |
| 11 | Oil boiler |

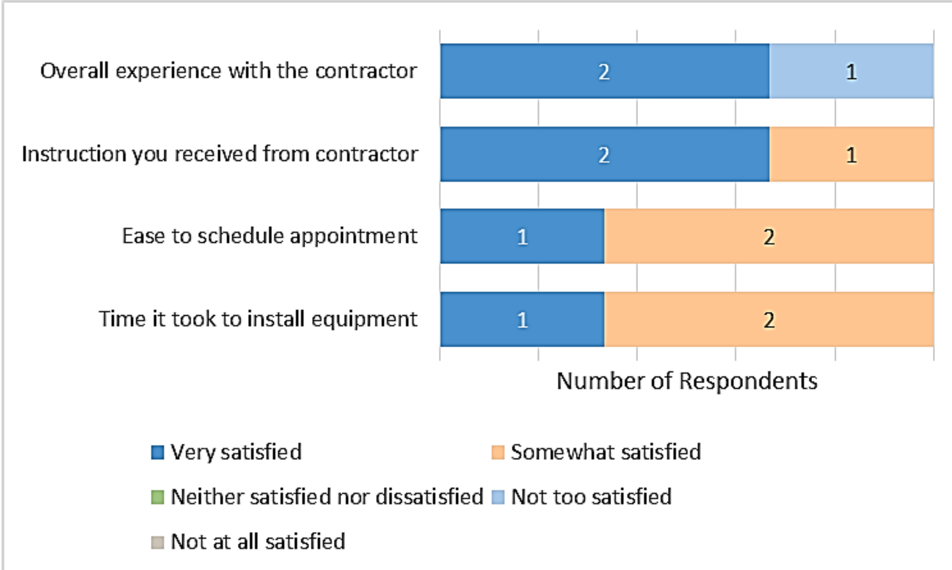
#### 9.7.4.7 Satisfaction

The survey assessed customer satisfaction in three categories—satisfaction with the contractor, satisfaction with the level of comfort and money saved, and overall satisfaction with the De Facto Heating Pilot.

##### *Satisfaction with the Contractor*

Figure 9-7 shows that two of three respondents were *very satisfied* with the contractor and one was *not too satisfied* with the contactor. All three respondents were either *very* or *somewhat satisfied* with the instruction they received from the contractor, the ease to schedule the appointment, and the time it took to install the equipment.

**Figure 9-7: Satisfaction with the Contractor**




Source: Survey question D3, "How satisfied are you with the following items regarding the contractor…", (n=3)

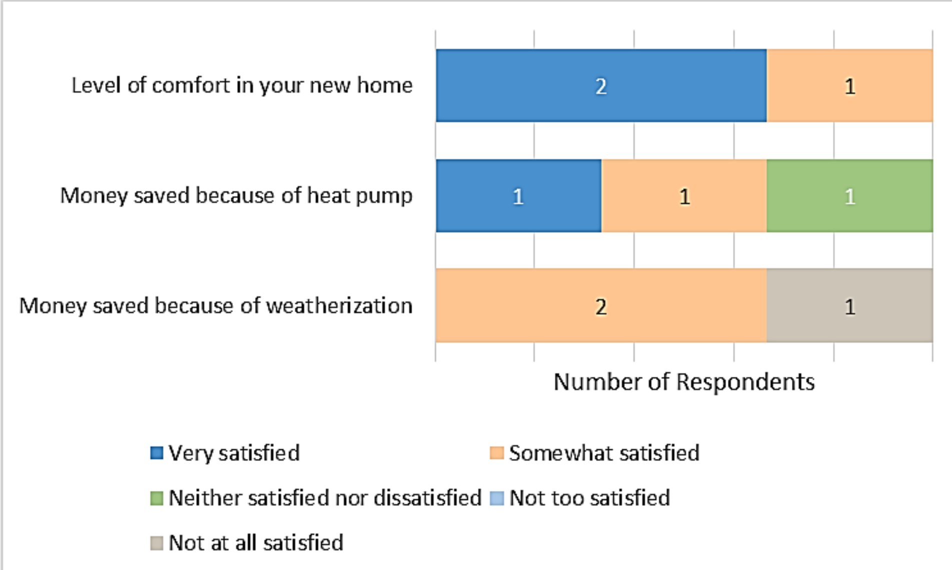
### *Level of Comfort and Money Saved*

Respondents answered questions about their satisfaction with their level of comfort and the money they saved from the new equipment (Figure 9-8).

- Two respondents were *very satisfied* and one respondent was *somewhat satisfied* with their physical comfort in their home.
- One respondent was *very satisfied* and one respondent was *somewhat satisfied* with the money they saved with the heat pump.
- Two respondents were *very satisfied* with the money they saved after PPL installed weatherization products and services; one was *not at all satisfied*.

The customer who was *not at all satisfied* with the money saved due to weatherization was upset because he/she wanted to receive products (such as a new roof) that were outside of the scope of this pilot and the WRAP guidelines.

**Figure 9-8: Satisfaction with Home's Comfort and Money Saved**




Source: Survey question D4, "Using the same scale, how satisfied are you with each of the following…", (n=3)

### *Overall Satisfaction*

Overall, the three participants interviewed were satisfied with the pilot. Two respondents said they were *very satisfied* and one said *somewhat satisfied*. One customer expressed dissatisfaction with the full-cost WRAP aspect of the pilot because he did not receive all the desired equipment. Again, the improvements were outside of the scope of the De Facto Heating Pilot.

Cadmus asked about the participants' satisfaction with PPL Electric Utilities as a provider of electric service, using a scale from 1 to 10 where 1 means *unacceptable* and 10 means *outstanding*. Two respondents gave a *high* rating (8 to 10); the other respondent gave *medium* rating (5 to 7). The mean of these responses was eight.

One respondent's opinion of PPL Electric Utilities *improved significantly* after participating in the pilot—this was the same respondent whose satisfaction with PPL Electric Utilities was a 10. The other two respondents gave satisfaction ratings of 9 and 5 and said their opinion did not change after the equipment was installed.

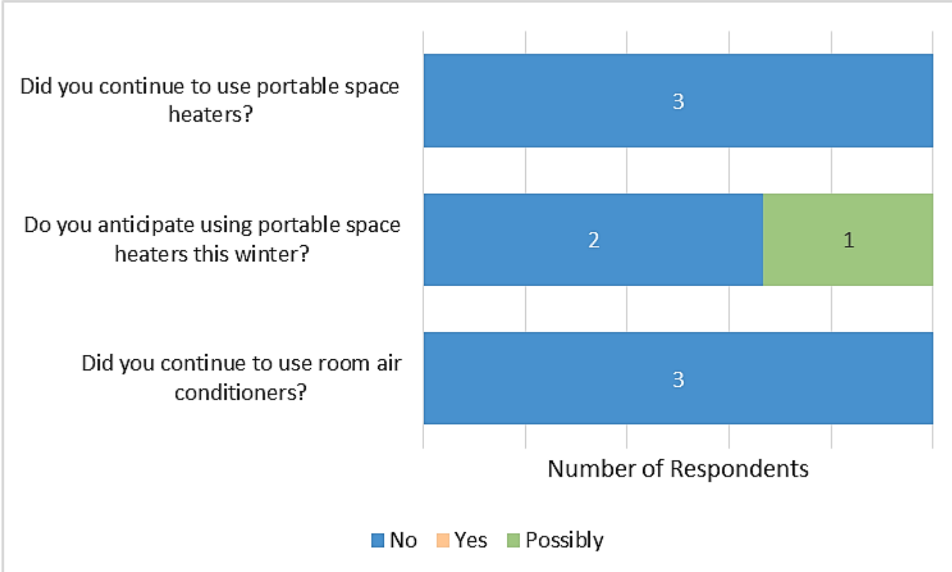
## 9.7.4.8 Retirement of Inefficient Equipment

Figure 9-9 shows that none of the three participants interviewed reported using portable space heaters this past winter. However, one of the customers surveyed received equipment in late February after the coldest part of the year so there may have been less need.[117] One respondent reported possibly using portable space heaters the next winter because he or she "*does not like being cold*." However, Cadmus notes that the possible use of space heaters would be as a supplemental heating source rather than as the primary heating source (as they were before the heat pump system was installed).

None of the respondents planned to continue to use room air conditioners after the equipment was installed.

[117] Note that seven of the 11 customers who received heat pumps received them in late February, March, or April of 2016.

**Figure 9-9: De Facto Heating Pilot Customers Use of Portable Space Heaters and Room Air Conditioners**




Source: Survey questions C1, C4, and C7, "PPL replaced some electric space heaters when they installed…", (n=3)

### 9.7.4.9 Marketing and Outreach

Cadmus asked participants about their awareness of other PPL Electric Utilities' rebate programs. One respondent said the contractor mentioned other rebate programs but could not remember the details. The other two respondents were not aware of other rebate programs, saying that the contractor did not mention any others.

### 9.7.4.10 Challenges

Cadmus' evaluation found that the De Facto Heating Pilot experienced several challenges related to selecting eligible participants, implementing the pilot, and working with contractors.

*Challenges Finding Eligible Participants*

PPL Electric Utilities prescreened more than 2,000 low-income homes income-qualified for the WRAP. It then distilled these homes by the other three qualifying criteria—own their home, have an inoperable oil heating source, and use electric space heaters as their primary heating—in several additional screenings. Ultimately, PPL Electric Utilities conducted in-home audits at 19 homes and selected 11 homes in which to install heat pumps.

However, finding homes that met all of the criteria used in the planning assumptions was extremely difficult. PPL Electric Utilities found only one home that fully matched its evaluation criteria, specifically, that the home would need a two-zone unit.[118]

The pilot's plan to meet energy savings and collect the appropriate data for an evaluation was very rigid, and the margin to achieve savings within the budget was very small. Additionally, the pilot's timeline was short: all installations must have been completed within Phase II (i.e., before June 1, 2016).

118 Note that only two homes had an equal number of space heaters and indoor units; however, with both of these homes, there was an unequal number of room air conditioners present.

To meet the timeline, the installation contractor suggested that, rather than targeting customers who heated their entire home with space heaters, PPL Electric Utilities could adjust the eligibility requirements to focus on low-income homes with one or two small problem areas. That is, the pilot could find low-income customers who supplemented their home's heating needs with space heaters in only one or two heating and cooling zones.

#### *Limitations Associated with the Technology*

PPL Electric Utilities discovered some limitations associated with the installation of heat pumps during the home audits. Some homeowners had multiple heat sources (each with different efficiencies) that heated different parts of the home. In some homes (such as row type homes), it was difficult to determine the effectiveness of installing a heat pump system (both in terms of equipment cost to PPL Electric Utilities and in energy bills for the customer); it was possible that installing the new efficient heat pump could actually cost the customer more money. Some selected homes had structural integrity problems, which made them difficult to assess and/or install heat pumps. Other homes (that would have been viable candidates) had working fossil fuel systems and were, thus, disqualified.

#### *Challenges with the Contractor*

PPL Electric Utilities experienced challenges communicating with the installation contractor, in part because the contractor had no standard cost-quotation process. The contractor did not always provide enough detail with its quote for the pilot to assess eligibility and have certainty in the verification. Subsequently, the contractor revisited some homes to collect more information. If the pilot were to continue, PPL Electric Utilities would ensure there is a standard cost-quotation process to improve the efficiency (save time and money) during various stages.

#### *Challenges with the Program Design*

Finally, PPL Electric Utilities believed the pilot design was too rigid to find participants within the budget. Although the De Facto Heating Pilot will not continue in Phase III, PPL Electric Utilities has considered conducting a needs assessment for future efforts of this type. If the pilot were to continue, PPL Electric Utilities would make design changes to control per-project cost and reach more participants.

### 9.7.5 Conclusions and Recommendations

Although there were many challenges in planning and delivering this pilot, PPL Electric Utilities successfully designed, launched, and completed the pilot. The utility intended that the pilot serve up to 20 income-qualified participants, and the pilot served 12 customers. Ultimately, this pilot was not cost-effective for the targeted customer base.[119] The cost-effectiveness was affected by the inability to achieve the planned savings, the planned costs per participant, and the planned number of participants.

Based on the findings, Cadmus suggests that PPL Electric Utilities consider the following recommendations.

**Conclusion**

The three customers interviewed (of the 11 participants who received heat pumps) were generally satisfied with the equipment they received. They were satisfied with the contractors, their level of comfort with the new equipment, their experience overall, and PPL Electric Utilities overall (see Section 9.7.4.7).

[119] The total resource cost (TRC) for this program was 0.21.

**Conclusion**

PPL Electric Utilities had difficulty finding participants who matched the pilot design and evaluation plan criteria (see Section 9.7, Section 9.7.1). Because of this, customers' heating systems cost more than anticipated ($7,000 per heat pump system planned and an average cost per heat pump system per home of $13,660). The average cost of the WRAP products and services was $4,355, which was within budget. Limited installations, in turn, limited overall energy and demand savings (see Section 9.7.1, Section 9.7.4.4). Participation was limited to maintain the overall budget (see Section 9.7.4.5 and Section 9.7.4.10).

**Conclusion**

The number of space heaters and room air conditioners in the home did not, on average, match the number of zones ascribed to the heat pump (see Section 9.7.4.4). This limited the savings potential. Additionally, some homes met all of the qualification criteria but were (appropriately) screened out because a heat pump would not have been an efficient method to heat the home (see Section 9.7.4.5, Section 9.7.4.10).

**Conclusion**

The pilot experienced a number of challenges in identifying the eligible population, delivering the pilot, and remaining within budget. The cost-effectiveness tests show that the pilot was not cost-effective. Overall, this particular approach to treat homes with unrepairable fossil fuel heating systems may not be the best approach, considering cost, the characteristics of the target population, and the applicable heating systems (see Section 9.7.4.5, Section 9.7.4.10, Section 9.7.6, Table 9-23).

**Recommendation**

PPL Electric Utilities decided to terminate the pilot in PY7 and not carry it forward into PY8. Cadmus agrees with this decision and recommends PPL Electric Utilities take additional steps to identify possible solutions for similar customers in future pilots. PPL Electric Utilities could consider conducting a market assessment when scoping and planning similar pilots in the future. The assessment would determine the size of the target market and its characteristics. PPL Electric Utilities could take advantage of available internal resources, such as Low-Income Usage Reduction Program (LIURP) data, to reduce research time and cost. The assessment could include a technical feasibility assessment to determine the most appropriate heating system for targeted housing types. The pilot design, delivery, and evaluation plans could be tailored to the market and pilot objectives.

**Conclusion**

PPL Electric Utilities experienced some challenges working with multiple contractors; two of the three initial contractors dropped out. Additionally, the remaining contractor had difficulty collecting the required data in one site visit (see Section 9.7.4.10).

**Recommendation**

Consider establishing a process for contractor scheduling earlier to reduce (or eliminate) ineffective performance by contractors. Likewise, consider establishing a standard bid process to obtain project cost estimates and all data required to evaluate the pilot.

**Conclusion**

Although one of the pilot's objectives was to promote other PPL Electric Utilities energy efficiency programs, participants were generally unaware of other PPL Electric Utilities rebate programs. One survey participant said the contractor provided information about other programs but could not remember the details and the other two survey participants did not remember whether the contractor mentioned other PPL Electric Utilities programs (see Section 9.7.4.9).

**Recommendation**

Cadmus recommends that future program implementers and installation contractors emphasize the availability of other PPL Electric Utilities programs and provide leave-behind materials describing the programs and how to contact the utility.

### 9.7.5.1 Status of Recommendations for Program

Table 9-34 contains the status of each PY7 process recommendation made to PPL Electric Utilities.

**Table 9-34: De Facto Heating Pilot Status Report on Process and Impact Recommendations**

| Recommendations | EDC Status of Recommendation (Implemented, Being Considered, Rejected AND Explanation of Action Taken by EDC) |
|---|---|
| **Winter Relief Assistance Program (WRAP) - De Facto Heating Pilot** | |
| Consider conducting an assessment of the market and technology in future pilot programs and adjust the evaluation plan accordingly. | Will be implemented for future pilots. |
| Consider establishing the contractor scheduling process earlier to reduce (or eliminate) effects of non-performing contractors. | Implemented. The scheduling process for Phase 3 WRAP work was significantly improved. |
| Encourage future implementers provide leave-behind materials describing the programs and how to contact the utility. | Being considered for future pilots. |

### 9.7.6 Financial Reporting

A breakdown of the De Facto Heating Pilot finances is presented in Table 9-35.

**Table 9-35: Summary of De Facto Heating Pilot Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs[6] ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs (Sum of rows 2 to 4) | $0 | $0 |
| 2 | EDC Incentives to Participants | $0 | $0 |
| 3 | EDC Incentives to Trade Allies | | 0 |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $0 | $0 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6, 7, 8, 9, 10 ) | $223 | $190 |
| 6 | Design & Development | $0 | $0 |
| 7 | Administration, Management, and Technical Assistance[1] | $223 | $190 |
| 8 | Marketing[2] | $0 | $0 |
| 9 | EDC Evaluation Costs | $0 | $0 |
| 10 | SWE Audit Costs | $0 | $0 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | $3 | $3 |
| | | | |
| 12 | Total TRC Costs[3] (Sum of rows 1, 5 and 11) | $226 | $193 |
| 13 | Total NPV Lifetime Energy Benefits | $45 | $39 |
| 14 | Total NPV Lifetime Capacity Benefits | $1 | $1 |
| 15 | Total NPV O&M Saving Benefits | $0 | $0 |
| 16 | Total NPV TRC Benefits[4] | $46 | $40 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | 0.21 | 0.21 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.

[2] Includes the marketing CSP and marketing costs by program CSPs.

[3] Total TRC Costs includes Total EDC Costs and Participant Costs.

[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.

[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.

[6] Phase II Costs in this table are discounted back to PY5, thus will not match cumulative costs reported in the PY6 Q4 quarterly report

# ADDENDUM A. PARTICIPANT SURVEY METHODOLOGY – DE FACTO HEATING PILOT

### 9.7.7 Dialing Instructions

PPL Electric Utilities provided dialing instructions for conducting surveys. Customers cannot be contacted for a survey if they have completed a survey in the three months prior to survey data collection or if they opted out of a survey. Telephone survey calls cannot take place on Sundays or national holidays.

Researchers called participants at different times of day and different days of the week to increase the probability of contact. Researchers attempted surveys with potential respondents four times each.

### 9.7.8 Sample Cleaning and Attrition

Cadmus coordinated with PPL Electric Utilities' survey contractor to screen the sample and remove the records of any customers called in the past year (whether for a Cadmus survey or a PPL Electric Utilities survey) and any who requested not to be contacted again. Cadmus also removed records with incomplete information. This cleaning and survey sample preparation process reduced the available sample.

Cadmus selected all remaining random sample of all remaining records and sent them to the survey subcontractor. Table 9-36 lists total number of records submitted to the survey subcontractor and the outcome (final disposition) of each record.

**Table 9-36: Survey Sample Attrition Table**

| Description of Call Outcomes | Number of Records |
|---|---|
| **Population** | **12** |
| Removed incomplete or bad phone number | 0 |
| Removed inactive customer | 0 |
| Removed completed survey in past year | 0 |
| Removed because on do not call list | 0 |
| Removed because selected for other survey | 0 |
| Removed because duplicate | 0 |
| Removed because did not install a heat pump | 1 |
| **Survey Sample Frame (sent to survey subcontractor)** | **11** |
| **Not attempted** | **0** |
| **Records Attempted** | **11** |
| Non-working number | 2 |
| Language barrier | 1 |
| Refusal | 1 |
| No answer/answering machine/phone busy | 4 |
| **Completed survey** | **3** |

# 10 LOW-INCOME ENERGY-EFFICIENCY BEHAVIOR & EDUCATION PROGRAM

PPL Electric Utilities began offering the Low-Income Energy-Efficiency Behavior & Education Program midyear of PY6 and continued through PY7. Like its residential program counterpart, the program informed customers about their home energy consumption and encouraged them to adopt energy-saving home improvements and behaviors. However, this program targeted households that were at or below 150% of the federal poverty income guideline.

Customers received a home energy report sent by mail every other month. Each report provided a summary of the customer's household energy use, a neighbor comparison of energy use, and three energy-saving action steps. Specifically for low-income customers, the action steps emphasized no-cost, rather than low-cost, energy-saving actions. Customers with valid e-mail addresses also received the home energy reports via e-mail every month.[120] The program did not provide any financial incentives for participating.

The program used an experimental design, called a randomized control trial, wherein eligible customers were randomly assigned to either a treatment group (recipients of home energy reports) or a control group (non-recipients). The control group was not aware of the home energy reports. This group functioned as a comparison group for measuring the treatment group's energy savings resulting from the program.

The objectives of the Low-Income Energy-Efficiency Behavior & Education Program were these: [121]

- Educate targeted low-income customers (at or below 150% of federal poverty income guideline) about free (no-cost) or low-cost products and behavior changes that may reduce energy consumption or demand
- Educate customers about PPL Electric Utilities' online resources
- Encourage low-income customers to adopt more energy-efficient behaviors and to install energy-efficient products in their homes by becoming more aware of how their behavior and practices impact their energy use
- Promote other PPL Electric Utilities energy efficiency programs for low-income customers
- Obtain participation by approximately 90,000 customers through 2016, with a total reduction of approximately 8,300 MWh/yr[122]

[120] The e-mailed home energy reports feature only the neighbor comparison. These e-mailed reports, because they are sent monthly, are intended to provide more current information on neighbor energy use than can be provided in the two-month intervals of the paper reports.

[121] Program objectives are stipulated in PPL Electric's revised EE&C Plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, p.89.

[122] The EE&C Plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015 states a participation count of 70,000 instead of 90,000. The Low-Income Energy-Efficiency Behavior and Education Program amended the participation count and added 20,000 customers in PY7 (Pennsylvania Public Utilities Commission. "Amendment Number 3 to the Act 129 Services Agreement 571809." Agreement between Opower, Inc., and PPL Electric Utilities Corporation. November 30, 2014.).

A summary of Phase II program metrics is presented in Table 10-1. Opower, the ICSP, reported 10,833 MWh/yr of energy savings in PY7. Cadmus verified 10,622 MWh/yr of energy savings and reported a TRC ratio of 0.75.

**Table 10-1: Phase II Low-Income Energy-Efficiency Behavior & Education Program**

| Program | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Net-to-Gross Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) | Program Acquisition Cost ($/Annual kWh) | Cost of Conserved Energy[1] (TRC $/kWh) | Phase II Participants [2] |
|---|---|---|---|---|---|---|---|---|---|
| Low-Income Energy-Efficiency Behavior & Education | 10,833 | 10,833 | 10,622 | 1.00 | 0.65 | $1,523 | $0.14 | $0.142 | 87,376 |
| **Total** | **10,833** | **10,833** | **10,622** | **1.00** | **0.65** | **$1,523** | **$0.14** | **$0.142** | **87,376** |

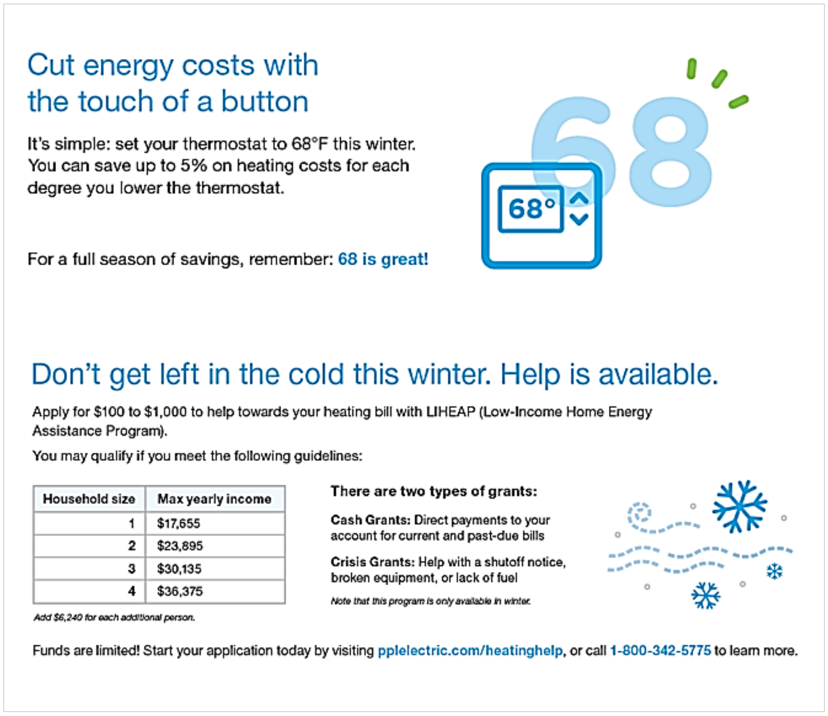
[1] Total TRC Costs divided by levelized lifetime kWh savings.
[2] Number of participants at the beginning of PY7, including opt-outs and households that went inactive at some point during PY7.

## 10.1 PROGRAM UPDATES

The program made two changes in PY7. First, it added a new wave of 20,000 customers to the treatment group, which brought the total to around 90,000 customers. Second, the program added the Winter of 68 and Low-Income Home Energy Assistance Program (LIHEAP) modules to the home energy reports at the end of Q2 through Q3. As shown in Figure 10-1, these modules were specifically intended to elicit a behavior change in setting the thermostat temperature and to increase participation in LIHEAP. Because home energy reports were customized, the energy-saving tips and program promotions often differed from report to report and customer to customer. However, report modules promoted the same tip and program during the same period.

Also during the PY7 Q2 to PY7 Q3 period, PPL Electric Utilities mailed a free LED bulb to approximately 45,000 high-energy use customers in the treatment group. These bulbs were distributed through PPL Electric Utilities' Residential Retail Program, which reported the associated energy savings. See the Residential Retail Program chapter for more details.

**Figure 10-1: Winter of 68 and LIHEAP Report Modules**




## 10.1.1 Definition of Participant

Participants were defined as residential customers who received at least one paper home energy report during PY7, had been identified as low-income, and constituted the treatment group. Customers who opted out of the program in a previous year and have active accounts were still considered treated customers and were included in the treatment group counts.[123]

Within the treatment and control groups, the customer population was divided into two waves:

- Low-Income Wave 1 received their first report in PY6, October or December 2014.
- Low-Income Wave 2 received their first report in PY7, June 2015.

In PY7, the Low-Income Energy-Efficiency Behavior & Education Program sent home energy reports to around 87,000 homes.[124] These participants received at least one home energy report in PY7. Table 10-2 shows the PY7 program design, and report delivery frequency, and number of customers.

[123] Control group customers did not receive home energy reports but were assigned a treatment start date matching the treatment customers in that wave, reflecting the date they would have received their first home energy report had they been in the treatment group. Control group customers who were still active in PY7 were included in the billing analysis but did not count toward the total number of "treatment days" used to aggregate per-customer daily savings to the PY7 level.

[124] 87,376 treatment customers were active participants and received home energy reports in the beginning of PY7 (June 2015).

**Table 10-2: PY7 Low-Income Energy-Efficiency Behavior & Education Program Design**

| Group and Wave | Year First Launched | Delivery Frequency | Number of Customers at Start of PY7 [1] |
|---|---|---|---|
| **Treatment Group** | | | |
| Low-Income Wave 1 | 2014 | Six bimonthly paper reports; 12 monthly e-mail reports | 66,760 |
| Low-Income Wave 2 | 2015 | Six bimonthly paper reports; 12 monthly e-mail reports | 20,616 |
| **Total Treatment Group** | | | **87,376** |
| **Control Group** | | | |
| Low-Income Wave 1 | 2014 | - | 16,926 |
| Low-Income Wave 2 | 2015 | - | 9,657 |
| **Total Control Group** | | | **26,583** |
| [1] Number of participants at the start of PY7. Excludes participants for which Cadmus did not receive billing data as well as participants who became inactive before the beginning of PY7. | | | |

## 10.2 IMPACT EVALUATION GROSS SAVINGS

### 10.2.1 Reported Gross Savings

The ICSP reported gross energy savings of 10,833 MWh/yr across both waves combined in PY7 at the sector level, as presented in Table 10-3. Cadmus followed the SWE's Behavioral Protocol assumption that behavioral programs have a one-year measure life.[125] As such, Phase II savings reflect only the savings that occurred in PY7.

**Table 10-3: Low-Income Energy-Efficiency Behavior & Education Program Reported Results**

| Wave | Participants [1] | Adjusted Gross Energy Savings (MWh/yr) | Incentives ($1,000) |
|---|---|---|---|
| **PY7 Total** | 93,044 | 10,833 | $0 |
| [1] Cadmus derived this number from the PY7 savings data provided by the ICSP. Note that this count of customers was received separate from the billing and tracking data provided by the ICSP, the counts for which are presented in Table 10-2. The count of customers in the ICSP savings data is not the same as the count of customers in the billing and tracking data. | | | |

### 10.2.2 Database Review

Cadmus reviewed the database of PPL Electric Utilities residential and low-income customers assigned to either the treatment group or control group (and across all waves) to ensure that EEMIS data matched the ICSP's program tracking data. Cadmus did not separate the database review between the residential and low-income behavior program customers because the EEMIS data did not include a field to denote in which program the customer was included; Cadmus used a field in the ICSP data to identify customers' program and waves.

The match rate was high; however, Cadmus found a discrepancy in the ICSP's program tracking data—the data did not include 8,587 of the records present in EEMIS. After thoroughly investigating its database,

[125] The SWE's Behavioral Protocol assumption states: "To date, the PUC has not prescribed the measure life for behavioral programs and has identified persistence of behavioral savings as an area of investigation for the Phase III SWE team to inform targets and reporting protocols for future phases of Act 129. Unless an alternative EUL was submitted and approved in a Phase III EE&C plan, EDCs should report annual savings consistent with the status-quo assumed one-year measure life." Pennsylvania Public Utility Commission. *Phase III Evaluation Framework*. June 9, 2016. See Section 1.1.9.

the ICSP discovered the upload to EEMIS had duplicated a number of accounts after assigning unique identifiers (account IDs). Ultimately, the ICSP left these duplicate EEMIS records out of the billing analysis and final estimate of savings. Cadmus determined that the most accurate data came from the ICSP's program tracking and billing files, so it also did not include the duplicate EEMIS records in its billing analysis and calculation of evaluated *ex post* savings.

Table 10-4 summarizes the findings of the database review.

**Table 10-4: Low-Income and Residential Energy-Efficiency Behavior & Education Program Database Review**

| Source | Population Size | Evaluation Activities |
|---|---|---|
| EEMIS[1] | 372,232 | Database Review, Census, Impact |
| ICSP Program Tracking Data[2] | 363,645 | Database Review, Census, Impact |
| **Difference** | **8,587** | Determined these were duplicate records and excluded these from analysis |
| **Program Total** | **363,645** | |

[1] Includes all records in EEMIS in the residential and low-income behavior and education program, including customers whose accounts became inactive. The EEMIS data did not include a field to denote in which program the customer was included; Cadmus used a field in the ICSP data to identify customers' program and waves.
[2] Includes all records in the program tracking data provided by the ICSP, including customers whose account became inactive.

Cadmus also found that some low-income treatment customers (less than 8%) did not appear to have received the home energy reports at the same time as the rest of their wave. The ICSP explained that it was not possible to generate home energy reports for these treatment customers for a number of possible reasons including data "staleness," data incompleteness, or extremely low usage.[126] The ICSP's database has a field titled "first generated date," which confirmed that the treatment group customer was mailed a home energy report. In some instances, however, the ICSP's database system did not generate a date in this field and therefore did not mail out any home energy reports even though the customer was assigned to the treatment group.

In a randomized control trial, it is important to maintain the randomization of customers into treatment and control groups to control for the expected variation between customers. To preserve the randomization, Cadmus decided to leave these customers in the billing analysis and final savings estimation. Including these customers likely dampened slightly the estimate of average savings per customer but did not affect the estimate of the program savings.

Back in PY6, the ICSP accidentally generated and sent home energy reports to a small batch of low-income control group customers (less than 18%). Cadmus left these customers in the energy savings analysis to preserve the integrity of the randomized control trial. Leaving these customers in the analysis sample may have had a temporary dampening effect on the estimated savings during PY6, but it is unlikely to have an effect on the estimated savings in PY7 and over the longer run as any savings effect of the report dissipates.

Table 10-5 shows the number of low-income treatment and control group homes by wave and customer accounts used in each step of the savings estimation.

126 Personal communication with the ICSP. August 4, 2016.

**Table 10-5: PY7 Low-Income Energy-Efficiency Behavior & Education Program Impact Evaluation Sampling Strategy**

| Stratum | Strata Boundaries | Customer Accounts in Billing Analysis[1] | Evaluation Activity | PY7 Participants[2] | Evaluation Activity |
|---|---|---|---|---|---|
| Low-Income Wave 1 | Treatment group customers who received first home energy report in October of PY6 | 72,794 | Regression analysis to estimate program treatment effect (decrease in average daily consumption) | 66,760 | Estimate program *ex post* corresponding to PY7 program participants |
| | Control group customers | 18,388 | | 16,926 | N/A |
| Low-Income Wave 2 | Treatment group customers who received first home energy report in June of PY7 | 21,277 | Regression analysis to estimate program treatment effect (decrease in average daily consumption) | 20,616 | Estimate program *ex post* corresponding to PY7 program participants |
| | Control group customers | 9,972 | | 9,657 | N/A |
| | **Treatment and control group customers** | **122,431** | | **113,959** | |

[1] Population includes all customers who were part of the randomized control trial and had at least 12 months of billing data prior to the start of treatment. Note that the count customer accounts in the billing analysis is not necessarily the same as the count of PY7 Participants due to attrition; customer accounts that became inactive *prior* to the beginning of PY7 are not included in the count of PY7 participants.
[2] Population was calculated in the beginning of PY7 and includes all customers who were part of the randomized control trial and were active during PY7, including customers who became inactive at some point during PY7.

The difference in population counts between the customer accounts in the billing analysis and the number of PY7 participants reflected the program's attrition rate through time. All customers who had at least 12 months of billing data prior to the start of the treatment were included in the billing analysis dataset. However, as time progressed, some customers became inactive or opted out of the program and their bills stopped being collected by the ICSP. By the start of PY7, just over 93% of the original customer accounts had bills.

### 10.2.3 EM&V Sampling Approach

PPL Electric Utilities contracted with the ICSP to select eligible customers for the program and to produce and distribute the home energy reports. Cadmus provided the random assignment of the eligible customers to the treatment or control group for Phase II.

To estimate the energy savings, Cadmus analyzed monthly PPL Electric Utilities customer electric bills for the census of treatment group and control group homes. Cadmus analyzed energy use of Low-Income Wave 1 customers between October 2013 and May 2016 and Low-Income Wave 2 customers between June 2014 and May 2016.

The impact evaluation's estimate of energy savings included the savings of homes that received at least one home energy report during PY7, including those who opted out of the program and homes whose accounts became inactive during the treatment period.[127] The estimate of energy savings did not include homes that went inactive or opted out before the beginning of PY7. Table 10-6 shows the number of treatment and control group homes included in the billing analysis.

[127] Homes that opted out of the program were kept in the analysis sample to preserve the equivalence of the treatment and control groups. In order to remove opt-out homes, Cadmus would have to have known which control group homes would have opted out if they had received a report and to have dropped these homes. Also, even homes that opted out may have saved energy because of the program.

**Table 10-6: PY7 Final Estimation Sample: Number of Homes by Group and Wave**

| Group | Low-Income Wave 1 | Low-Income Wave 2 |
|---|---|---|
| Treatment Group Homes | 66,760 | 20,616 |
| Control Group Homes | 16,926 | 9,657 |
| **Total Homes[1]** | **83,686** | **30,273** |

[1] Cadmus analyzed the monthly energy consumption bills of the census of the treatment and control group homes in PY7. Savings estimate included savings during all months with an active account in homes whose accounts became inactive during PY7. See *Appendix G: Energy-Efficiency Behavior & Education Program Savings Counted in Other Energy-Efficiency Programs*.

### 10.2.4 *Ex Ante* Savings Methodology and Findings

The ICSP determined gross savings of 10,833 MWh/yr in PY7, based on regression analysis of monthly energy use of treatment and control group homes. Cadmus did not make any adjustments to the PY7 reported *ex ante*; therefore, adjusted *ex ante* are the same at 10,833 MWh/yr.

The ICSP reported *ex ante* demand savings of 14.8 MW/yr in PY7. Cadmus did not adjust *ex ante* demand savings.

### 10.2.5 *Ex Post* Savings Methodology and Findings

Cadmus used regression analysis of customer average daily consumption to estimate the electricity savings. Cadmus confirmed the number of customers in each wave and number of days in the treatment period. It then employed regression analysis of customer average daily electricity consumption using the approach of Allcott and Rogers (2014),[128] as recommended in the SWE's PY6 annual report.[129] This conforms with the Uniform Methods Protocol and the IPMV Option C.[130]

Savings estimates were expected to be unbiased because of the randomized assignment of eligible homes to treatment and control groups. Although the savings (treatment effect) was small relative to annual energy consumption, the regression analysis could detect it because the study groups were large and the analysis included billing data from all treatment and control customers. The details of the regression analysis are described in *Appendix M: Residential and Low-Income Energy-Efficiency Behavior & Educaiton Origran Impact Analysis.*

Before evaluating savings, Cadmus analyzed pre-treatment average daily energy consumption in the treatment and control groups to ensure that the groups were balanced using a t-test of the difference in means. A p-value greater than 0.10 indicates that the groups are well balanced due to adequate randomization as there is *no* statistically significant evidence that the mean pre-treatment period consumption of the two groups was different at the 90% confidence level. Conversely, a p-value less than

128 Allcott, Hunt, and Todd Rogers. 2014. "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation." *American Economic Review*, 104(10): 3003-37.

129 Pennsylvania Public Utility Commission. *Act 129 Statewide Evaluator Annual Report.* Prepared by GDS Associates, Inc., Research into Action, and Apex Analytics, LLC. Final Report, March 8, 2016. Available online: http://www.puc.state.pa.us/Electric/pdf/Act129/SWE_PY6-Final_Annual_Report.pdf

130 Efficiency Valuation Organization. *International Performance Measurement & Verification Protocol (IPMVP); Concepts and Options for Determining Energy and Water Savings: Volume 1*. September 2009. EVO 10000 – 1:2009. Available online: www.evo-world.org. Cadmus approach is also consistent with the SEE Action Network and DOE UMP protocols. See State and Local Energy Efficiency Action Network. 2012. *Evaluation, Measurement, and Verification of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations*. Prepared by A. Todd, E. Stuart, S. Schiller, and C. Goldman.

0.10 suggests that there *is* a statistically significant difference between the groups' means and the random assignment may not have resulted in a well-balanced groups.

As shown in Table 10-7, no significant differences existed between the pre-treatment consumption of treatment and control groups in each wave.

**Table 10-7: T-Tests to Confirm Balance in Treatment and Control Groups**

| Statistic | Low-Income Wave 1 | Low-Income Wave 2 |
|---|---|---|
| Treatment Group Pre-Treatment Period Annual Consumption (kWh) | 11,894 | 8,172 |
| Control Group Pre-Treatment Period Annual Consumption (kWh) | 11,843 | 8,248 |
| Difference (kWh) | 51 | -76 |
| Percentage Difference | 0.4% | -0.9% |
| t-value | 0.9 | 0.8 |
| p-value (Pr>t) | 0.37 | 0.45 |

## 10.2.6 Savings Realization Rate Methodology

Cadmus calculated the realization rate for the program as the ratio of *ex post* verified gross savings to *ex ante* reported savings. Cadmus did not calculate a realization rate for each wave separately because the reported *ex ante* savings appeared in EEMIS for the program as a whole, and not for each wave.

## 10.2.7 Summary of Evaluation Results

### 10.2.7.1 Energy Savings Estimation

Table 10-8 shows the program energy savings and realization rate in PY7. Note that EEMIS did not provide reported savings by wave; therefore, Table 10-8 shows reported savings only at the program level. The ICSP reported program gross *ex ante* savings of 10,833 MWh/yr, which represents the 12-month period between June 2015 and May 2016. Cadmus estimated the *ex post* verified savings as 10,622 MWh/yr, which provided a realization rate of 98% in PY7. The 85% confidence interval for the *ex post* verified savings (the range from 8,411 MWh/yr to 12,833 MWh/yr) included the ICSP's reported savings, meaning estimates were not significantly different.

The precision of 21% with 85% confidence around program total savings is outside of compliance. This may be due to a number of factors, including the duration of treatment and unexplained variance of customer electricity consumption. The residential Expansion Wave and Low-Income Wave 1 both launched in 2014 and have similar precisions around track-verified savings, while longer-running tracks have more precisely estimated savings.

It may be that savings are more heterogeneous at the beginning of the program than after the program has run for longer, and thus, the precisions are higher for these tracks. Another factor may be that there is more unexplained variability in low-income customer consumption than in non-low-income customer consumption. Low-income customers are more likely to have variable incomes, which may increase the variability of consumption of electricity, leading to worse precision in the low-income program.

**Table 10-8: PY7 Low-Income Energy-Efficiency Behavior & Education Program Summary of Evaluation Results for Energy**

| Stratum | PYTD Reported Gross Energy Savings (MWh/yr) | PYTD Adjusted *Ex Ante* Energy Savings (MWh/yr) | Energy Realization Rate (%) | PYTD Verified Gross Energy Savings (MWh/yr) [1] | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 85% C.L.[1] |
|---|---|---|---|---|---|---|
| Low-Income Group 1 | - | - | - | 9,694 | 0.1506 | 21.69% |
| Low-Income Group 2 | - | - | - | 928 | 0.5133 | 73.89% |
| Original Reported | 10,833 | 10,833 | - | - | - | - |
| **Program Total** | **10,833** | **10,833** | **98%** | **10,622** | **N/A** | **20.82%** |

[1] This evaluation analyzed the census of randomized control trial treatment and control group homes; therefore, the final savings estimate was not subject to sampling error. Verified gross energy savings were based on regression analyses of monthly average daily consumption. Standard errors were adjusted for correlation over time in each customer's consumption using Huber-White robust standard errors.

The two waves yielded differing levels of energy savings in PY7, in terms of per-customer average kWh savings, normalized per-customer percentage savings, and total aggregated savings. The next three figures show these differences at the wave level.

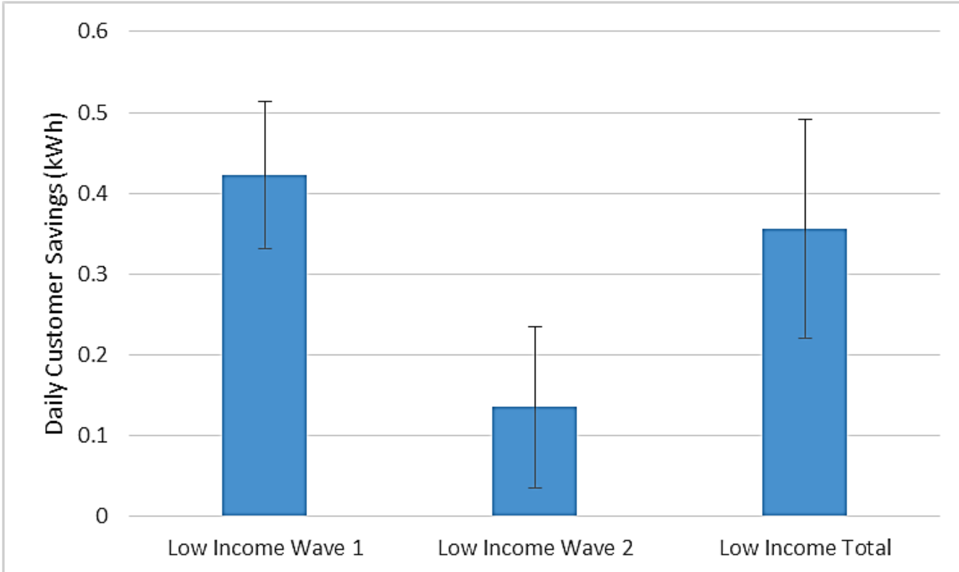
Figure 10-2 shows that Low-Income Wave 1 had the highest average daily savings per customer, at more than 0.42 kWh. The Low-Income Wave 2 saved at a lower rate of 0.14 kWh. These differences in average daily kWh savings were most probably driven by a combination of factors, including the number of years customers in the wave had received home energy reports and the customers' mean annual consumption before the program began. Across the two waves, the program's mean kWh average daily savings per customer was 0.36 kWh.[131]

Figure 10-3 shows the estimates of savings normalized by each wave's baseline usage.[132] It is useful to compare the waves' savings on a consumption-normalized basis to see how they compare in the *relative* magnitude of savings. Generally, the two waves saved within the expected 1% to 3% range for home energy reports programs with a weighted average of 1.29%. However, as a percentage of consumption, Low-Income Wave 1 saved more than double that of Low-Income Wave 2. The latter was the most recently added wave of customers and was in the process of ramping up savings during PY7. Low-Income Wave 2 may be expected to reach similar percentage savings levels by the end of its next program year (PY8).

131 Note that the average per-customer daily savings rate for the three non-Low-Income Behavior and Education waves was nearly 2.5 times higher at 0.868 kWh in PY7.

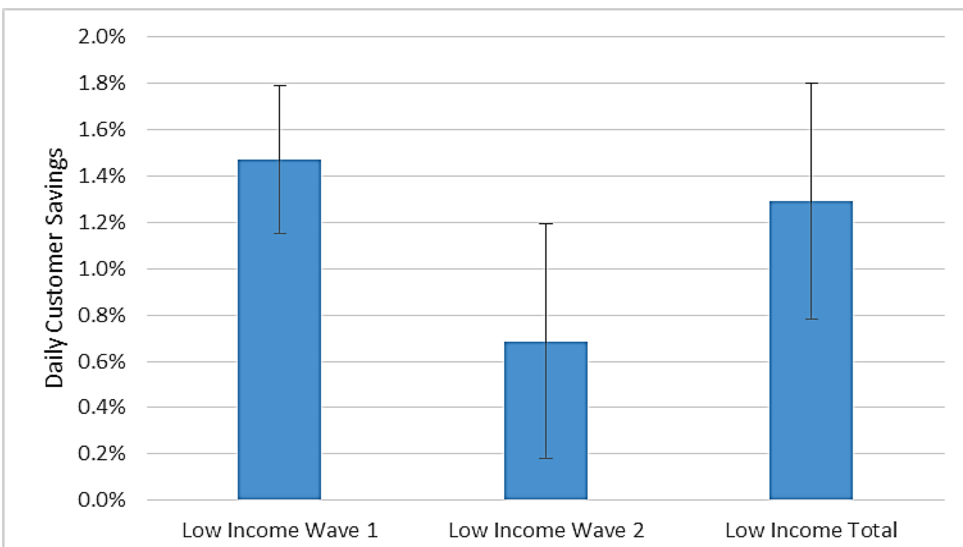
132 Cadmus defined the waves' baseline energy usage as the control group's daily mean consumption (kWh) in PY7, that is, the customers' typical consumption in the absence of the program.

**Figure 10-2: Per-Customer Daily Savings (kWh) by Wave**




The program total is the mean per-customer daily savings, weighted by the waves' sum of treatment days (sum of all days treatment group customers were active (i.e., exposed to effect of home energy reports) in PY7. The error bars represent the 85% confidence interval surrounding the point estimates.

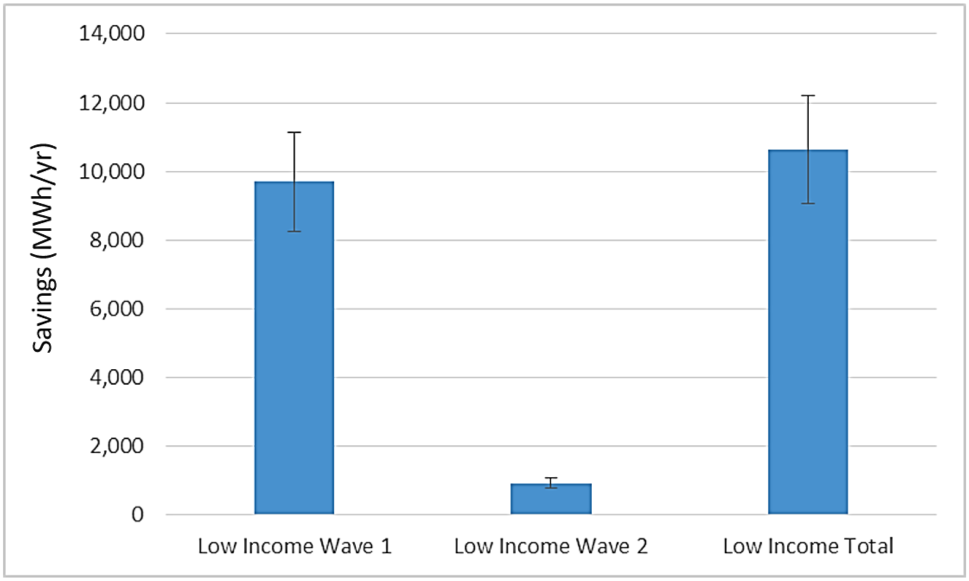
**Figure 10-3: Per-Customer Daily Savings (Percentage) by Wave**




Cadmus calculated percentage savings as the quotient of daily savings (kWh) over the baseline daily usage, defined as mean Control Group customers' daily consumption (kWh) in PY7. The program total is the mean per-customer daily savings, weighted by the waves' sum of treatment days, defined as the sum of all Treatment Group customers' number of days they were active (i.e., exposed to the treatment effect of the home energy reports) in PY7. The error bars represent the 85% confidence interval surrounding the point estimates.

Figure 10-4 shows the total PY7 *ex post* savings by wave, estimated as the product of per-customer daily savings and total number of days across customers that treatment group customers had active accounts in PY7. Again, the Low-Income Wave 1 accounted for a higher portion—more than 10 times—of the program's savings because its per-customer savings rate was higher and it had more treatment group customers.

**Figure 10-4: Total Savings by Wave**




Cadmus calculated total savings by wave as the product of per-customer daily savings and total treatment days. The error bars represent the 85% confidence interval surrounding the point estimates.

Cadmus also evaluated the savings for these two waves over time to determine if there were a ramp-up trend, any seasonal effects, and any ways that savings generally persisted or decayed. The next two figures show the monthly energy savings for each wave.

Figure 10-5 shows positive energy savings after December 2014 and throughout the rest of the program in the Low-Income Wave 1, with savings increasing steadily through February 2016 then decreasing slightly. The monthly increase in savings occurred at a slower rate for this low-income wave than was observed for the residential waves, suggesting that this group of customers adopted the advice from the home energy reports at a slower, but still steady, rate.

**Figure 10-5: Low-Income Wave 1 Monthly Savings over Time**

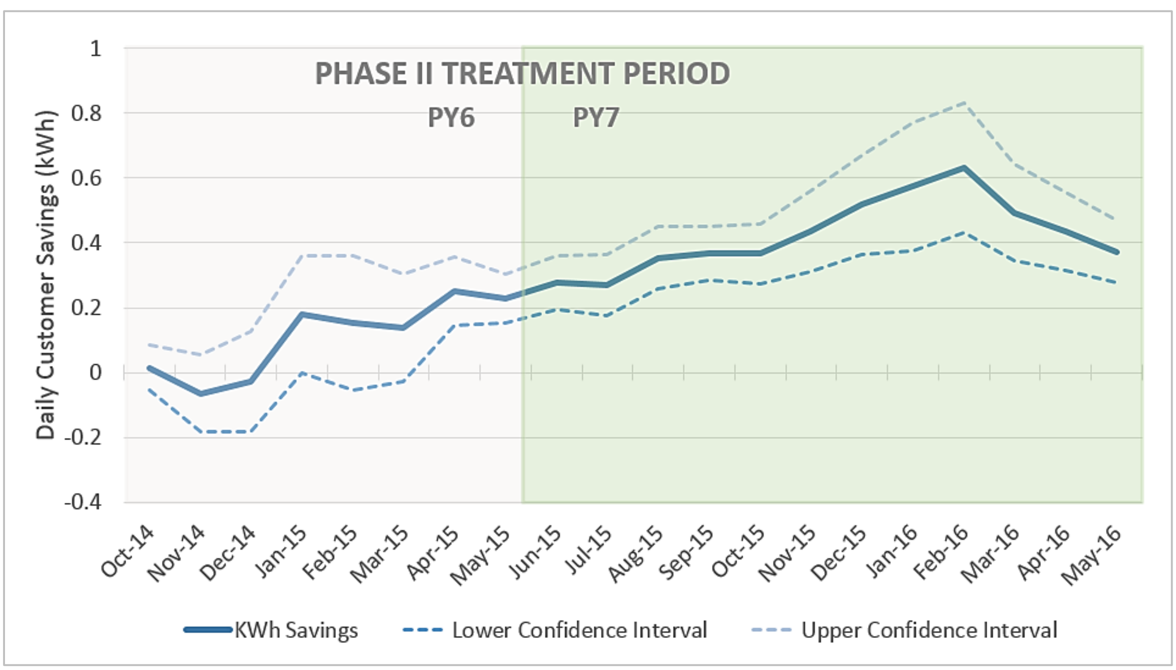


Figure 10-6 shows positive energy savings throughout the course of the Low-Income Wave 2, with savings reaching a plateau after February 2016. Similar to the first low-income wave, the monthly increase in savings was slower for Low-Income Wave 2 than it was for any of the residential waves.

**Figure 10-6: Low-Income Wave 2 Monthly Savings over Time**

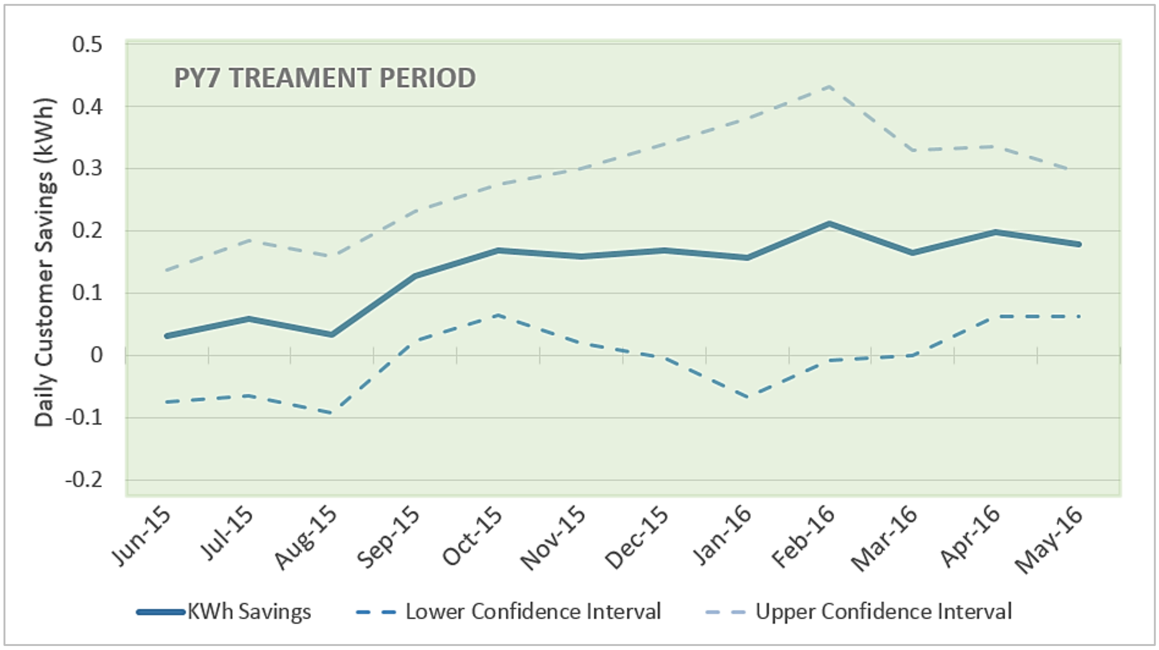



Figure 10-7 shows that the monthly increase in savings was consistent between both low-income waves; both waves appeared to have adopted the energy saving advice from the home energy reports at a slower rate than the residential waves. Trends in monthly savings were similar between waves as well. They both produced positive savings between August 2015 and October 2015, a slight decrease in savings through January 2016, and finally a slower increase in savings through the end of PY7.

**Figure 10-7: Low-Income Waves' Percentage Savings over Time: Through Calendar Months**

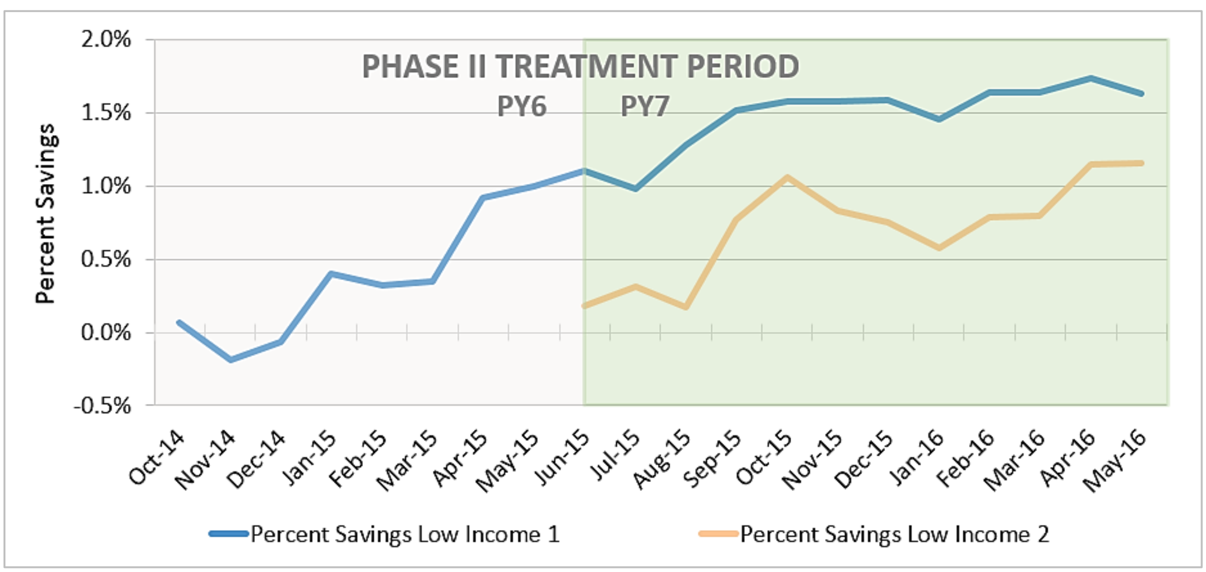
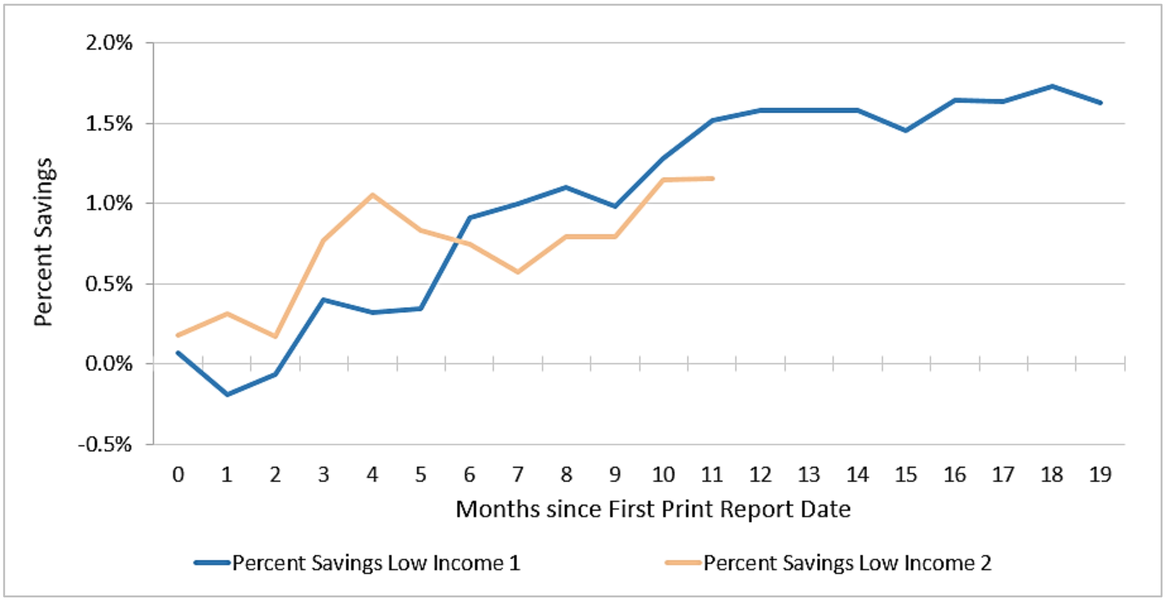


Figure 10-8 shows the ramp-up period of the two waves overlaid, starting in the first month of treatment. The increase in savings for both waves was generally gradual, although Low-Income Wave 2 appeared to suffer a decrease in the ramp-up of savings between its fourth and seventh month that the Low-Income Wave 1 did not experience.

**Figure 10-8: Low-Income Waves' Percent Savings over Time: Treatment Start Dates Aligned**




## 10.2.7.2 Demand Reduction Estimation

The ICSP reported program demand savings of 14.821 MW in PY7. Since PPL Electric Utilities did not have compliance targets for demand savings, Cadmus did not evaluate demand savings in PY7 using customers' hourly interval data, as was done in PY4.

In the PY4 evaluation, across the Residential Energy-Efficiency Behavior & Education Program's Legacy Wave 1 and Legacy Wave 2, Cadmus found an average per-customer demand reduction of 0.041 kWh/hr and 0.056 kWh/hr, respectively. These peak demand reduction values were 193% and 108% of the waves' average per-customer energy savings per hour, respectively. Assuming those ratios stay constant through time, assuming they are equally applicable to the Low-Income Energy-Efficiency Behavior & Education Program waves, and using the weighted average of these ratios (148%), Cadmus converted each wave's PY7 average energy savings into demand reductions, allowing the impacts to be scaled by the magnitude of the current program year's energy savings.

Therefore, as shown in Table 10-9, the waves' average demand reduction were 1.880 and 0.186 MW respectively, totaling 2.065 MW, for a combined realization rate of 13%.

**Table 10-9: PY7 Low-Income Energy-Efficiency Behavior & Education Program Summary of Evaluation Results for Demand [1]**

| Stratum | PYTD Reported Gross Demand Savings [1] (MW) | PYTD Adjusted *Ex Ante* Demand Savings [2] (MW) | Demand Realization Rate (%) | PYTD Verified Gross Demand Savings [3] (MW) | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Low-Income Wave 1 | - | | - | 1.880 | 0.3489 | 50.22% |
| Low-Income Wave 2 | - | | - | 0.186 | 0.5212 | 75.03% |
| Original Reported | 14.821 | 16.056 | 0% | - | N/A | 0.00% |
| **Program Total** | **14.821** | **16.056** | **13%** | **2.065** | **N/A** | **46.20%** |

[1] Reported gross demand reductions do not include the gross-up to reflect T&D losses.
[2] *Ex ante* and verified gross demand reductions include T&D losses.
[3] PY7 verified gross demand savings were derived using PY4 evaluated demand savings.

## 10.3 IMPACT EVALUATION NET SAVINGS

### 10.3.1 Net-to-Gross Ratio Methodology

Cadmus did not conduct a separate NTG savings estimate because there was no evidence of significant spillover from treatment to non-treatment homes in information feedback programs. The program savings estimates, which were based on analysis of a randomized control trial, inherently included freeridership and spillover in program homes (Table 10-10).

**Table 10-10: PY7 Low-Income Energy-Efficiency Behavior & Education Summary of Evaluation Results for NTG Research**

| Target Group or Stratum (if appropriate) | Estimated Freeridership | Estimated Participant Spillover | NTG Ratio | Observed Coefficient of Variation or Proportion | Relative Precision |
|---|---|---|---|---|---|
| Low-Income Energy-Efficiency Behavior & Education | N/A | N/A | 1.0 | N/A | N/A |

Spillover in treatment group homes would have included the adoption of energy-efficient products or behaviors other than those encouraged by the program. Because home energy reports encourage general energy conservation in addition to promoting the adoption of energy-efficient products, spillover savings in treatment group homes was not well-defined. Spillover in homes that were not participants in the Low-Income Energy-Efficiency Behavior & Education Program would have to have been from the adoption of energy-efficient products because of the influence of home energy reports, which these homes did not receive.

The regression methodology does not capture spillover from treatment to control group homes. Such spillover would have lowered the consumption of control group homes and potentially biased the Low-Income Energy-Efficiency Behavior & Education Program impact estimates downward to the extent that neighboring homes used as comparisons in the home energy reports would have to have been included in the control group. However, to date, there is no evidence that such spillover in information feedback programs was significant; therefore, Cadmus did not account for this type of spillover.

## 10.4 UPLIFT ANALYSIS

The Low-Income Energy-Efficiency Behavior & Education Program savings reflected both behavioral changes, such as turning off lights in unoccupied rooms and adjusting thermostat settings, and investments in energy-efficient products, such as high-efficiency furnaces and LEDs. In PY7, some customers who installed efficiency measures because of home energy reports may have received rebates from PPL Electric Utilities for installing the measures through other Act 129 programs. Customers could also have received rebates in previous program years following receipt of their first home energy report, and these efficiency products could have continued to yield savings in PY7. In these cases, savings from home energy reports and from the rebate program would be double-counted. To avoid this, Cadmus subtracted cross-participation savings from the low-income portfolio savings.

Cadmus conducted an uplift analysis to estimate the impacts of the Low-Income Energy-Efficiency Behavior & Education Program on participation in PPL Electric Utilities' residential efficiency programs and the energy savings from that participation.[133] In PY7, Cadmus updated its uplift methodology to conform to the Phase III Evaluation Framework.[134] This new method did not conflict with the method described in the Phase II Evaluation Framework but was useful because Cadmus could look not only at cross-program participation in PY7 but could also compare these data to all Low-Income Energy-Efficiency Behavior & Education Program treatment and control group customers starting with the launch of the first low-income wave in October of PY6.

### 10.4.1 Participation Uplift

Cadmus defined participation uplift as the effect of the program on the participation rate of other PPL Electric Utilities efficiency programs. The baseline participation rate captured the business-as-usual effect of marketing and word-of-mouth impacts on customers' participation in other PPL Electric Utilities' Act 129 programs in the absence of the Low-Income Energy-Efficiency Behavior & Education Program's effects. This baseline participation rate was defined as the number of control group customers who participated in at least one other Act 129 program in PY7 divided by the total number of control group customers. If this cross-program participation rate was greater for treatment group customers, then the home energy reports had an additive effect in encouraging these treatment group customers to participate in the other programs, and therefore participation uplift would be positive and vice versa.

Table 10-11 shows the results for PY7. Low-Income Wave 1 had positive participation uplift, while Low-Income Wave 2 had negative participation uplift, meaning that for the latter, control group customers participated in other programs about 4% more frequently than did treatment group customers. On the aggregate, however, the program total participation uplift was positive at 6.2%.

133 Cadmus conducted an uplift analysis for downstream rebate programs, in which participation was tracked at the individual customer level, in EEMIS. Cadmus did not estimate the impact of the Low-Income Energy-Efficiency Behavior and Education Program on participation in upstream PPL Electric Utilities lighting programs.

134 Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs.* August 29, 2016. See section 6.1.1.8, pg 128.

**Table 10-11: Participation Uplift Summary**

| Wave | Baseline Participation Rate (per 1,000 Customers) | Participation Uplift (Treatment Effect on Participation Rate) | Percentage of Participation Uplift |
|---|---|---|---|
| Low-Income Wave 1 | 32.4 | 3.2 | 9.9% |
| Low-Income Wave 2 | 33.2 | -1.4 | -4.1% |
| **Program Total [1]** | **32.7** | **2.0** | **6.2%** |
| [1] The overall program rates are calculated as the total number of cross-program participants across the two waves divided by the total number of customers across the two waves. The percentage of participation uplift for the entire program is the overall participation uplift rate divided by the overall baseline rate. | | | |

## 10.4.2 Savings Uplift

Cadmus also calculated savings uplift to determine whether treatment group customers also *saved* more than control group customers from downstream energy efficiency program participation. Cadmus calculated savings uplift for each wave as the difference in average cross-program savings per customer between treatment group customers and control group customers multiplied by the number of treatment group customers. Savings uplift was positive if the treatment group saved more per customer in PY7 from their current or previous participation in other Act 129 programs than did the control group.

In estimating savings uplift, Cadmus accounted for measure install dates, customer account inactive dates, the weather-sensitivity of measure savings, and measure life. *Appendix G: Energy-Efficiency Behavior & Education Program Savings Counted in Other Energy-Efficiency Programs* describes the details of the uplift methodology.

In PY7, the total Low-Income Energy-Efficiency Behavior & Education Program savings from other efficiency program participation in PY7 or during other program years of Act 129 Phase I or Phase II was 223 MWh/yr (just over 2% of the Low-Income Energy-Efficiency Behavior & Education Program's PY7 *ex post* savings), as shown in Table 10-12. Cadmus subtracted these savings from the residential portfolio but not from the Low-Income Behavior & Education Program.

**Table 10-12: Savings Uplift Summary**

| Summary | Low-Income Wave 1 | Low-Income Wave 2 | Program Total |
|---|---|---|---|
| Average Uplift Savings per PY7 Treatment Customer (kWh/yr) | 39 | 18 | 34 |
| Average Uplift Savings per PY7 Control Customer (kWh/yr) | 36 | 19 | 30 |
| Cross-Program Savings Uplift Difference per PY7 Treated Customer (kWh/yr) | 4 | -1 | 3 |
| **Total Savings Uplift in PY7 (MWh/yr) [1]** | **245** | **-22** | **223** |
| **Percent of Program Savings Double Counted** | **2.5%** | **-2.3%** | **2.1%** |
| [1]Total savings uplift is the product of the uplift difference and the total number of treatment customers in PY7. | | | |

Low-Income Wave 1 saw uplift savings of about 2.5%, which was consistent with the uplift savings observed for the Residential Energy-Efficiency Behavior & Education Program. Cadmus calculated negative savings uplift of 2.3% for Low-Income Wave 2, which correlates to its negative participation rate uplift: more control group customers participated in and received savings from other rebate programs than did treatment group customers. The two low-income waves combined, however, did still result in positive savings uplift.

Though participation and savings uplift figures are both also shown in percentages, their denominators are different (i.e., they are being compared to different things), so it is challenging to directly compare and draw conclusions between the 6.2% participation uplift and the 2.1% savings uplift. They are both positive, however, which means that the additional participation in other programs caused by the home energy reports was also associated with higher levels of savings from that participation.

Cadmus deducted Low-Income Energy-Efficiency Behavior & Education Program uplift savings from the low-income portfolio savings.

## 10.5 PROCESS EVALUATION

### 10.5.1 Research Objectives

The evaluation of the program involved these research objectives:

- Assess the effectiveness of the energy efficiency and behavior program model
- Assess the level of influence the home energy reports have on customers
- Identify the energy-saving improvements and behavioral actions taken by customers in response to information provided through the home energy reports
- Determine the readership of and reception to the home energy reports
- Identify attitudes toward and barriers to saving energy and any differences between the treatment and control groups
- Evaluate customer satisfaction with the home energy reports and with PPL Electric Utilities

### 10.5.2 Evaluation Activities

In PY7, Cadmus conducted these process evaluation activities:

- Program staff and implementer interviews (n=2)
- Customer surveys (n=301)
    - Treatment group (n=151)
    - Control group (n=150)

The research activities were consistent with the evaluation plan.

### 10.5.3 Methodology

This section presents the methodology used for the process evaluation activities. Additional information on sampling details and survey attrition tables is provided in *Addendum A. Customer Survey Attrition and Final Disposition.*

#### 10.5.3.1 Program Staff and Implementer Interviews

Cadmus conducted one interview each with the PPL Electric Utilities program manager and the ICSP's program staff in January 2015. The interviews focused on program design changes, key performance indicators, implementation successes and challenges, and a general discussion of the program implementation in PY7.

#### 10.5.3.2 Customer Surveys

In February and March 2016, Cadmus administered two similar surveys over the telephone, one with treatment group customers and the other with control group customers, to correspond with the program's experimental design. Cadmus selected a stratified random sample of treatment and control group customers. The surveys asked the same questions about familiarity with energy efficiency and other PPL Electric Utilities programs, recent energy-saving improvements made, energy-saving behaviors taken, attitudes toward and barriers to energy efficiency, and satisfaction with the utility. The treatment group survey also asked questions about the content of the home energy reports. The control group survey also asked questions about awareness of energy-saving tips.

The treatment group survey also asked about the free LED bulb distributed through the Residential Retail Program to the high-energy use customers in the Low-Income Behavior & Education Program's treatment group. Cadmus stratified the sample so the survey asked only the recipients of the free LED bulbs if they had installed them. Cadmus used these data to attribute any savings for installing LED bulbs to the Residential Retail Program and remove any double-counting of such savings from the Low-Income Behavior & Education Program. (See *Appendix G: Energy-Efficiency Behavior & Education Program Savings Counted in Other Energy-Efficiency Programs* for the savings uplift methodology and the Residential Retail Program chapter for installation results.)

Potential sources of bias in the surveys include nonresponse, recall, and social desirability biases. Cadmus attempted to mitigate these sources of bias by applying random sampling and survey design and survey data collection best practices. Cadmus designed surveys that did not include leading or ambiguous questions, were not double-barreled, and provided clear interviewing and programming instructions for consistent administration across interviewers and surveys. Cadmus also attempted to reach respondents up to five times over several days, at different times of the day, and scheduled callbacks whenever possible.

#### 10.5.3.3 Survey Sampling

Cadmus used stratified random sampling that matched the program's group and wave categories. To prepare the sample frames, Cadmus divided the population first by group (treatment or control) then stratified the treatment group by LED recipient or non-recipients. Next, Cadmus removed customers ineligible for the survey according to these criteria:

- Home energy report opt-outs
- Inactive accounts
- Accounts without valid phone numbers
- Accounts with phone number entry errors
- Accounts with no home energy report date generated (indicating that reports were not sent)

After removing these ineligible customers, Cadmus randomly selected the sample frames and completed standard sample cleaning procedures as described in *Addendum A. Customer Survey Attrition and Final Disposition* and shown in Table 10-13.

#### 10.5.3.4 Survey Analysis

Cadmus applied group-level statistical weights to the survey data to reflect actual program population proportions. *(Addendum B. Weighting of Survey Data* provides the statistical weights applied to the survey analysis.) Cadmus then used a t-test to compare proportions and means to determine if statistically significant differences exist between two independent groups. Cadmus tested at the 5% ($p \leq 0.05$) and 10% ($p \leq 0.10$) significance levels. All references to significant findings in this chapter mean statistically significant findings at the 5% or 10% levels.

**Table 10-13: PY7 Low-Income Energy-Efficiency Behavior & Education Program Process Evaluation Sampling Strategy**

| Stratum | Stratum Boundaries | Population Size | Assumed Proportion or CV in Sample Design | Assumed Levels of Confidence & Precision | Target Sample Size | Number of Records Selected for Sample Frame | Achieved Sample Size | Percent of Sample Frame Contacted [1] | Evaluation Activities |
|---|---|---|---|---|---|---|---|---|---|
| PPL Electric Utilities Program and ICSP Staff | Staff | 2 | N/A | N/A | 2 | 2 | 2 | 100% | Process, program staff interview, census |
| Treatment Group | LED Recipients | 44,877 [2] | 0.5 | 90/10 | 75 | 3,294 | 76 | 46% | Process, customer survey, stratified random sample |
| | LED Non-Recipients | 49,815[2] | 0.5 | 90/10 | 75 | 3,322 | 75 | 45% | |
| Control Group | Control Group | 28,540[2] | 0.5 | 90/10 | 150 | 6,662 | 150 | 38% | Process, customer survey, stratified random sample |
| **Program Total** | | **123,234** | **N/A** | **N/A** | **302** | **13,280** | **303** | **N/A** | **N/A** |

[1] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means the percentage of the sample frame called to complete interviews.
[2] Cadmus used the total number of customers in the Treatment and Control groups at the time of the survey activity. These numbers may not match those reported in the impact analysis sections of this report due to different time periods. The impact analysis reported customer counts at the start of PY7 and at the end of PY7; the survey activity reported counts taken midway.

### 1.1.1 Achievements Against Plan

The Low-Income Energy-Efficiency Behavior & Education Program exceeded its PY7 planned MWh/yr energy savings and nearly met its planned participation (Table 10-14). At the end of PY7, the program had achieved:

- 128% of its 8,280 MWh/yr three-year planned savings
- 97% of its three-year planned participation of approximately 90,000 customers

**Table 10-14: Low-Income Energy-Efficiency Behavior & Education Program Savings**

| Unit | PY6 | | PY7 | | | PY5–PY7[1] | | |
|---|---|---|---|---|---|---|---|---|
| | Planned | Verified | Planned[2] | Verified | Percentage of Planned | Planned | Verified | Percentage of Planned |
| MWh/yr | 2,695 | - [3] | 8,280 | 10,622 | 128% | 8,280 | 10,622[4] | 128% |
| Participation[5] | 70,000 | 72,988 | 90,000 | 87,376 | 97% | 90,000 | 87,376 | 97% |

[1] The program was not delivered in PY5.
[2] PPL Electric Utilities' revised EE&C plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, Table L6, p.96. The Low-Income Energy-Efficiency Behavior & Education Program amended the participation count, which added 20,000 customers in PY7. Pennsylvania Public Utilities Commission. "Amendment Number 3 to the Act 129 Services Agreement 571809." Agreement between Opower, Inc., and PPL Electric Utilities Corporation. November 30, 2014.
[3] Cadmus did not verify savings in PY6 because the program had operated for approximately six months. Partial program year data would not have provided a sufficient billing data analysis.
[4] The expected measure life is one year. Savings are not cumulative over multiple program years.
[5] Number of households receiving home energy reports at the start of PY7.

The program had a very strong PY7 savings performance for two possible reasons:

- **Very strong savings performance from Low-Income Wave 1.** Low-Income Wave 1, which had a longer period with the home energy reports than Low-Income Wave 2, drove the large majority of program savings (90% of achieved savings). The program would have achieved its planned savings without Low-Income Wave 2.
- **Savings ramp-up expected in PY6 occurred in PY7.** Most programs that distribute home energy reports typically begin to see a rise in savings within the first six months. However, this did not occur in PY6 and, furthermore, the program's launch was delayed, therefore, experienced a shorter program year in PY6. Instead, the ramp-up of savings occurred in PY7. Interestingly, savings ramped up much slower for the low-income program compared to the residential program. Cadmus suggests that the slower ramp-up of savings for the low-income program is likely due to strong pre-existing energy-saving practices; low-income participants may have started the program already engaging with various energy-saving practices (behaviors and product adoption) as a means to save money, and any additional actions taken would be of a smaller magnitude and therefore take longer to show up in the savings.

### 10.5.4 Program Delivery

The program worked well in PY7. PPL Electric Utilities' program manager and the ICSP did not report any implementation challenges in PY7. The program delivered home energy reports to customers as planned (bimonthly) for the duration of PY7.

#### 10.5.4.1 Key Performance Indicators

In addition to the program's energy savings, PPL Electric Utilities and the ICSP monitored two key performance indicators on a monthly basis, as shown in Table 10-15. During PY7, the program sent reports to fewer than its goal of 90,000 customers because of attrition in PY6. However, this reduction in overall participants reduced the number of customer calls to the call center.

**Table 10-15: PY7 Low-Income Energy-Efficiency Behavior & Education Program Key Performance Indicators**

| Key Performance Indicator | Metric | Goal | PY7 Result |
|---|---|---|---|
| Home Energy Report Recipients | Number of home energy report recipients | Minimize attrition (opt-outs, move-outs, and inactive accounts) so that the number of report recipients does not fall below 90,000 customers | Did not achieve goal. The program experienced high attrition during PY6 largely because of inactive accounts; as a result, the program started PY7 with 87,376 report recipients. |
| Call Center (operated by ICSP) | Number of calls received to ICSP's call center, number of calls that get routed to PPL Electric Utilities, length of call time, and documentation of customer issue | No goals established even though call center metrics are tracked | Number of calls substantially decreased from PY6 |

## 10.5.5 Participant Profile

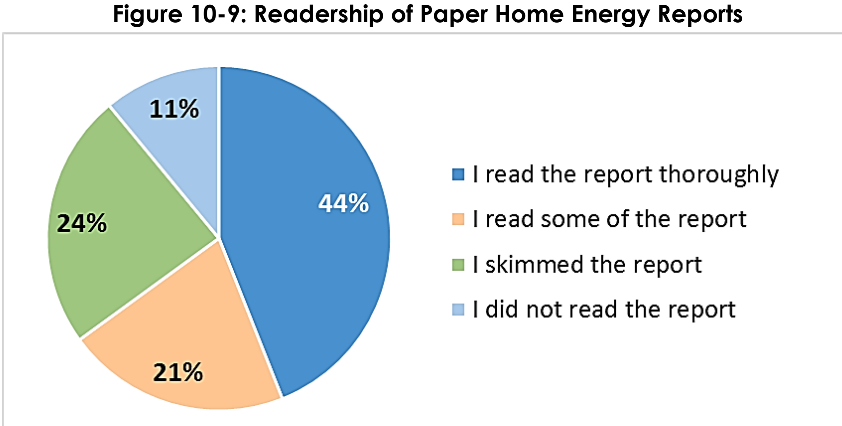
Based on the demographic data collected through the customer surveys, the majority of treatment group customers (weighted n=223) fall into these categories:

- Live in a single-family home (59%)
- Have a household size of two to three people (mean 2.4)
- Have a high school diploma, an equivalent, or less (58%)
- Are 55 years of age or older (61%)
- Have an annual household income below $50,000 (72%)

## 10.5.6 Readership of the Home Energy Reports

The customer surveys showed that 89% of treatment group respondents (weighted n=220) read, partially read, or skimmed the paper home energy reports—a lower readership level than the residential behavior program, which reported 95% (n=358) of respondents in the PY6 survey read, partially read, or skimmed the reports. Specifically, 44% of respondents from the low-income behavior program said they *read the report thoroughly,* 21% said they *read some of the report*, 24% said they *skimmed the report*, and 11% said they *did not read the report*. Figure 10-9 shows the readership level of the paper home energy reports.

**Figure 10-9: Readership of Paper Home Energy Reports**




Source: Survey question, "Which of the following statements best describes what you did with the last report you received?" (weighted n=220)

Cadmus' survey question about readership did not directly ask if the respondent had *ever* read the home energy reports; instead, the question asked what respondents did with the *last* report received. Although 11% said they had not read the last report received, it is possible they read the first, second, or third report. Therefore, respondents who said they had not read the last report received were not excluded from answering the remaining survey questions about the report. This and the survey screener, which targeted customers who were familiar with the home energy reports, ensured that survey respondents would not have difficulty answering questions.

### 10.5.7 Reception of the Home Energy Reports

The survey asked treatment group respondents to provide attitudinal ratings for three statements on a 10-point scale, where 1 meant *strongly disagree* and 10 meant *strongly agree*. On average, respondents gave these ratings to the three statements:

- 8.0 for *The reports are easy to understand* (weighted n=205)
- 7.6 for *The information in the reports is useful* (weighted n=203)
- 5.7 for *The reports get others in my household involved in saving energy* (weighted n=196)

The mean attitudinal ratings showed that respondents found the home energy reports were easy to understand and useful but did little in getting other household members involved in saving energy.

A large majority of respondents (79%; weighted n=231) remembered seeing the neighbor comparison in the home energy reports. Of the respondents who remembered seeing the neighbor comparison, they gave a mean attitudinal rating of 6.9 for the statement *I believe the neighbor comparison is accurate* (weighted n=160). Interestingly, the respondents from the low-income behavior program exhibited a significantly stronger belief in the accuracy of the neighbor comparison than the respondents from the residential behavior program who gave a mean rating of 4.8 (n=292) in the PY6 survey.[135]

### 10.5.8 Awareness of Energy Efficiency Programs

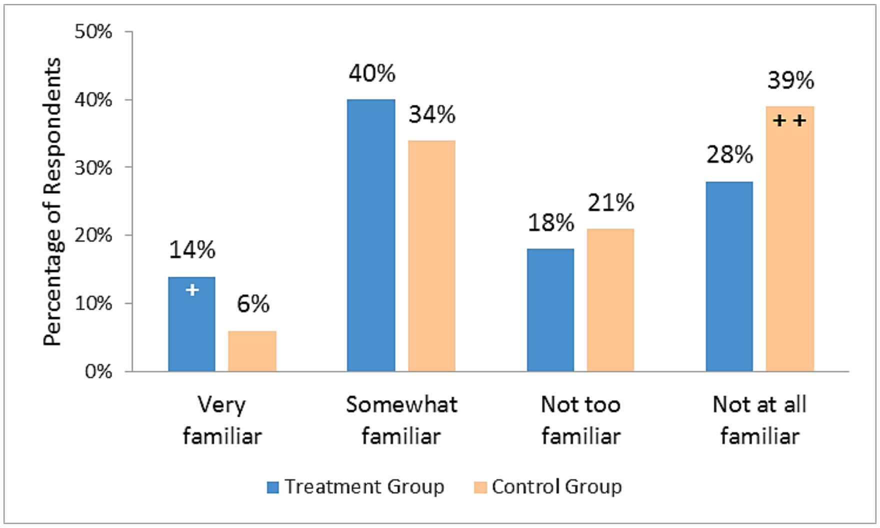
The home energy reports appeared to have influenced customers' awareness of energy efficiency programs. As shown in Figure 10-10, a significantly higher proportion of treatment group respondents (14%; weighted n=220) than control group respondents (6%; weighted n=64) reported they were *very familiar* with energy efficiency programs or rebates from PPL Electric Utilities.

A significantly higher proportion of control group respondents (39%) than treatment group respondents (28%) reported they were *not at all familiar*. Moreover, when *very familiar* and *somewhat familiar* responses were combined to represent familiar and *not too familiar* and *not at all familiar* responses were combined to represent not familiar, treatment group (54% familiar) and control group (40% familiar) still showed a significant difference. [136]

[135] Significant difference at the 5% level (p≤0.05) for 95% confidence.

[136] Significant difference at the 5% level (p≤0.05) for 95% confidence.

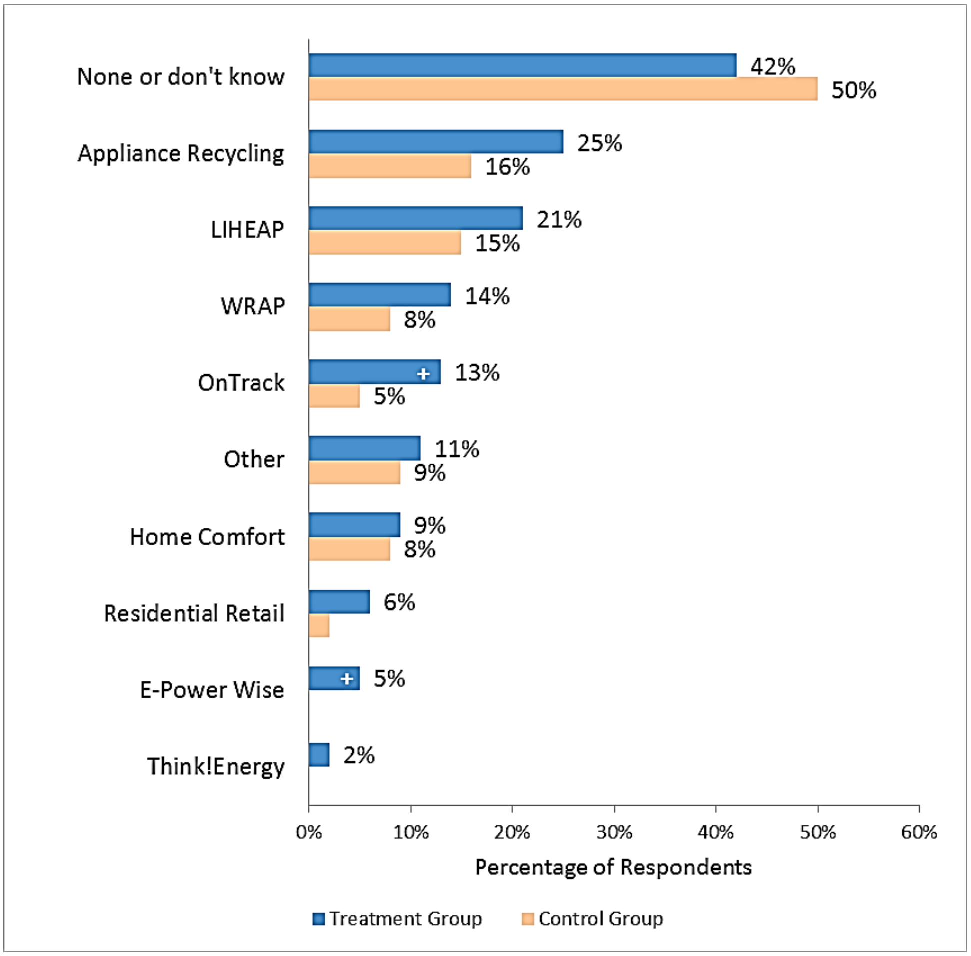
**Figure 10-10: Familiarity with Energy Efficiency Programs or Rebates**




+ Significant difference at the 10% level (p≤0.10) for 90% confidence.
++ Significant difference at the 5% level (p≤0.05) for 95% confidence.
Source: Survey question, "How familiar are you with energy efficiency rebates or programs from PPL Electric Utilities that help you with ways to use less energy? Would you say you are..." (Treatment group weighted n=220, control group weighted n=64)

When asked to name an energy efficiency program offered by PPL Electric Utilities, more treatment group respondents than control group respondents could do so. As shown in Figure 10-11, a significantly higher proportion of treatment group respondents named the OnTrack and E-Power Wise programs compared to control group respondents.

**Figure 10-11: Awareness of Energy Efficiency Programs from PPL Electric Utilities**




+ Significant difference at the 10% level (p≤0.10) for 90% confidence.
Source: Survey question, "What energy saving rebates or programs have you heard about that PPL Electric Utilities offers? [MULTIPLE RESPONSE]" (Treatment group weighted n=158, control group weighted n=39).

### 10.5.8.1 LIHEAP Module

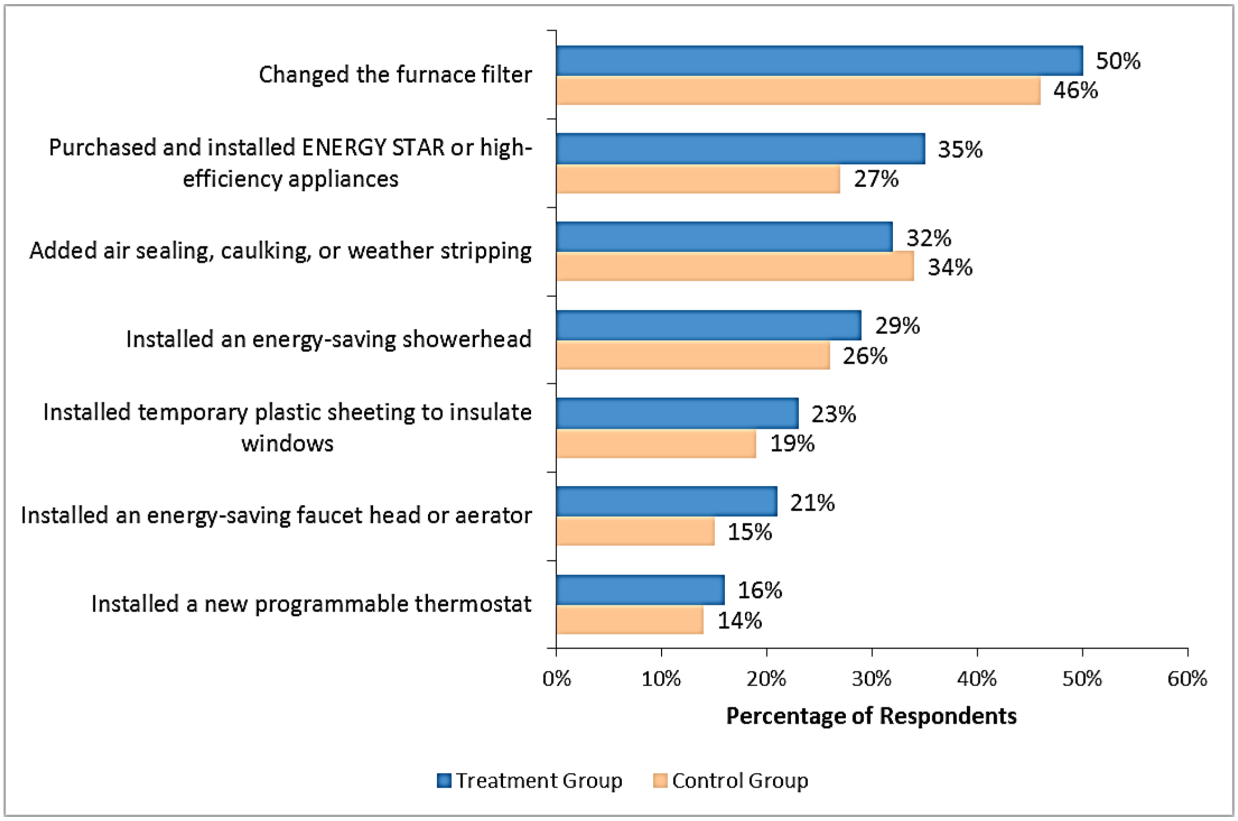
During PY7 Q2 and Q3, the home energy reports promoted LIHEAP to spur awareness and elicit participation. All treatment customers received the LIHEAP module in their home energy report (see Figure 10-1 above), even those who may have already applied to the program. Following this promotion, Cadmus expected to see a significant difference between treatment and control group in awareness of LIHEAP. Treatment group respondents showed a slightly greater ability to name LIHEAP (21%) compared to the control group (15%), but this was not a statistically significant difference.

When asked if they remembered seeing information about LIHEAP in the home energy reports, 47% of treatment group respondents (weighted n=231) said they had (*yes*). When asked if they had heard about LIHEAP for the first time through the home energy reports, 40% (weighted n=231) said they had (*yes*). A total of 94 treatment group respondents in the survey sample reported that they had applied to LIHEAP. Of these, 11% said they had applied because of the information they saw in the home energy reports.

### 10.5.9 Self-Reported Energy-Saving Improvements

Based on customer self-reports, the home energy report did not appear to have influenced customers to make energy-saving improvements. The survey asked respondents about implementing seven energy-saving improvements since the date they received the first home energy report. For all seven improvements listed in Figure 10-12, the results showed no significant differences between treatment and control group respondents. However, even though significant differences did not emerge, treatment group respondents nonetheless tended to have higher implementation rates than control group respondents for six out of the seven improvements.

**Figure 10-12: Self-Reported Energy-Saving Improvements**



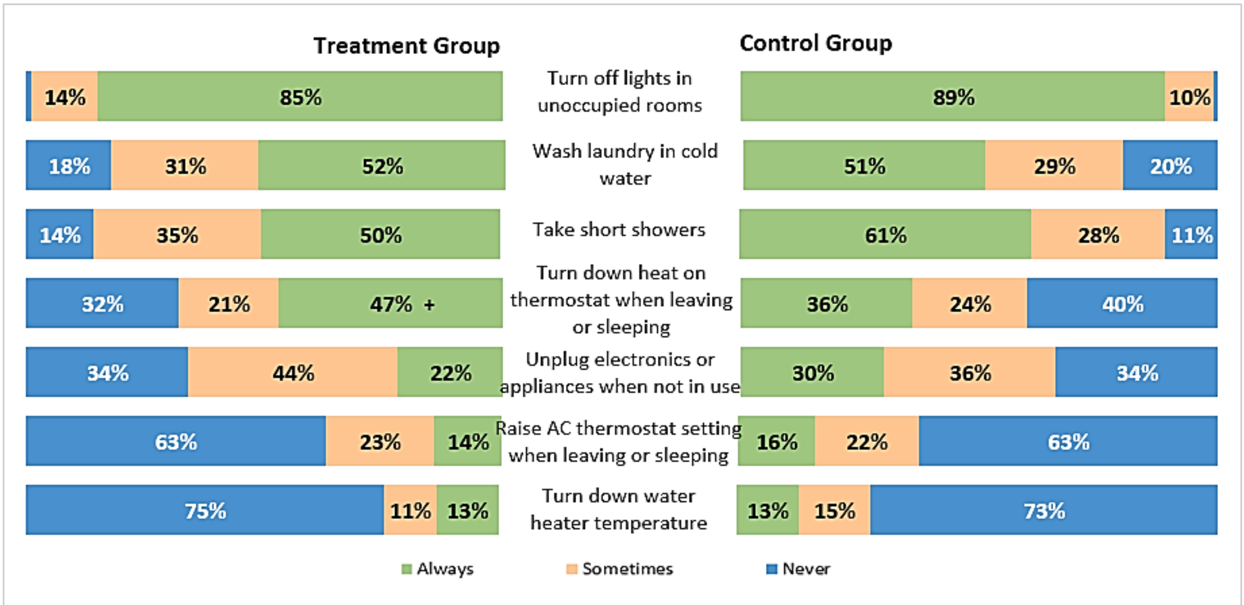

Source: Survey question, "Now I would like to understand more about some of the things you might have done to save energy in your home. I will read you a list of energy-saving improvements. Tell me if you have done any of the following in your home since [DATE]." (Treatment group weighted n=183, control group weighted n=52)

### 10.5.10 Energy-Saving Behaviors

Survey data indicated that the home energy reports had some influence on customers to take energy-saving behaviors more frequently. The survey asked respondents how often they took the seven common energy-saving actions shown in Figure 10-13. Overall, treatment and control group respondents reported similar frequencies, with only one statistically significant difference.

A significantly higher proportion of treatment group respondents (47%; weighted n=206) than control group respondents (36%; weighted n=57) reported always turning down the heating thermostat temperature when leaving or sleeping. Because the home energy reports had featured the module Winter of 68 (a behavioral action of lowering the thermostat to 68 degrees during the winter), Cadmus expected to see a significant difference between treatment and control group for this particular behavior.

**Figure 10-13: Frequency of Taking Energy-Saving Behaviors**




+ Significant difference at the 10% level (p≤0.10) for 90% confidence.
Source: Survey question, "I will read through some energy-saving actions you may have heard or read about. Please let me know if you always, sometimes, or never have taken these actions in your home." (Treatment Group weighted n=206, Control Group weighted n=57)

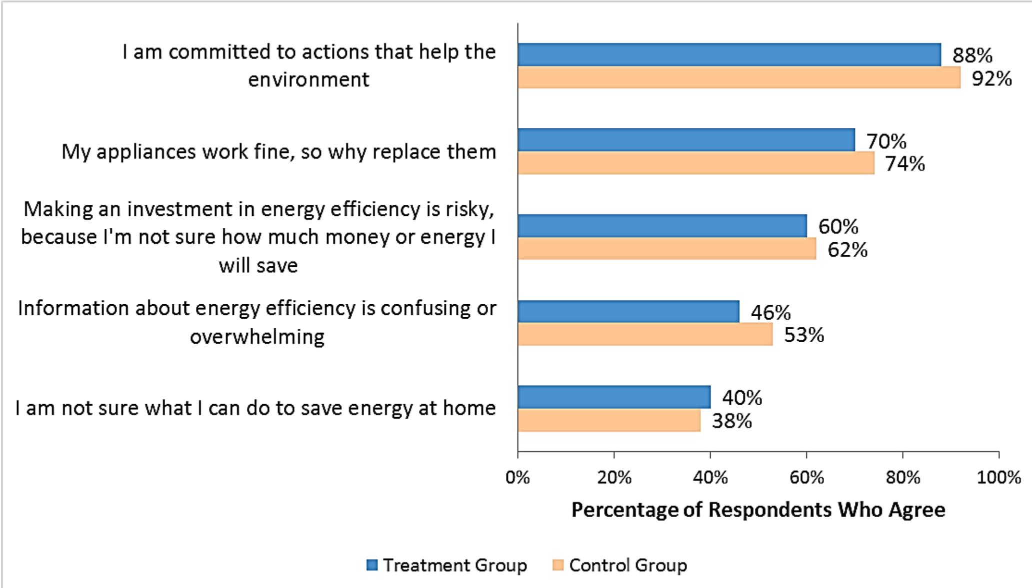
#### 10.5.10.1 Winter of 68 Module

During PY7 Q2 and Q3, the home energy reports featured a specific behavioral action module called Winter of 68 (Figure 10-1 above). When asked if they had remembered seeing information about Winter of 68 in the home energy reports, 59% of treatment group respondents (weighted n=231) said they had (*yes*). Of these (weighted n=130), 29% reported turning down their thermostat to 68 degrees after seeing the information, and 23% said they had already set their thermostat to 68 degrees. However, 40% said they did not change the thermostat temperature.

### 10.5.11 Attitudes and Barriers

The home energy reports did not appear to have improved customers' attitude toward energy efficiency. The survey asked respondents to agree or disagree with five statements on attitudes and barriers to energy efficiency, as shown in Figure 10-14. Treatment and control group respondents showed no significant differences in their level of agreement to all five statements.

**Figure 10-14: Agreements with Statements About Energy Efficiency**



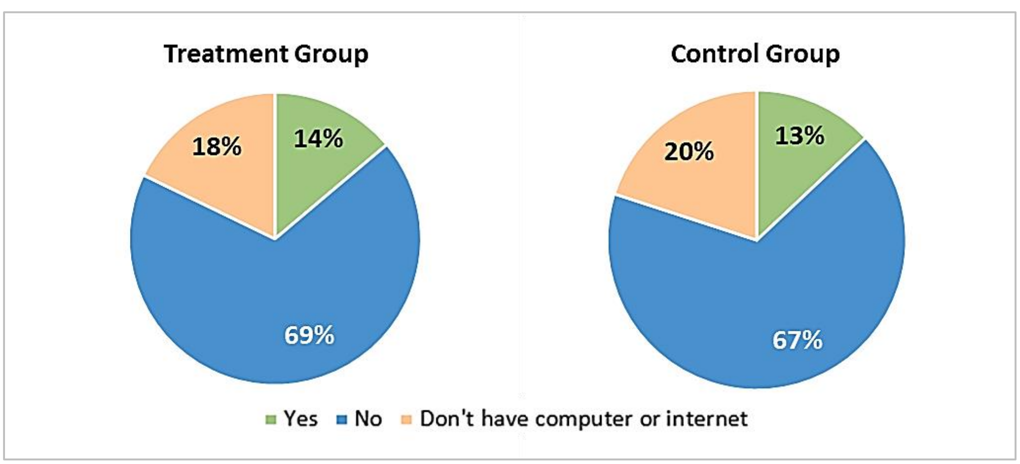

Source: Survey question, "I'm going to read a list of scenarios that people might face when purchasing new appliances or considering energy-efficient improvements to their home. Please tell me whether you agree with these statements…" (Treatment Group weighted n=207, Control Group weighted n=60)

The survey also asked respondents to rate how difficult or easy it is to save energy in the home using a 10-point scale where 1 means *extremely difficult* and 10 means *extremely easy*. Treatment and control group respondents did not significantly differ in their rating on how easy or difficult it is to save energy in their home. On average, treatment group respondents gave a mean rating of 7.0 (weighted n=217) and control group respondents gave a mean rating of 6.9 (weighted n=63).

### 10.5.12 Online Engagement

Treatment and control group respondents did not significantly differ in reported visits to PPL Electric Utilities' website to look for ways to save money on their electric bill. As shown in Figure 10-15, 14% of treatment group respondents (weighted n=231) and 13% of control group respondents (weighted n=69) visited the utility website. In general, few low-income respondents reported visiting the utility website.

**Figure 10-15: Visits to PPL Electric Utilities' Website**




Source: Survey question, "Have you ever visited the PPL Electric Utilities website to look for ways to save money on your electric bill?" (Treatment Group weighted n=231, Control Group weighted n=69)

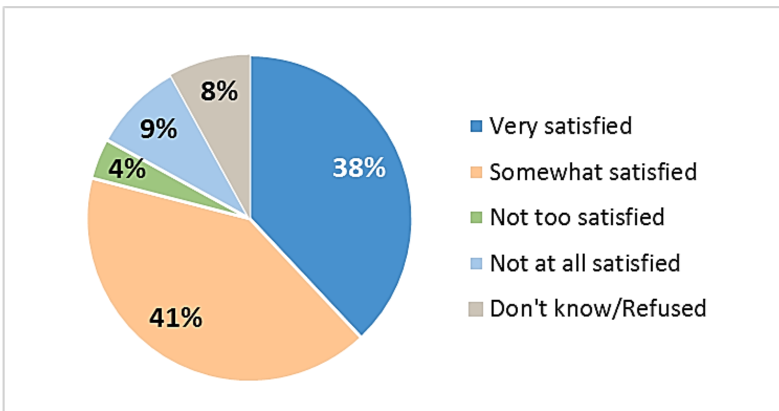
Notably, a significantly lower proportion of low-income treatment and control respondents reported visiting the utility website (14%; n=300) than the residential respondents from the PY6 survey (32%; n=536).[137] Access to the Internet appeared to have been a barrier for low-income customers as Figure 10-15 shows that about 19% of respondents did not have a computer or Internet. Moreover, 55% of low-income respondents (n=235) agreed in general with the statement *my access to the Internet is very limited at home.*

## 10.5.13 Satisfaction

### 10.5.13.1 Satisfaction with Home Energy Reports

As shown in Figure 10-16, 38% of treatment group respondents reported they were *very satisfied* with the home energy reports, and 41% reported they were *somewhat satisfied* (weighted n=231). A significantly higher proportion of low-income respondents reported they were *very satisfied* (38%) compared to residential respondents in the PY6 survey (28%; n=355).[138] Because of the length of the survey, Cadmus did not include a follow-up question to capture the reasons behind satisfaction ratings that were less than *very satisfied*. One plausible explanation for greater satisfaction among low-income respondents than residential respondents was their stronger belief in the accuracy of the neighbor comparison.

**Figure 10-16: Satisfaction with Home Energy Reports**




Source: Survey question, "How satisfied are you with the Home Energy Reports? Would you say..." (Treatment Group weighted n=231)

Cadmus also found an interesting effect involving the free LED bulb giveaway. Customers who did not receive the free LED bulb showed greater satisfaction with the home energy reports than did customers who received the LED bulb. A significantly higher proportion of LED bulb non-recipients (49%; weighted n=122) reported they were *very satisfied* with the report, compared to LED bulb recipients (25%; weighted n=109).[139]

137 Significant difference at the 5% level (p≤0.05) for 95% confidence.

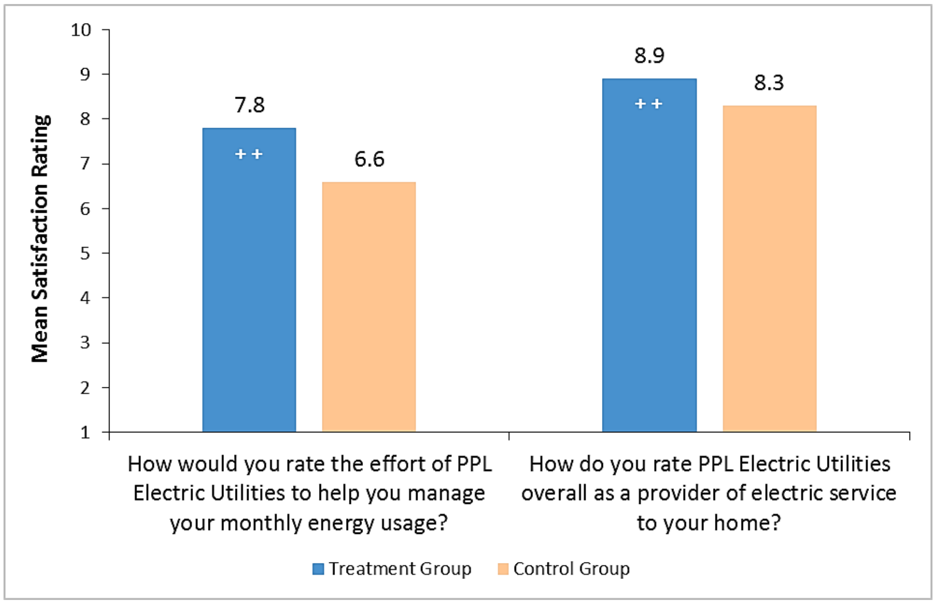
138 Significant difference at the 5% level (p≤0.05) for 95% confidence.

139 Significant difference at the 5% level (p≤0.05) for 95% confidence.

### 10.5.13.2 Satisfaction with PPL Electric Utilities

The home energy reports had a positive impact on overall customer satisfaction with PPL Electric Utilities as a service provider. As shown in Figure 10-17, treatment group respondents gave a significantly higher rating of on average 8.9 (weighted n=224) than control group respondents who gave a rating of 8.3 (weighted n=63). Moreover, 88% of treatment group respondents gave a rating of 8, 9, and 10 compared to 73% of control group respondents.

**Figure 10-17: Satisfaction with PPL Electric Utilities**




++ Significant difference at the 5% level (p≤0.05) for 95% confidence.
Source: Survey question, "Using a 10-point scale where 1 means 'unacceptable' and 10 means 'outstanding,' how would you rate the effort of PPL Electric Utilities to help you manage your monthly energy usage?" (Treatment group weighted n=219, control group weighted n=62). Question, "Using the same scale, how do you rate PPL Electric Utilities overall as a provider of electric service to your home?" (Treatment group weighted n=224, control group weighted n=63).

Again, Cadmus found that the low-income behavior program generated greater overall customer satisfaction with PPL Electric Utilities than did the residential behavior program. On average, low-income treatment group respondents gave a significantly higher rating (8.9) than the residential treatment group respondents in the PY6 survey (8.1; n=355).[140]

The PY7 survey also asked respondents to rate their satisfaction with PPL Electric Utilities' efforts to help them manage their monthly energy usage. Results showed a statistically significant difference between treatment and control group respondents' energy management satisfaction with PPL Electric Utilities. As Figure 10-17 shows, on average, treatment group respondents gave a rating of 7.8 (weighted n=219) and control group respondents gave a rating of 6.6 (weighted n=62).

Lastly, the majority of treatment group respondents (60%; weighted n=215) did not change their opinion of PPL Electric Utilities after receiving the home energy reports. For the remaining respondents, 11% reported that their opinion of PPL Electric Utilities had *improved significantly*, 26% reported their opinion

140 Significant difference at the 5% level (p≤0.05) for 95% confidence.

*improved somewhat*, 1% reported their opinion *decreased somewhat*, and 1% reported their opinion *decreased significantly*.

## 10.6 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings, Cadmus offers the following conclusions and recommendations. The new Phase III behavior program will merge the Phase II low-income and residential behavior program populations into one. (See the Residential Energy-Efficiency Behavior & Education Program chapter for additional recommendations pertaining to this program.)

**Conclusion**
The Low-Income Energy-Efficiency Behavior & Education Program exceeded its PY7 planned savings for two reasons—savings ramped up in PY7, albeit slowly, and Low-Income Wave 1 had very strong savings (see Section 10.2.1).

The savings ramp-up expected within the first six months of program launch in PY6 did not occur. The savings ramp-up was slower for the low-income behavior program compared to the residential behavior program. Cadmus suggests that the slower ramp-up of savings for the low-income program was probably because of strong pre-existing energy-saving practices; low-income participants may have started the program already engaging with various energy-saving practices (behaviors and product adoption) as a means to save money, and any additional actions taken would have been of a smaller magnitude and therefore taken longer to show up in the savings.

Low-Income Wave 1 (launched in PY6) drove 90% of the program savings, large enough that the program would still have achieved its PY7 planned savings without Low-Income Wave 2 (launched in PY7). Differences in the savings performance between the two waves may be driven by a combination of factors including the number of years customers in the wave had been receiving home energy reports and the customers' mean annual consumption before the program began (see Section 10.2.7). Low-Income Wave 1 participants had one additional year with the home energy reports compared to Low-Income Wave 2 which only had one year with the reports.

**Conclusion**
Based on survey responses, customers who received the home energy reports did not make energy-saving improvements any more than customers who did not receive the reports (see Section 10.5.9); instead, the reports appeared to have had some influence on engaging customers in targeted energy-saving behavior (see Section 10.5.10). The survey analysis showed no statistically significant differences between treatment and control group respondents on implementation rates of seven energy-saving activities. Treatment and control group respondents reported similar frequencies of making energy-saving behaviors except one particular behavior: a significantly higher proportion of treatment group respondents than control group respondents reported always turning down the heating thermostat temperature when leaving or sleeping. This significant difference could be attributed to the home energy report's *Winter of 68* module, which promoted lowering the thermostat to 68 degrees during the winter. Of the 59% of treatment group respondents who remembered seeing the Winter of 68 module, 29% said they turned down their thermostat to 68 degrees after seeing the information in the home energy reports.

**Conclusion**
The home energy reports boosted customer satisfaction with PPL Electric Utilities (see Section 10.5.13). Treatment group respondents gave a significantly higher rating (8.9) than the control group's rating (8.3) for overall satisfaction with PPL Electric Utilities. Notably, the low-income behavior program also generated a significantly higher rating for PPL Electric Utilities than did the residential behavior program (8.1).

Moreover, low-income behavior program participants exhibited greater satisfaction with the home energy reports compared to the residential behavior program participants (see Section 10.5.13.1). A significantly higher proportion of low-income respondents reported they were *very satisfied* (38%) with the home energy reports compared to residential respondents (28%). One plausible explanation was the low-income respondents' stronger belief in the accuracy of the neighbor comparison.

**Conclusion**
Fewer low-income customers may be visiting the PPL Electric Utilities website because they lack Internet access (see Section 10.5.12). A significantly lower proportion of low-income respondents reported visiting the utility website (14%) than residential respondents (32%). Access to the Internet appears to have been a barrier for low-income customers as about 19% of respondents did not have a computer or Internet. Moreover, 55% of low-income respondents in general agreed with the statement *my access to the internet is very limited at home*.

**Recommendation**
Consider sending additional paper home energy reports and/or developing print versions of some of the digital content to send to low-income customers. The new Phase III behavior program will have several new features in addition to the home energy reports, and most of these new features will be available through digital channels. However, low-income customers will probably not be able to access digital content and, as a result, will not receive as much encouragement to save compared to customers with Internet access. The new program will need to provide alternative, non-digital ways of informing low-income customers about ways to save energy. One suggestion could be to send a monthly or seasonal letter that compiles the energy-saving challenges that appear in the weekly challenge e-mails.

**Conclusion**
Low-income and non-low-income customers have low online engagement with PPL Electric Utilities' website (see Section 10.5.12). Based on customer surveys, a large majority of low-income and non-low-income customers do not visit PPL Electric Utilities' website to look for ways to save money on their electric bill. Only 14% of low-income respondents in PY7and 32% of residential respondents in PY6 reported visiting the utility's website.

Every other month in Phase III, PPL Electric Utilities will send paper home energy reports encouraging customers to visit the new behavior program's web portal, which will be hosted through the utility's Customer Engagement Hub. The reports will also promote the home energy assessment that customers can complete online on the Customer Engagement Hub.

**Conclusion**
The home energy reports provided uplift in other PPL Electric Utilities programs but only for customers in Low-Income Wave 1 (see Section 10.4.1 and Section 10.4.2). Low-Income Wave 1 showed positive uplift of just over 2%, whereby treatment group customers saved more energy from other PPL Electric Utilities programs compared to control group customers. This savings uplift rate was consistent with the positive uplift of about 2% per year found in the residential waves. Low-Income Wave 2 showed negative uplift of about 11%, whereby the control group customers saved more energy than the treatment group. This negative uplift rate was largely because of the control group's participation in the Low-Income WRAP Wise Home pilot program. No treatment group customers from Low-Income Wave 2 participated in this program.

**Recommendation**
Consider using other channels besides the paper home energy reports to encourage all treatment customers (low-income and non-low-income) to visit the new Phase III program's web portal. Consider promoting the web portal through e-mail, billing statements, text message, or programs such as WRAP

and E-Power Wise. Should PPL Electric Utilities decide to try out a behavioral demand response program, it could test the use of text messaging to encourage customers to visit the portal.

**Recommendation**

Investigate whether the home energy reports convinces treatment customers (low-income and non-low-income) to visit the Customer Engagement Hub and the program's web portal and to complete the home energy assessment. Consider evaluating any resulting non-energy uplift through the Phase III survey activities.

### 10.6.1 Status of Recommendations for Program

Table 10-16 contains the status of each PY7 process recommendation made to PPL Electric Utilities.

**Table 10-16: Low-Income Energy-Efficiency Behavior & Education Program Status Report on Process and Impact Recommendations**

| Recommendations | EDC Status of Recommendation (Implemented, Being Considered, Rejected AND Explanation of Action Taken by EDC) |
|---|---|
| **Low-Income Energy-Efficiency Behavior & Education Program** | |
| Consider sending additional paper home energy reports and/or developing print versions of some of the digital content to send to low-income customers. | Implemented as part of the Phase III marketing strategy. Information targeted for low-income customers is rarely limited to a digital channel. |
| Consider using other channels (e-mail, billing statements, and programs) to encourage all treatment customers (low-income and non-low-income) to visit the new Phase III program's web portal. | Will be implemented shortly when PPL markets the portal/hub ("soft launch" was October 2016). |
| Investigate whether the home energy reports convinces treatment customers (low-income and non-low-income) to visit the Phase III Customer Engagement Hub and the program's web portal and to complete the online home energy assessment. | Will be implemented. |

## 10.7 FINANCIAL REPORTING

A breakdown of the Low-Income Energy-Efficiency Behavior & Education Program finances is presented in Table 10-17.

**Table 10-17: Summary of Low-Income Energy-Efficiency Behavior & Education Program Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs[6] ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs (Sum of rows 2 to 4) | $0 | $0 |
| 2 | EDC Incentives to Participants | $0 | $0 |
| 3 | EDC Incentives to Trade Allies | - | - |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $0 | $0 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6, 7, 8, 9, 10 ) | $385 | $1,402 |
| 6 | Design & Development | $0 | $0 |
| 7 | Administration, Management, and Technical Assistance[1] | $385 | $1,402 |
| 8 | Marketing[2] | $0 | $0 |
| 9 | EDC Evaluation Costs | $0 | $0 |
| 10 | SWE Audit Costs | $0 | $0 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | $0 | $0 |
| | | | |
| 12 | Total TRC Costs[3] (Sum of rows 1, 5 and 11) | $385 | $1,402 |
| 13 | Total NPV Lifetime Energy Benefits | $960 | $821 |
| 14 | Total NPV Lifetime Capacity Benefits | $103 | $88 |
| 15 | Total NPV O&M Saving Benefits | $0 | $0 |
| 16 | Total NPV TRC Benefits[4] | $1,062 | $908 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | 2.76 | 0.65 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.
[2] Includes the marketing CSP and marketing costs by program CSPs.
[3] Total TRC Costs includes Total EDC Costs and Participant Costs.
[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.
[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[6] Phase II Costs in this table are discounted back to PY5, thus will not match cumulative costs reported in the PY6 Q4 quarterly report.

# ADDENDUM A. CUSTOMER SURVEY ATTRITION AND FINAL DISPOSITION

## 10.7.1 Dialing Instructions

PPL Electric Utilities provided dialing instructions for conducting surveys. Customers cannot be contacted for a telephone survey until a year has passed since they last completed a survey (with PPL Electric Utilities or Cadmus). Telephone survey calls cannot take place on Sundays or national holidays.

Researchers called participants at different times of day and different days of the week to increase the probability of contact. Researchers attempted surveys with potential respondents up to five times each.

## 10.7.2 Sample Cleaning and Attrition

Prior to the start of survey data collection, Cadmus coordinated with PPL Electric Utilities' survey subcontractor to screen the sample and remove records of any customers who were called in the past year (whether for a Cadmus survey or a PPL Electric Utilities survey) or who requested not to be contacted again.

Duplicate records across all groups in the program were removed along with records with incomplete information. Cadmus selected all remaining records and sent them to the survey subcontractor. Table 10-18 and Table 10-19 list the total number of records submitted and the final outcome of each record for Treatment Group and Control Group, respectively.

**Table 10-18: Treatment Group Survey Sample Attrition**

| Description of Call Outcomes | LED Recipient Records | LED Non-Recipient Records |
|---|---|---|
| **Total Population (Number of Customers) [1]** | **44,877** | **49,815** |
| **Random Initial Sample Selection** | **10,125** | **10,125** |
| Removed because selected for Upstream Lighting general pop. survey | 115 | 103 |
| Removed because selected for Residential Retail program survey | 9 | 2 |
| Removed because incomplete or missing phone number | 59 | 114 |
| Removed because duplicate record | 51 | 71 |
| Removed because inactive account | 171 | 153 |
| Removed because on do not call or opt-out list | 2 | 18 |
| Removed because missing first generated date in data file[2] | 43 | 1,462 |
| Removed because completed survey in past year | 206 | 161 |
| Removed because not needed to reach survey targets | 6,161 | 4,733 |
| **Random Final Sample Selection** | **3,308** | **3,308** |
| Changed LED flag [3] | -14 | 14 |
| **Sent to Survey Subcontractor** | **3,294** | **3,322** |
| **Records Not Attempted [4]** | **1,794** | **1,822** |
| **Records Attempted** | **1,424** | **1,425** |
| Nonworking number | 194 | 217 |
| Business/wrong number | 32 | 27 |
| Refusal | 199 | 248 |
| Language barrier | 23 | 28 |
| Ineligible; PPL Electric Utilities or market research employee | 7 | 5 |
| Ineligible; no one in household familiar with reports | 26 | 61 |

| Description of Call Outcomes | LED Recipient Records | LED Non-Recipient Records |
|---|---|---|
| No answer/answering machine/phone busy | 541 | 495 |
| Nonspecific or specific callback scheduled | 381 | 325 |
| Partial complete | 21 | 19 |
| **Completed Survey** | **76** | **75** |

[1] These were the total number of customers in the Treatment Group at the time of the survey activity. These numbers may not match those reported in the impact analysis sections of this report due to different time periods. The impact analysis reported customer counts at the start of PY7 and at the end of PY7; the survey activity reported counts taken midway of PY7.
[2] A date included in the field "first generated date" confirms that the Treatment Group customer was mailed a home energy report. In some instances, the ICSP's database system did not generate a date in this field and therefore, did not mail out any home energy reports even though the customer was assigned to the Treatment Group.
[3] Customers were reassigned to Treatment Group based on LED flag status.
[4] These records were not needed because the overall survey target was reached before they were attempted.

**Table 10-19: Control Group Survey Sample Attrition**

| Description of Call Outcomes | Records |
|---|---|
| **Total Population (Number of Customers) [1]** | **28,540** |
| **Random Initial Sample Selection** | **20,250** |
| Removed because selected for Upstream Lighting general pop. survey | 231 |
| Removed because selected for Residential Retail program survey | 9 |
| Removed because incomplete or missing phone number | 186 |
| Removed because duplicate record | 114 |
| Removed because inactive | 289 |
| Removed because on do not call or opt-out list | 0 |
| Removed because missing first generated date in data file [2] | 2,183 |
| Removed because completed survey in past year | 291 |
| Removed because not needed to reach survey targets | 10,285 |
| **Sent to Survey Subcontractor** | **6,662** |
| **Records Not Attempted [3]** | **4,161** |
| **Records Attempted** | |
| Nonworking number | 349 |
| Business/wrong number | 51 |
| Refusal | 36 |
| Language barrier | 313 |
| Ineligible; PPL Electric Utilities or market research employee | 17 |
| No answer/answering machine/phone busy | 940 |
| Nonspecific or specific callback scheduled | 605 |
| Partial complete | 40 |
| **Completed Survey** | **150** |

[1] These were the total number of customers in the control group at the time of the survey activity. These numbers may not match those reported in the impact analysis sections of this report due to different time periods. The impact analysis reported customer counts at the start of PY7 and at the end of PY7; the survey activity reported counts taken midway of PY7.
[2] Control group customers are also assigned a "first generated date" even though they do not receive the home energy reports. This date, instead, acts as a way to match control group customers to treatment group customers for equivalency. Again, In some instances, the ICSP's database system did not generate a date in this field.
[3] These records were not needed because the overall survey target was reached before they were attempted.

# ADDENDUM B. WEIGHTING OF SURVEY DATA

Cadmus fielded the surveys with a target sample size of 300 completes, equally split between treatment group and control group. However, the actual population size of the treatment group is about three times larger than the control group (as shown in Table 10-20). Therefore, Cadmus calculated and applied statistical weights to the survey data to reflect the actual group population proportions. The statistical weighting also factored in the population proportions of the LED recipient stratum (LED recipients and LED non-recipients) within the treatment group. Table 10-20 also shows the statistical weights used in the survey data analysis and how the weights were calculated.

**Table 10-20: Determination of Statistical Weights for Customer Survey Data**

| Group and Stratum | Population Count [1] | Proportion of Population | Survey Sample Achieved | Proportion of Survey Sample | Statistical Weight [2] |
|---|---|---|---|---|---|
| Treatment Group – LED Recipients | 44,877 | 36.4% | 76 | 25.2% | 1.44 |
| Treatment Group – LED Non-Recipients | 49,815 | 40.4% | 75 | 24.9% | 1.62 |
| Control Group | 28,540 | 23.2% | 150 | 49.8% | 0.46 |
| **Total** | **123,232** | **100.0%** | **301** | **100.0%** | **N/A** |

[1] These were the total number of customers in the treatment and control groups at the time of the survey activity. These numbers may not match those reported in the impact analysis sections of this report due to different time periods. The impact analysis reported customer counts at the start of PY7 and at the end of PY7; the survey activity reported counts taken midway of PY7.

[2] The statistical weight is calculated by dividing two columns, Proportion of Population divided by Proportion of Survey Sample.

# 11 MASTER METERED LOW-INCOME MULTIFAMILY HOUSING PROGRAM

The Master Metered Low-Income Multifamily Housing (MMMF) Program targets energy efficiency improvements in master metered multifamily low-income housing buildings. Eligible multifamily buildings must have five or more residential units and be customers of PPL Electric Utilities. Tenants must also be income-eligible (meeting the low-income definition of 150% of the federal poverty level). The program targets decision-makers, that is, property owners and managers of multifamily buildings, to install energy improvements in both tenant units and common areas. MMMF Program savings are reported in the GNE sector.

The program provides a free walk-through audit of master metered multifamily buildings followed by an analysis and a report that shows the potential energy savings for installing recommended improvements, which may include direct installation and prescriptive energy efficiency equipment. Customers may also qualify for rebates offered by other PPL Electric Utilities programs to help offset the incremental costs between high-efficiency and baseline equipment.

A turnkey ICSP, SmartWatt Energy, manages the program and handles initiation, planning, and completion of customers' energy projects.

The objectives of the MMMF Program include these:

- Provide energy-saving opportunities to customers in the multifamily master metered housing segment
- Offer these customers incentives for the adoption of high-efficiency and ENERGY STAR-rated appliances, lighting equipment, and HVAC systems
- Enhance the adoption of energy-saving equipment among low-income populations within the PPL Electric Utilities service territory
- Increase the market penetration of high-efficiency technologies
- Promote other PPL Electric Utilities energy efficiency programs
- Target up to three all-electric buildings for a comprehensive building approach
- Achieve approximately 130,000 installed products through 2016, with a total reduction of approximately 6,900 MWh/yr

A summary of program metrics can be found in Table 11-1.[141]

[141] The number of Phase II participants (140) consists of 55 projects in PY7, 49 projects in PY6, and 36 projects in PY5 based on unique CSP Job numbers. However, the number of Phase II participants in the PY5 annual report was reported as 37 instead of 36 (therefore, 141 total Phase II participants) because the ICSP reported lighting and direct install equipment retrofits completed in two different quarters for the same property, using the same CSP Job number. Because these retrofits were reported in two different quarters, Cadmus counted them as distinct project participants. To avoid this confusion in PY6 and PY7, the ICSP has used a distinct CSP Job number for retrofit projects completed during different quarters, even if the retrofits were completed in the same property.

**Table 11-1: Phase II Master Metered Multifamily Summary Results**

| Program | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Net-to-Gross Ratio[1] | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) | Program Acquisition Cost[2] ($/Annual kWh) | Cost of Conserved Energy[3] (TRC $/ Lifetime kWh) | Phase II Participants |
|---|---|---|---|---|---|---|---|---|---|
| Master Metered Multifamily | 6,012 | 5,948 | 6,488 | 0.78 | 1.52 | $2,172 | $0.33 | $0.056 | 141 |
| **Total** | **6,012** | **5,948** | **6,488** | **0.78** | **1.52** | **$2,172** | **$0.33** | **$0.056** | **141** |

[1] Cadmus did not calculate a NTG ratio for PY7. This value is a weighted average of PY5 and PY6.
[2] Total EDC Costs divided by first year kWh savings.
[3] Total TRC Costs divided by levelized lifetime kWh savings.

## 11.1 PROGRAM UPDATES

The MMMF Program began offering incentives in late 2013.[142] PPL Electric Utilities projected completion of a total of 88 audits during Phase II, or an estimated 29 properties per year.[143] In PY7, the MMMF Program successfully completed 65 audits that led to 55 projects in 54 multifamily properties across PPL Electric Utilities' service territory.

Program implementation in PY7 did not change from prior years. However, starting in Q4 of PY6, PPL Electric Utilities added nursing homes as a program-eligible building type. In PY7, partly because of this change, the ICSP successfully enrolled several large projects into the program.

There were no installations of water heater tank wraps and refrigerator recycling equipment in PY7.

### 11.1.1 Definition of Participant

Participants are defined as master metered multifamily buildings located in PPL Electric Utilities' service territory and identified by unique service account numbers. The program requires that multifamily property owners and/or managers sign a participation agreement and, by working with the ICSP, complete at least one project at the property. Each individual project is assigned a unique CSP Job number. Note that one participating property can be assigned more than one CSP Job number, for example, if the ICSP returns to the same property to complete additional retrofits.

142 PPL Electric Utilities. *PPL Electric Utilities Corporation Energy Efficiency and Conservation Plan Act 129 Phase II*. Pennsylvania Public Utilities Commission. Docket Number M-2012-2334388. Compliance Filing June 5, 2015.

143 Ibid. Pg. 156.

## 11.2 IMPACT EVALUATION GROSS SAVINGS

### 11.2.1 Reported Gross Savings

Table 11-2 shows the MMMF Program reported results for Phase II by sector.

**Table 11-2: Phase II Master Metered Multifamily Reported Results by Customer Sector**

| Sector | Phase II Participants | Phase II Reported Gross Impact (MWh/yr) | Phase II Reported Gross Demand Reduction (MW) | Incentives ($1,000) |
|---|---|---|---|---|
| Residential | - | - | - | - |
| Low-Income | - | - | - | - |
| Small Commercial and Industrial | - | - | - | - |
| Large Commercial and Industrial | - | - | - | - |
| Government/Nonprofit/Education | 141 | 6,012 | 0.69 | $872 |
| **Phase II Total** | **141** | **6,012** | **0.69** | **$872** |

### 11.2.2 Database Review

Cadmus conducted a review of the database records for a census of PY7 MMMF Program participants to verify that EEMIS accurately captured all required project data and that the reported quantity and savings estimates were reasonable. For all common area lighting equipment, Cadmus checked the reported savings against savings calculated using the inputs recorded in EEMIS. For all direct install equipment (including those installed in tenant units and common areas), Cadmus checked the reported savings against those calculated using the associated algorithms in the 2015 Pennsylvania Technical Reference Manual (TRM).[144] Cadmus identified the *ex ante* adjustments that were needed for low-flow aerators and T8 linear fluorescent fixtures, which are explained in Section 11.2.4 Ex Ante Savings Methodology and Findings.

The EEMIS database is structured to house data about the program equipment as direct install, common area lighting, or appliance recycling. For the impact evaluation, Cadmus assigned direct install equipment reported in EEMIS to a Direct Install – Apartments or Direct Install – Common Area strata. Similarly, Cadmus assigned common area lighting equipment reported in EEMIS to the Common Area Lighting strata. Cadmus corrected the assignment of T8 linear fluorescent fixtures and LEDs reported in EEMIS as direct install in common areas to the Common Area Lighting stratum. Cadmus corrected the assignment of 24 medium screw base LEDs installed in 12 apartments reported as common area lighting in EEMIS to the Direct Install - Apartments strata.

### 11.2.3 EM&V Sampling Approach

In PY7, Cadmus performed these evaluation activities:

- Reviewed the EEMIS database for the census of projects completed (n=55 projects)
- Reviewed the ICSP project records for projects selected for site visits (n=20 projects), as described below

144 Pennsylvania Public Utility Commission. *2015 Pennsylvania Technical Reference Manual.* June 2015.

- Conducted site visits to 20 projects completed in Q1 (n=10), Q2 (n=6), Q3 (n=2), and Q4 (n=2)

Cadmus completed verification site visits in two rounds, one after the end of Q2 and the other after the end of Q4. For its first round of verifications, given the recent addition of nursing homes to program-eligible building types, Cadmus selected all seven nursing home projects and a random sample of eight multifamily projects completed in Q1 and Q2.

During Q4, the ICSP reported that 40% of the program's total PY7 energy savings resulted primarily from retrofits in three large nursing home projects. To ensure that Cadmus achieved results with 85% confidence at 15% precision at the program level as stipulated in the evaluation framework,[145] Cadmus selected projects based on the magnitude of their reported savings in the second round of verification site visits.

Cadmus estimated it would require a verification sample size of 19 projects in PY7 to reach the stipulated levels of 85% confidence with 15% precision at the program level. Cadmus verified 20 of the 55 PY7 projects, representing 62% (1,639,872 kWh/yr) of the 2,651,648 kWh/yr reported PY7 savings. At the program level, the evaluation achieved a 10% precision at 85% confidence level of energy saving realization rates. Table 11-3 shows the summary of PY7 completed verifications by building type.

**Table 11-3: Summary of PY7 Completed Verifications by Building Type**

| Building Type | PY7 Population | | | PY7 Verification Sample | | |
|---|---|---|---|---|---|---|
| | Completed Projects | Reported kWh/yr Savings | Reported kWh/yr Savings as Percentage of Total | Completed Projects | Reported kWh/yr Savings | Reported kWh/yr Savings as Percentage of Total |
| Multifamily | 41 | 799,652 | 30% | 10 | 328,884 | 20% |
| Nursing Home | 14 | 1,851,996 | 70% | 10 | 1,310,988 | 80% |
| **Total** | **55** | **2,651,648** | **100%** | **20** | **1,639,872** | **100%** |

In these projects, Cadmus verified:

- A sample of lighting and direct install products installed in building common areas (e.g., hallways, stairwells, laundry rooms) and on the exterior of the building (on the building structure and in adjacent areas such as parking lots).
- All direct install products installed in a sample of tenant units, which included screw-in LEDs, T8 fixtures, low-flow bath and kitchen aerators, low-flow showerheads, and thermostatic shower restriction valves.

Cadmus selected its sample of apartments or common area lighting equipment in each building to achieve results with 90% confidence at 20% precision as stipulated in the Evaluation Framework.[146] The sampling strategy for the MMMF Program is shown in Table 11-4.

[145] GDS Associates, Inc. et al. *Evaluation Framework, For Pennsylvania Act 129 Phase II Energy Efficiency and Conservation Programs.* July 14, 2015.

[146] Ibid.

**Table 11-4: PY7 Master Metered Multifamily Impact Sampling Strategy**

| Stratum | Population Size | Target Levels of Confidence & Precision | Target Sample Size | Achieved Sample Size | Evaluation Activity |
|---|---|---|---|---|---|
| EEMIS Database[1] | 55 (projects) | All available | 55 | All available | Database review |
| Projects[1] | 55 (projects) | 85/15 | 19 | 20 | Site visits |
| Common Area Lighting [2] | 2,596 (unique records in EEMIS) | 90/20 | 403 | 403 | Site visits |
| Direct Install-Common Area [2] | 32 (unique records in EEMIS) | 90/20 | 19 | 19 | Site visits |
| Direct Install – Apartments [3] | 938 (apartments) | 90/20 | 144 | 144 | Site visits |
| | **55 projects, 938 apartments** | | **As above, per sampling unit** | **As above, per sampling unit** | |

[1] Identified by unique CSP Job number.
[2] Identified by unique records in EEMIS, which represent unique products installed in a unique location (that may have been installed in more than one quantity).
[3] Identified by unique unit numbers within each CSP Job number selected for site visits.

### 11.2.4 *Ex Ante* Savings Methodology and Findings

Cadmus adjusted the reported savings from EEMIS to align with assumptions specified in the 2015 Pennsylvania TRM. These adjustments were made to the population and account for differences among planning assumptions, the 2015 Pennsylvania TRM assumptions, and specifications of the equipment. The result of these adjustments to the population are the adjusted *ex ante* savings used in the equation to determine the program's realization rate.

Cadmus provided *ex ante* adjusted energy and demand savings for all low-flow aerators (kitchen and bath) and T8 linear fluorescent fixtures installed in tenant units:

- **Kitchen and bath aerators.** The ICSP used a placeholder value for kitchen and bath faucet aerators. Cadmus calculated the *ex ante* adjusted savings for 1.5-gpm bath and kitchen low-flow aerators according to the 2015 Pennsylvania TRM section 2.3.9 low-flow aerators and the product specifications provided by the ICSP for installed aerators.
- **T8 linear florescent fixtures.** The ICSP had calculated the savings for all T8 fixtures according to Table 3-6 of the 2015 Pennsylvania TRM section 3.1.1 Lighting Fixture Improvements, (Multi-Family (Common Areas) – High-rise & Low-rise), including common areas and fixtures installed in tenant units. The residential areas required *ex ante* adjusted savings using residential factors specified in 2015 Pennsylvania TRM section 2.1.1 ENERGY STAR Lighting for Indoor CFL Fixture (hard-wired, pin-based).

All 2015 Pennsylvania TRM *ex ante* adjustments to reported savings in PY7 are summarized in Table 11-5.

**Table 11-5: PY7 Summary of 2015 Pennsylvania TRM Ex Ante Adjustments to Reported Savings**

| Stratum | Equipment Type | Factors | Reported Savings | Adjusted Savings |
|---|---|---|---|---|
| **Direct Install – Apartments** | Bath aerators | Adjustment to calculate according to 2015 Pennsylvania TRM | 1.5 gpm aerator:<br>30 kWh/yr<br>0.0041 kW | 1.5 gpm aerator:<br>31.64 kWh/yr<br>0.0042 kW |
| | Kitchen aerators | Adjustment to calculate according to 2015 Pennsylvania TRM | 1.5 gpm aerator:<br>148 kWh/yr<br>0.0199 kW | 1.5 gpm aerator:<br>154.54 kWh/yr<br>0.0207 kW |
| | T8 linear fluorescent fixtures | Adjustment to calculate according to the HOU, coincidence factor, and interactive factors provided for residential retrofits in 2015 Pennsylvania TRM section 2.1.1 ENERGY STAR Lighting) | Average per fixture (to account for different fixtures and lamp quantities):<br>34.31 kWh/yr per fixture<br>0.0042 kW per fixture | Average per fixture (to account for different fixtures and lamp quantities):<br>26.04 kWh/yr per fixture<br>0.0030 kW per fixture |

## 11.2.5 *Ex Post* Savings Methodology and Findings

### 11.2.5.1 Records Review

For the sample of 20 projects selected for site visits, Cadmus compared project documentation (the ICSP Measure Report and the TRM Appendix C calculator for common area lighting products installed in the project) to the data reported in EEMIS.[147] The discrepancies found during records review were limited to the common area lighting stratum. The 2015 Pennsylvania TRM groups projects with a change in connected load of less than 20 kW and projects with a change in connected load of equal to or greater than 20 kW:[148]

- **For common area lighting projects with a change in connected load of less than 20 kW,** the 2015 Pennsylvania TRM requires a stipulated whole building annual hours of use (HOU) and coincidence factor be used for the entire facility in the 2015 TRM Appendix C Lighting Inventory Tool (Appendix C) calculations.
- **For common area lighting projects with a change in connected load of equal to or greater than 20 kW,** the 2015 Pennsylvania TRM requires the ICSP to consider usage groups instead of stipulated whole building hours, where possible. Hours of use values should be estimated for each usage group using information from facility staff interviews, posted schedules, building monitoring system (BMS), or metered data.

According to the 2015 Pennsylvania TRM reporting requirements for each group, Cadmus found the following discrepancies in the sampled projects:

- **Common area lighting projects with a change in connected load of less than 20 kW.** In nine of 20 projects, rather than using a single whole building stipulated hours of use and coincidence factor, the ICSP used 2015 Pennsylvania TRM Table 3-6 stipulated Dusk-to-Dawn / Exterior Lighting values for exterior lighting retrofits, and interior values (Nursing Home or Multi-Family (Common Areas) – High-rise & Low-rise, as applicable) for interior lighting retrofits. In each instance, Cadmus corrected this error in its verified 2015 TRM Appendix C calculations and used a single whole building hours of use and coincidence factor from the 2015 Pennsylvania TRM Table 3-6 based on the building type or use. If the building type was nursing home or multifamily, but the retrofits were largely on the building

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147 Pennsylvania Public Utility Commission. *2015 Pennsylvania Technical Reference Manual:* Appendix C - Lighting Inventory Tool. June 2015.

148 Pennsylvania Public Utility Commission. 2015 Pennsylvania Technical Reference Manual. June 2015. PP 222-223.

exterior, Cadmus used 2015 Pennsylvania TRM Table 3-6 stipulated Dusk-to-Dawn / Exterior Lighting HOU and coincidence factor in its verified Appendix C lighting calculations.

- **Common area lighting projects with a change in connected load of equal to or greater than 20 kW.** Seven of the 20 projects selected for site visits had a change in connected load of greater than 20 kW, but the ICSP used stipulated whole building hours of use and coincidence factor. In these instances, Cadmus identified usage groups, collected hours of use during interviews with facility staff, and calculated coincidence factors for each usage groups. Cadmus reminded the ICSP about the TRM requirements after the first round of verifications, and the ICSP incorporated usage groups in its Appendix C calculations, where required, starting in PY7 Q4.

  The Appendix C calculator provided to document common area lighting savings for two of these projects did not include all of the fixtures reported in EEMIS. Cadmus included all EEMIS-reported retrofits in its verified Appendix C calculations and performed verifications accordingly.

### 11.2.5.2 Site Visits

During site visits, Cadmus verified key calculation inputs to determine verified gross savings and also collected model numbers and other information that informed but were not directly included in verified gross savings calculations.

Table 11-6 lists the number of verification site visits conducted by Cadmus and the sites with identified discrepancies. Discrepancies ranged from small items, such as the count of products installed, to products that were not functioning properly at the time of the site visit. In a few instances, the tenant had removed the product because they were dissatisfied with its performance. In other instances, tenants took a product with them when they moved.[149]

**Table 11-6: PY7 Master Metered Multifamily Summary of Site Visits**

| Program | Equipment Type | Inspection Firm | Inspections Planned | Inspections Conducted | Sites with Discrepancies from Reports | Resolution of Discrepancies |
|---|---|---|---|---|---|---|
| Master Metered Multifamily | All | EM&V CSP (Warren Energy Engineering) | 19 projects[1] | 20 projects | 20 projects | Inputs adjusted for verified savings calculation based on site-specific data |
| [1] Cadmus estimated verification sample size to reach the stipulated levels of 85% confidence with 15% precision at the program level. | | | | | | |

Table 11-7 summarizes the site visit sample attrition.

**Table 11-7: PY7 Master Metered Multifamily Site Visits Sample Attrition**

| Site Visit Sample | Count |
|---|---|
| Program Projects | 55 |
| Projects Sampled for Site Visits | 21[1] |
| Site Visits Conducted | 20 |
| [1] Includes one alternate site selected to replace an unresponsive project. | |

149 While verifying the direct-install LED measures in apartments, Cadmus found a few instances where the units were vacated by the tenant who originally received the light bulbs. Cadmus interviewed the building managers and found that when tenants move out, they generally take the LEDs with them. In these instances, consistent with the in-service rate Cadmus found for this equipment in PY6, Cadmus assumed the verified LED quantities to be equal to 95% of the reported LED quantities. This in-service rate, similar to the TRM in-service rate, does not include an adjustment for leakage, and assumes bulbs are relocated into the same or adjacent EDC service territory (2015 Pennsylvania TRM Table 2-1, Source 2).

The next sections discuss site visit findings for direct install and common area lighting equipment.

### *Direct Install Equipment*

Cadmus conducted site visits to verify that products rebated or funded by the MMMF Program were installed and operating as reported and that correct equipment-specific data were used to calculate *ex ante* savings. Discrepancies were documented and these site-specific data were used to calculate the verified gross savings. Reasons for adjustments to the reported *ex ante* savings included corrections to the variables listed in Table 11-8.

**Table 11-8: Key Information Verified on Site for Direct Install Products**

| Stratum | Equipment Type | Location | Quantity | GPM | Equipment Capacity or Size | Lamps per Fixtures | Lamp Type | Lamp Length | Watts per Lamp/Bulb | Ballast Type |
|---|---|---|---|---|---|---|---|---|---|---|
| Direct Install Apartments | LEDs | ✓ | ✓ | | | | | | ✓ | |
| | Bath aerators | ✓ | ✓ | ✓ | | | | | | |
| | Kitchen aerators | ✓ | ✓ | ✓ | | | | | | |
| | Shower heads | ✓ | ✓ | ✓ | | | | | | |
| | T8s[1] | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Thermostatic Shower Restriction Valves | ✓ | ✓ | ✓ | | | | | | |
| Direct Install – Common Area | Beverage Vending Machine Controls | ✓ | ✓ | | ✓ | | | | | |

[1] Key inputs also collected for replaced fixtures, to the extent available.

The records review and site visits to verify equipment installed in PY7 revealed slight differences between the ICSP reported in-service rate and the verified in-service rate for several projects. Table 11-9 provides the deemed 2015 Pennsylvania TRM in-service rate estimates, by equipment, used by the ICSP in the reported energy savings calculation and the in-service rate verified while on the site. As shown in Table 11-9, fewer were verified than reported.

**Table 11-9: Verified Direct Install Equipment In-Service Rates[1]**

| Stratum | Equipment Type | 2015 Pennsylvania TRM ISR | EEMIS Equipment Count Reported for All Participants [A] | EEMIS Equipment Count Reported for Sampled Apartments/ Areas [B] | Equipment Count Verified for Sampled Apartments/ Areas [C] | Verified ISR [C/B] |
|---|---|---|---|---|---|---|
| Direct Install - Apartments | Bath Aerators | 100%[2] | 20 | 10 | 10 | 100% |
| | Kitchen Aerators | 100%[2] | 31 | 8 | 8 | 100% |
| | Medium Screw Base LEDs | 97%[3] | 3,835 | 458 | 440 | 96% |
| | Showerheads | 100%[2] | 44 | 8 | 6 | 75% |
| | T8 Linear Fluorescent Fixtures | 95%[4] | 92 | 11 | 11 | 100% |
| | Thermostatic Shower Restriction Valves[3] | 100%[2] | 44 | 8 | 6 | 75% |
| Direct Install - Common Area | Beverage Vending Machine Controls | 100%[2] | 10 | 7 | 5 | 71% |
| | Medium Screw Base LEDs[5] | 97% | 111 | 70 | 68 | 97% |

[1] 2015 Pennsylvania TRM ISR values are to be used absent EDC data gathering. If no ISR is provided in the TRM, the ICSP used 100% in the reported saving calculations.
[2] No deemed ISR estimate specified in 2015 Pennsylvania TRM for this equipment.
[3] Value specified for medium screw base LEDs is according to 2015 Pennsylvania TRM, p.20.
[4] Value specified for T8 linear fluorescent lamps is based on the value listed for indoor CFL fixture (hard-wired, pin-based) on p.20 of 2015 Pennsylvania TRM.
[5] EEMIS includes 111 medium screw base LEDs as direct install equipment installed in common areas. Cadmus corrected this assignment and moved this equipment to the common area lighting stratum for the impact evaluation. Therefore, the Direct Install – Common Area strata shown in Table 11-10 and Table 11-11 do not include medium screw base LEDs.

Of note in Table 11-9 are the relatively low verified in-service rates for beverage vending machine controls, showerheads, and thermostatic shower restriction valves compared to the other equipment installed as part of the program. Two of the seven vending machine controls sampled during Cadmus' site visits were not functioning properly, resulting in a 71% in-service rate for this equipment.

Showerheads and thermostatic shower restriction valves were installed concurrently in three properties (28, 13, and three reported units of the equipment pair for a total of 44). Cadmus visited the properties that had 28 and three reported quantities of the equipment pair but was not able to access enough units in the property with 28 reported units. It visited the building with three of the equipment pairs installed and verified that all three were still in service. In total, Cadmus verified 75% (six out of eight) showerheads and thermostatic shower restriction valves reported.

### *Common Area Lighting Equipment*

Key information verified on site and used to determine gross savings for common area lighting equipment includes these:

- Building type
- Equipment location—inside or outside building (e.g., second floor storage room, parking lot)
- Equipment hours of use and coincidence factor
- Space cooling where equipment was installed
- Pre- and post-installation fixture quantity
- Pre- and post-installation fixture lamps per fixture

- Pre- and post-installation fixture lamp type
- Pre- and post-installation fixture lamp length
- Pre- and post-installation fixture watts per lamp
- Pre- and post-installation fixture ballast type
- Pre- and post-installation fixture controls

The differences between the EEMIS-reported *ex ante* savings and the verified gross savings for common area lighting equipment result from these two adjustments:

- **Retrofit-specific adjustments** made to reflect differences in equipment quantities, specifications, replaced equipment, controls, or other factors observed by Cadmus while on site.
- **Adjustments to the verified saving calculations to conform to the 2015 Pennsylvania TRM requirements.**

**Retrofit-specific adjustments.** Cadmus confirmed that the vast majority of the key project information (listed above) was correctly reported, with only slightly different quantities and types. These adjustments had a minor impact on overall verified savings for the projects reviewed.

**Adjustments to conform to 2015 Pennsylvania TRM.** To document lighting retrofit savings in nursing homes, the ICSP assumed all tenant units are part of the nursing home and subject to the requirements described in the 2015 TRM section 3.1.1 Lighting Fixture Improvements. The ICSP used Table 3-6 stipulated nursing home hours of use and coincidence factor or, for the projects where usage groups were required, the hours of use data collected during the interviews for the tenant unit usage groups.

Cadmus distinguished two categories of residential tenant units in the participating nursing homes:

- **Skilled care and personal care nursing home units.** The residents in these units are assisted with daily tasks and are often served prepared meals.
- **Independent living apartment units.** Similar to those found in retirement communities, the residents in these units live independently and receive nursing home services, as needed.

Cadmus determined that given the existence of in-unit kitchens, the retrofits performed at independent living units are considered residential retrofits and that the hours of use, coincidence factor, and interactive factors specified in the 2015 TRM section 2.1.1 ENERGY STAR Lighting are most appropriate for these spaces when calculating the verified savings. Cadmus used residential hours of use, coincidence factor, and interactive factors specified in the 2015 TRM section 2.1.1 ENERGY STAR Lighting, as applicable, to calculate the verified savings for these lighting retrofits. For linear fluorescent retrofits, Cadmus used the hours of use listed for indoor CFL fixture (hard-wired, pin-based) in 2015 Pennsylvania TRM Table 2-1 (ENERGY STAR Lighting – References).

These adjustments along with those described under Section 11.2.5.1 Records Review had the largest impact on the project verified savings, realization rates, and the program overall *ex post* savings.

### 11.2.6 Summary of Evaluation Results

Cadmus computed stratum- and program-level realization rates, *ex post* gross savings, and confidence and precision within each stratum using the following steps:

- Calculated verified savings estimates for sampled apartment or common area equipment based on a records review and site visits
- Added the *ex ante* adjusted savings estimates and verified savings estimates for sampled apartments or common areas in each building to determine project level totals

- Added the project-level *ex ante* adjusted savings estimates and verified savings estimates for each stratum to determine stratum-level *ex ante* and verified totals for sampled units
- Divided the stratum-level total verified savings by the stratum total *ex ante* adjusted savings to estimate the stratum gross saving realization rate
- Multiplied the stratum realization rate to the stratum total *ex ante* savings from the population of jobs to estimate the stratum total gross *ex post* evaluated savings

Adjustments to the key calculation inputs identified above resulted in the evaluation results summarized in Table 11-10 and Table 11-11.

**Table 11-10: PY7 Master Metered Multifamily Summary of Evaluation Results for Energy[1]**

| Stratum | PYTD Reported Gross Energy Savings (MWh/yr) | PYTD Adjusted *Ex Ante* Energy Savings (MWh/yr) | Energy Realization Rate (%) | PYTD Verified Gross Energy Savings (MWh/yr) [2] | Coefficient of Variation (Cv), Error Ratio (ER), or Proportion in Sample Design | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Multifamily - Common Area Lighting | 616 | 616 | 113% | 694 | 0.0963 | 4.79% |
| Multifamily - Direct Install - Apartments | 170 | 171 | 95% | 163 | 0.0456 | 2.84% |
| Multifamily - Direct Install - Common Areas | 13 | 13 | 54% | 7 | 0.7603 | 73.15% |
| Nursing Home - Common Area Lighting | 1,816 | 1,816 | 111% | 2,007 | 0.3016 | 15.01% |
| Nursing Home - Direct Install - Apartments | 33 | 33 | 57% | 19 | N/A | 0.00% |
| Nursing Home - Direct Install - Common Areas | 3 | 3 | 89% | 3 | N/A | N/A |
| **Program Total** | **2,652** | **2,651** | **109%** | **2,892** | **N/A** | **9.85%** |

[1] Estimates in this table refer to savings at the point of consumption. Due to line losses, savings at the point of generation are systematically larger.
[2] Adjusted *ex ante* multiplied by the realization rate will not equal verified gross energy savings due to rounding.

The relative precision for the PYTD verified gross energy savings in Multifamily – Direct Install – Common Areas is much higher than other strata. In PY7, this stratum included beverage vending machine controls exclusively.

As noted previously under Section 11.2.5.2 Site Visits, Cadmus sampled seven beverage vending machine controls in PY7: five in multifamily buildings and two in nursing homes. Two of the five controls in multifamily buildings did not function properly during the verification site visit, resulting in zero verified savings, and a large variation in the savings verified for other units in this stratum.

Cadmus verified all equipment reported under Nursing Home – Direct Install – Common Areas and therefore this stratum does not have an assigned precision. Cadmus verified that all sampled vending machine controls were functioning, but made *ex post* adjustments to the machine capacity based on on-site observations. There are no reported or verified demand savings for beverage vending machine controls; therefore, Table 11-11 includes no entries for the Direct Install – Common Areas stratum in participating nursing homes and multifamily buildings.

**Table 11-11: PY7 Master Metered Multifamily Summary of Evaluation Results for Demand**

| Stratum | PYTD Reported Gross Demand Savings [1] (MW) | PYTD Adjusted *Ex Ante* Demand Savings [2] (MW) | Demand Realization Rate (%) | PYTD Verified Gross Demand Savings [2] (MW) | Observed Coefficient of Variation (Cv), Error Ratio (ER), or Proportion in Sample Design | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Multifamily - Common Area Lighting | 0.049 | 0.052 | 145% | 0.075 | 0.3581 | 17.82% |
| Multifamily - Direct Install - Apartments | 0.018 | 0.020 | 93% | 0.018 | 0.0427 | 2.67% |
| Multifamily - Direct Install - Common Areas | - | - | N/A | - | - | - |
| Nursing Home - Common Area Lighting | 0.315 | 0.335 | 107% | 0.357 | 0.1920 | 9.56% |
| Nursing Home - Direct Install - Apartments | 0.005 | 0.005 | 31% | 0.002 | N/A | 0.00% |
| Nursing Home - Direct Install - Common Areas | - | - | N/A | - | - | - |
| **Program Total** | **0.387** | **0.411** | **110%** | **0.452** | **N/A** | **7.62%** |

[1] Reported gross demand reductions do not include the gross-up to reflect T&D losses.
[2] *Ex Ante* and Verified gross demand reductions include T&D losses.

Table 11-10 and Table 11-11 show that nursing homes played a large role in the MMMF program's PY7 achievements, and that PY7 evaluated energy and demand savings resulted primarily from lighting retrofits in common areas of multifamily and nursing home buildings (93% of evaluated energy and 95% of evaluated demand). As shown previously in Table 11-9, lighting equipment made up the majority of the equipment retrofitted in the Direct Install – Apartments stratum as well. This is consistent with the findings in previous evaluations from PY5 and PY6.

## 11.3 IMPACT EVALUATION NET SAVINGS

Cadmus met the requirement to conduct a full process evaluation in PY5 and PY6. Interview questions related to freeridership were included in process evaluation interviews conducted with building managers and decision-makers (who received the program's incentives). PPL Electric Utilities does not plan to continue this MMMF Program into Phase III. Cadmus did not conduct interviews with program decision-makers in PY7—a very hard-to-reach population—having collected data in PY5 and PY6. Additionally, with resource and budget constraints, Cadmus did not conduct interviews with decision-makers because they would not inform a Phase III program.

To report the Phase II verified net savings and Phase II verified net lifetime savings in Table 1-6, Cadmus calculated a weighted average of PY5 and PY6 NTG ratios using PY5 and PY6 rebated lighting ex post gross population savings and applied the weighted NTG ratio to PY7 rebated lighting projects.

## 11.4 PROCESS EVALUATION

### 11.4.1 Research Objectives

The purpose of the process evaluation is to assess the MMMF Program's effectiveness in generating awareness, driving participation to achieve desired savings, and disseminating information. The evaluation examines whether the program operates efficiently and effectively and assesses whether tenants of master metered multifamily buildings are satisfied with the products installed. The program also increases awareness about energy efficiency and energy-efficient equipment and appliances.

### 11.4.2 Evaluation Activities

Cadmus conducted a full process evaluation in PY6. In PY7, research activities were limited and consistent with the EM&V plan:

- Program staff and implementer interviews (n=2)
- Leave-behind tenant postcard surveys (n=44 responses received from individual building tenants)

Cadmus conducted these additional research activities:

- Analyzed results of the ICSP-administered tenant education workshop surveys at 10 buildings selected by Cadmus based on stratified random sampling for impact evaluation (n=156 responses received from individual building tenant workshop attendees)
- Reviewed building characteristic data collected by Cadmus at verification site visits during Phase II (n=50 buildings)

### 11.4.3 Methodology

#### 11.4.3.1 Process Evaluation Sampling Plan

For the process evaluation data collection activities, all records available were included in the sample frame. Cadmus analyzed all responses received from the survey or interview activities (convenience sample). Table 11-12 summarizes the survey sampling strategy for the MMMF Program for PY7.

#### 11.4.3.2 Program Staff and Implementer Interviews

Cadmus conducted telephone interviews with the PPL Electric Utilities program manager and ICSP staff at the beginning of PY7 Q4. The interviews asked questions about Cadmus' PY6 recommendations, discussed program design changes in PY7, key performance indicators, and implementation successes and challenges.

**Table 11-12: PY7 Master Metered Multifamily Program Process Evaluation Sampling Strategy**

| Stratum | Stratum Boundaries | Population Size | Assumed Proportion or $C_V$ in Sample Design | Assumed Levels of Confidence & Precision | Target Sample Size | Records Selected for Sample Frame | Achieved Sample Size | Percent of Sample Frame Contacted to Achieve Sample[1] | Used For Evaluation Activities (Impact, Process, NTG) |
|---|---|---|---|---|---|---|---|---|---|
| PPL Electric Utilities Program and ICSP Staff | Staff | 2 | N/A | N/A | 2 | 2 | 2 | 100% | Process, Program Staff Interview, Census |
| Program Participating Tenants Leave Behind Postcard | PY7 apartments | 938 apartments | N/A | N/A | As many as possible | All | 44 | 100% | Process, Leave Behind Postcard Survey, Convenience Sample |
| Tenant Education Workshop Participating Tenant Survey | PY7 apartments | 938 apartments | N/A | N/A | As many as possible | 156[2] | 156 | 100% | Process, ICSP-Administered Tenant Education Workshop Survey Results Analysis, Convenience Sample |
| Participating Buildings Characteristics Summary | Phase II projects | 141 projects | N/A | N/A | As many as possible | 60 buildings sampled for impact evaluation | 50 | 100% | Process, Building Characteristics Survey, Convenience Sample |
| **Program Total[5]** | | **938 tenant units and two staff members in PY7; 141 projects in Phase II** | | | | | **156 tenant units and two staff members in PY7; 50 projects in Phase II** | | |

[1] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means the percentage of the sample frame called to complete interviews, it does not represent the survey response rate.
[2] The survey responses were provided to Cadmus along with other data for 10 multifamily buildings selected for impact evaluation activities.

#### 11.4.3.3 Leave-Behind Tenant Postcard Surveys

The purpose of the survey was to assess tenants' satisfaction with the products installed and experience with the program. The ICSP's installation contractors left a short postcard survey during their installation visits. Cadmus' inspectors also left the same postcard survey during their verification site visits.[150] Inspectors also left behind an explanatory letter from PPL Electric Utilities asking the tenant to complete and mail the postcard. If tenants were home during the site visit, Cadmus verbally requested their participation in the survey.

Cadmus and the ICSP distributed 1,082 postcard surveys and received responses between August 2015 and August 2016.[151] A total of 44 tenants returned postcards, for a 4% response rate in PY7. By contrast, in PY6, 137 tenants completed postcards with a 14.9% response rate. Because a lower number of apartments were retrofitted in PY7 (938) compared with PY6 (2,125), the tenant responses in PY7 represented a similar proportion of the PY6 participant population. In PY7, the responses received represented 5% of the total participant population. In PY6, the responses represented 6% of the total participant population.

All returned postcard surveys were included in the analysis (a convenience sample). A few of the questions had fewer than 10 responses. The potential for response bias affecting the results is discussed with the findings (Section 11.4.7 Satisfaction).

#### 11.4.3.4 ICSP-Administered Tenant Education Workshop Satisfaction Surveys

The ICSP conducted tenant energy education workshops between June 2015 and December 2015 at all participating multifamily properties that allowed it. (In respect for the sensitivity of the occupants, some multifamily properties and most nursing home properties declined to allow an energy education workshop.) The ICSP provided workshop survey results to Cadmus for the buildings that Cadmus sampled for the PY7 impact verification. Only 10 of the multifamily projects selected for impact verification had held tenant education workshops. Three of these properties remained as alternates that were not included in the impact evaluation.

The ICSP offered food and drinks at the workshop and the opportunity for attendees to participate in a raffle for a gift card. At the end of each workshop, the ICSP passed out a satisfaction survey to collect feedback about the workshop.

A total of 156 workshop participants responded to the survey. The ICSP reported that over 2,000 tenants and residents participated in the workshops during Phase II. The workshop survey responses represent 26% of the tenant units in the sampled buildings and 8% of the entire workshop Phase II participants.[152]

Cadmus reviewed and analyzed tenant education satisfaction survey responses for all projects selected for impact evaluation verification (samples and alternates).[153] All responses for each of the 10 buildings

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[150] Cadmus selected apartments randomly inside each building, using a stratified random sampling. Within a building, the sample size was designed to meet 90% confidence and 20% precision. Refer to Section 11.2.3 EM&V Sampling Approach for further details on the sampling approach Cadmus used for impact evaluation.

[151] 938 apartments were retrofitted as part of the program. Cadmus verified 144 of these apartments. Therefore, the total number of postcards left behind was 1,082.

[152] The number of survey respondents (156) divided by the total number of apartments in the 10 buildings sampled (598) is 26%.

[153] Please refer to Section 11.2.3 EM&V Sampling Approach for further details about the impact evaluation sampling methodology.

sampled were included in the analysis (convenience sample). Given the high response rate, Cadmus does not believe there is any significant response bias in the findings.

#### 11.4.3.5 Phase II Building Characteristics Survey Review

During their verification site visits, Cadmus inspectors collected building characteristics data for 50 buildings in Phase II: 11 in PY5, 21 in PY6, and 18 in PY7. Building characteristics information was primarily for buildings that received direct install equipment in the apartments (tenant units).

Cadmus prioritized projects with higher reported energy savings for nine out of 50 impact evaluation site visits and records reviews during PY5 and PY7; however, this did not bias the survey results toward larger projects. Additionally, of the 50 buildings reviewed, nine (18%) were nursing homes that were retrofitted during PY7.

The building characteristics survey collected the following information when it could be observed or provided by the site contact:

- Year constructed
- Area
- Number of stories above grade
- Number of stories below grade
- Number of occupants
- Estimated vacancy rate
- Primary heating system and fuel source for apartments
- Primary heating system and fuel source for common areas
- Primary domestic hot water system and fuel source
- Primary cooling system and fuel source for apartments
- Primary cooling system and fuel source for common areas
- General notes

A summary of findings about year constructed, area, number of occupants, primary heating system and fuel source for apartments, primary domestic hot water system and fuel source, and primary cooling system and fuel source for apartments is discussed in Section 11.4.6 Participant Building Profile.

### 11.4.4 Achievements Against Plan

The PY7 planned program savings reflect a ramp-down of program activities, and were therefore, less than PY6 planned savings. The PY7 planned savings were 2,429 MWh/yr for energy and 0.40 MW for demand compared to the PY6 planned savings of 2,736 MWh/yr for energy and 0.45 MW for demand. Table 11-13 shows that the evaluated program savings for PY7 constituted 119% of the planned energy saving and 112% of the planned demand savings.

In PY6, PPL Electric Utilities and the ICSP realized that there were not enough buildings remaining in their qualified opportunities list to reach the program savings by the end of Phase II. In Q4 of PY6, PPL Electric Utilities extended participation eligibility to nursing homes that met all of the program eligibility requirements, waiving one requirement, i.e., the tenant units did not have self-contained kitchens and bathrooms. PPL Electric Utilities also extended program participation eligibility requirements to include common areas of non-master metered multifamily buildings. This change in program eligibility requirements was instrumental in PPL Electric Utilities meeting its PY7 planned savings.

**Table 11-13: Master Metered Low-Income Multifamily Housing Program Savings [1]**

| | PY5 Verified | PY6 Verified [1] | PY7 | | | Phase II: PY5-PY7 | | |
|---|---|---|---|---|---|---|---|---|
| | | | Planned [2] | Verified [3] | Percentage of Planned | Planned [2] | Verified [3],[4] | Percentage of Planned |
| MWh/yr | 2,039 | 1,563 | 2,429 | 2,892 | 119% | 6,885 | 6,488 | 94% |
| MW | 0.17 | 0.16 | 0.40 | 0.45 | 112% | 1.14 | 0.77 | 68% |
| Participants [5] | 37 | 49 | N/A | 55 | N/A | N/A | 141 | N/A |

[1] Cadmus updated the PY6 annual savings in PY7 to reflect savings resulting from repaired water heater tank wraps.
[2] Planned savings from PPL Electric Utilities in *PPL Electric Utilities Corporation Energy Efficiency and Conservation Plan Act 129 Phase II.* Pennsylvania Public Utilities Commission. Docket Number M-2012-2334388. Compliance Filing June 5, 2015.
[3] Verified gross demand reductions include the gross-up to reflect T&D losses.
[4] The verified annual savings are higher than the Phase II total due to expiring savings resulting from fixture removals.
[5] The number of Phase II participants in the PY5 annual report was reported as 37 instead of 36. The ICSP reported lighting and direct install equipment retrofits completed in two different quarters for the same property, using the same CSP Job number. Since these retrofits were reported in two different quarters, Cadmus counted them as distinct project participants. To avoid this confusion in PY6 and PY7, the ICSP has used a distinct CSP Job number for retrofit projects completed during different quarters, even if the retrofits were completed in the same property.

Table 11-13 also shows that the program almost met its Phase II planned savings. The total verified savings through PY7 constituted 94% of energy and 68% of Phase II energy and demand planned savings. Given a more diverse portfolio of measure installations with the same number of participants, the program might have been able to achieve its Phase II planned savings completely.

In Phase II, the program retrofits focused primarily on lighting installations, because they were easy to install and have relatively low incremental cost to participants improving common areas. Past evaluations of this program showed that building tenants also had a favorable view of the lighting, particularly the screw base LEDs. (Tenants did not have a similar favorable view of aerators, showerheads, or thermostatic restriction flow valves.)[154] In PY7, there were relatively few installations of aerators, showerheads, or thermostatic restriction flow valves, and no installations of water heater tank wraps, energy-efficient appliances, or HVAC equipment.

Whereas PPL Electric Utilities planned to target three all-electric buildings for comprehensive retrofits,[155] the ICSP did not find any opportunities for such retrofits. Stakeholders noted that the main barrier to HVAC equipment or comprehensive retrofits is the large upfront cost required of program participants to bridge the financial gap between program incentives and actual retrofit costs, including labor and equipment.

## 11.4.5 Program Delivery

In PY7, the PPL Electric Utilities program manager and the ICSP said they were pleased with the addition of program-eligible nursing homes and with the MMMF Program's progress during PY7 toward achieving the Phase II planned savings.

154 Cadmus. *Annual Report Program Year 6: June 1, 2014 – May 31, 2015.* Prepared for PPL Electric Utilities. November 16, 2015. P. 429

155 PPL Electric. *PPL Electric Utilities Corporation Energy Efficiency and Conservation Plan Act 129 Phase II.* Pennsylvania Public Utilities Commission. Docket Number M-2012-2334388. Compliance Filing June 5, 2015. P. 149.

#### 11.4.5.1 Program Updates

The most important program update in PY7 was to broaden the target audience by adding nursing homes from the GNE sector as well as continuing to serve its original audience of low-income master metered multifamily buildings.

The MMMF Program—as offered in Phase II--is not offered in Phase III. However, income-eligible residential units in master metered multifamily buildings and nursing homes will be served under the low-income Winter Relief Assistance Program (WRAP). Common areas in master metered multifamily buildings and nursing homes can qualify for the Prescriptive Equipment program. In Phase III, eligibility for master metered multifamily building eligibility under the WRAP is not restricted to GNE, which addresses Cadmus' recommendation in PY6 to remove the GNE requirement for participation.

#### 11.4.5.2 Key Performance Indicators

Aside from energy savings, PPL Electric Utilities and the ICSP internally monitor specific factors to assess how the program is performing. The metrics include customer complaints, safety violations, and tenant energy education workshops satisfaction. Table 11-14 shows these indicators with the PY7 results.

**Table 11-14: Master Metered Low-Income Multifamily Housing Program Key Performance Indicators**

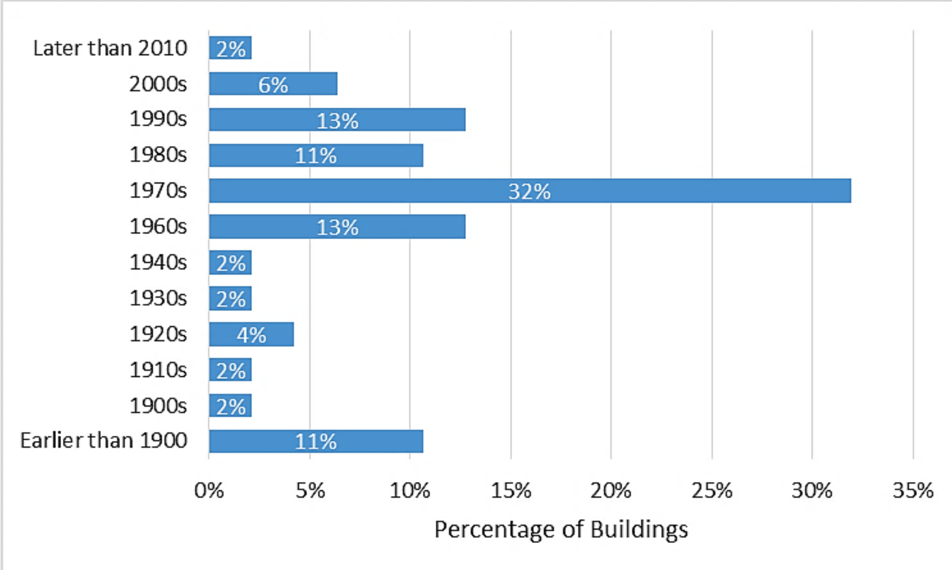
| Key Performance Indicator | Metric | Company Tracking the Metric | Goal | PY7 Results |
|---|---|---|---|---|
| Customer Complaints | Number of customer complaints about the program | PPL Electric Utilities | Low number of customer complaints | No customer complaints |
| Safety Violations | Number of safety violations for the program | PPL Electric Utilities | Zero safety violations | No safety violations |
| Tenant Energy Education Workshop Satisfaction | Level of satisfaction among tenants who attend energy education workshops | Cadmus | High satisfaction | 94% of 33 respondents were *very satisfied* |
| Tenant Energy Education Workshop Satisfaction | Level of satisfaction among tenants who attend energy education workshops | ICSP | High satisfaction | 71% of 127 respondents said the education workshop and/or handouts were very beneficial |

### 11.4.6 Participant Building Profile

Cadmus reviewed the building characteristics survey data it collected during verification activities at 50 participating properties. Certain characteristics reported here represent data for fewer than 50 buildings, because the inspector was not able to find the information during the site visit. This review about the size, age, and systems in participating buildings will help future program planners and implementers understand the participants, and to tailor program requirements, incentives, and marketing.

About one-third of the reviewed buildings were constructed during the 1970s (Figure 11-1). Five participating building were constructed in the 1800s, two of which were recently renovated.

**Figure 11-1: Master Metered Multifamily Program Participating Building Construction Year**




Source: Building Characteristic Survey Data: Year Constructed (n=47 buildings)

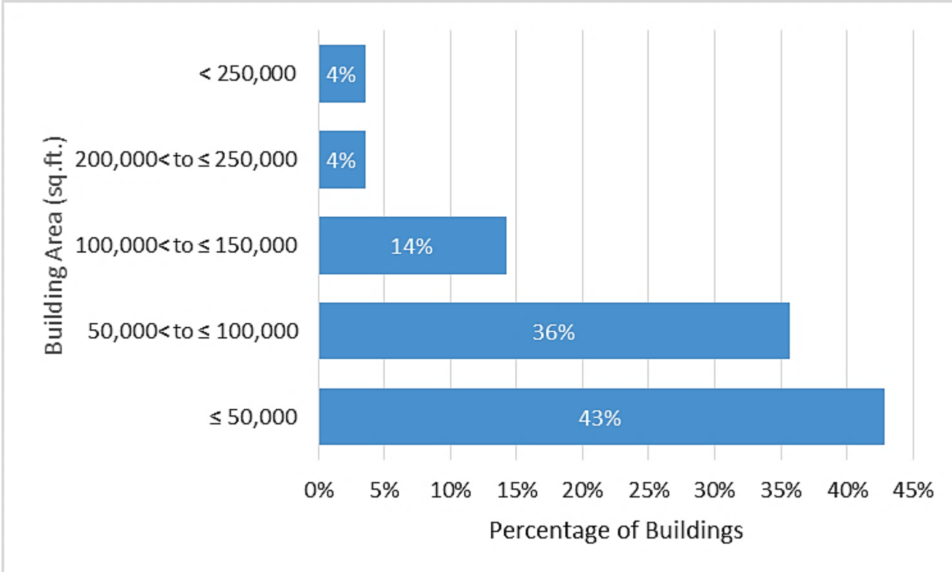
Twelve of 28, or 43%, of the buildings were less than 50,000 square feet (sq. ft.) and two were larger than 200,000 sq. ft. (Figure 11-2). Nineteen of the 50 buildings surveyed (38%) had fewer than 50 tenant units (Figure 11-3).

The most common heating systems serving the apartments were natural gas fired boilers (38%; n=50) (Figure 11-4), followed by electric heat pumps (26%; n=50). The primary cooling system serving the apartments was window air-conditioning (23%; n=40) and 20% had no air-conditioning system (n=40) (Figure 11-5). The most common domestic hot water systems were natural gas fired boilers (52%; n=50) and electric water heaters (42%; n=50) (Figure 11-6).

Note that the percentage of buildings found with electric water heaters is similar to the deemed percentage in the 2015 Pennsylvania TRM for homes with electric water heating (43%).[156]

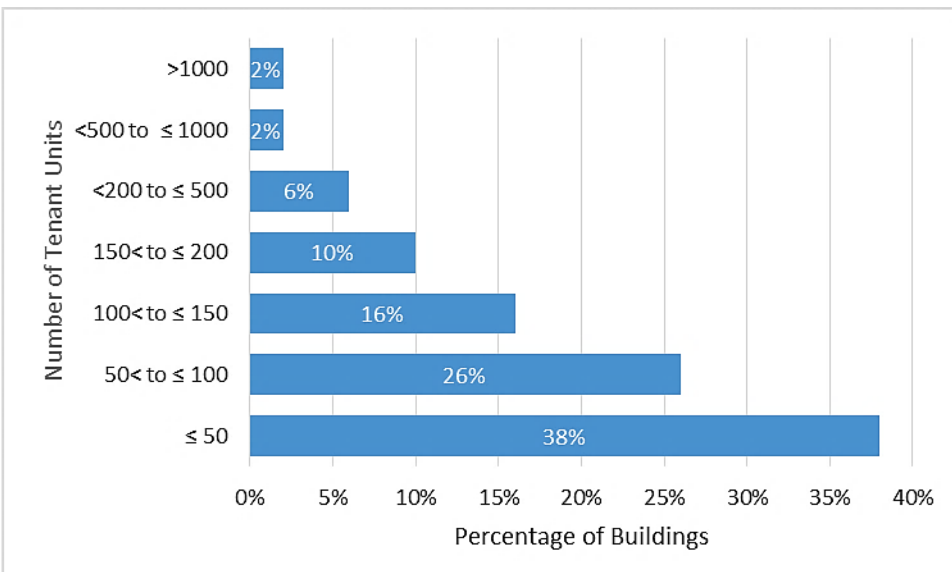
[156] Pennsylvania Public Utility Commission. *2015 Pennsylvania Technical Reference Manual*. June 2015. P. 117.

**Figure 11-2: Master Metered Multifamily Program Participating Building Area (sq. ft.)**



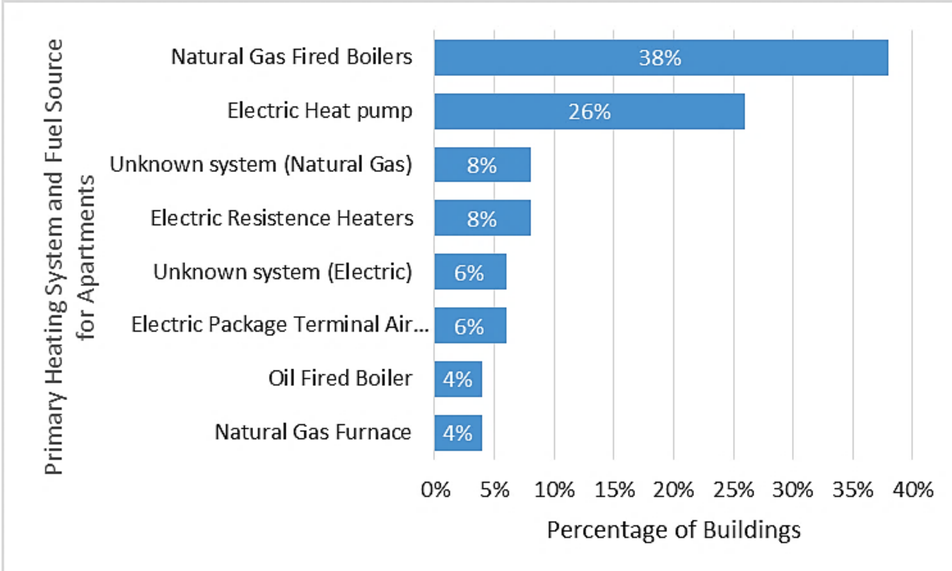

Source: Building Characteristics Survey Data: Building Area (n=28 buildings)

**Figure 11-3: Master Metered Multifamily Program Participating Building Tenant Units**



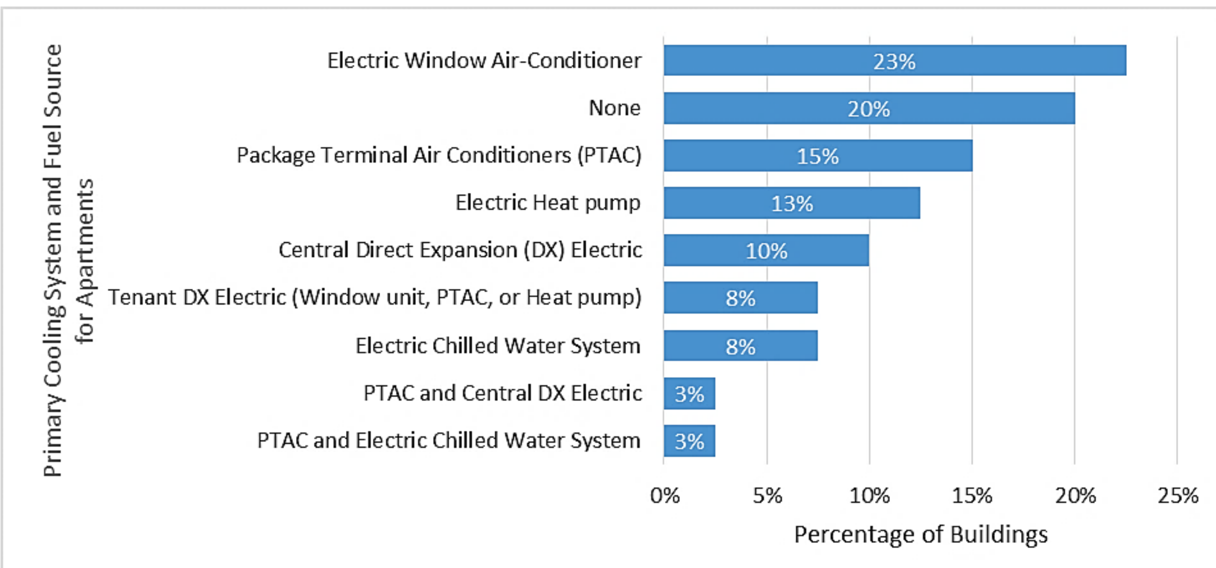

Source: Building Characteristics Survey Data: Number of Tenant Units (n=50 buildings)

**Figure 11-4: Master Metered Multifamily Program Participating Building Primary Heating System and Fuel Source for Apartments**



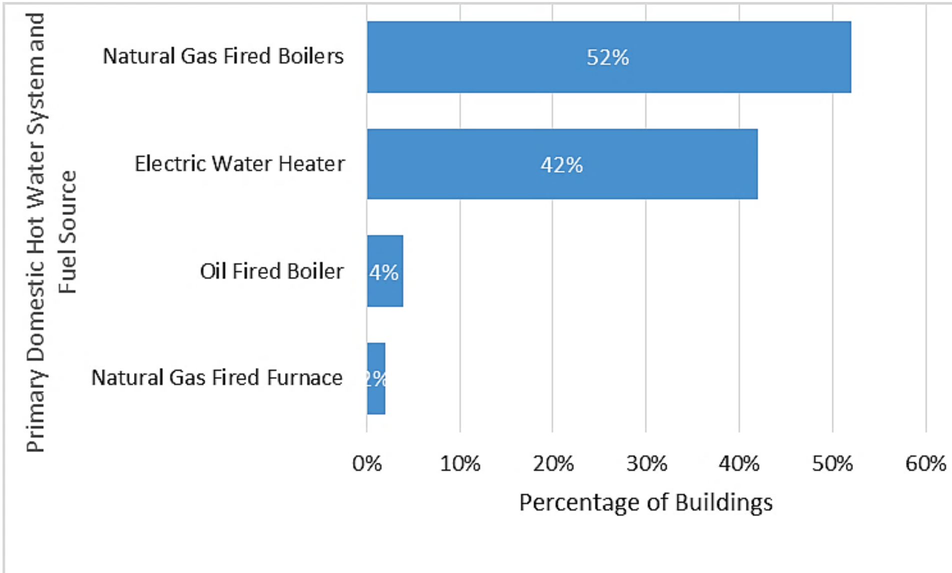

Source: Building Characteristics Data: Primary Heating System and Fuel Source for Apartments (n=50 buildings)

**Figure 11-5: Master Metered Multifamily Program Participating Building Primary Cooling System and Fuel Source for Apartments**




Source: Building Characteristics Survey Data: Primary Cooling System and Fuel Source for Apartments (n=40 buildings)

**Figure 11-6: Master Metered Multifamily Program Participating Building Primary Domestic Hot Water System and Fuel Source**




Source: Building Characteristics Survey Data: Primary Domestic Hot Water System for Buildings (n=50 buildings)

## 11.4.7 Satisfaction

### 11.4.7.1 Tenant Satisfaction

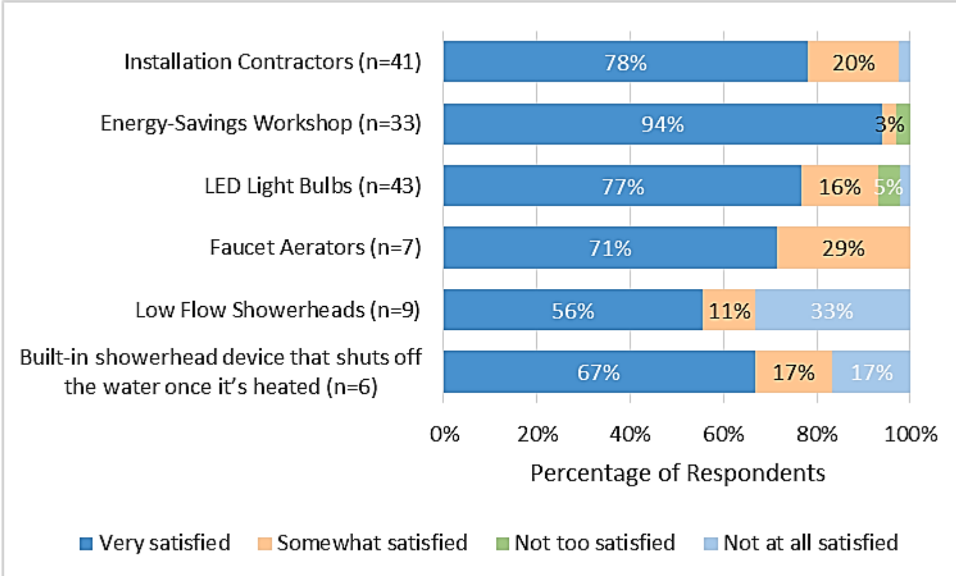
Seventy-eight percent of the tenants who responded to the leave-behind postcard survey (n=41) reported they were *very satisfied* with the installation contractors (Figure 11-7). Ninety-four percent of respondents who completed the tenant energy education workshop (n=33) said they were *very satisfied* with the workshops.

The leave-behind postcard survey asked about the respondents' satisfaction with products installed. In PY7, LEDs constituted 94% of the products installed in the apartments. Almost all respondents rated the LEDs; 77% of respondents were *very satisfied* with the LEDs (n=43).

In PY7, faucet aerators, low-flow showerheads, and the thermostatic shower restriction valves were installed in small quantities, each constituting 1% of the products installed in all treated apartments. Few respondents gave ratings—seven rated the faucet aerators, nine rated the low-flow showerheads, and six respondents rated the thermostatic shower restriction valves. The remaining survey respondents said these technologies did not apply to them.

Given the low number of responses, the satisfaction ratings are not representative of the population of tenants. Nevertheless, the responses indicated that the lowest technology satisfaction ratings were for low-flow showerheads. Three (33%; n=9) reported they were *not satisfied at all* with low-flow showerheads, while one respondent was *not satisfied at all* about the thermostatic shower restriction valve.

**Figure 11-7: Tenant Leave-Behind Survey Satisfaction Results with Program Elements and Products**



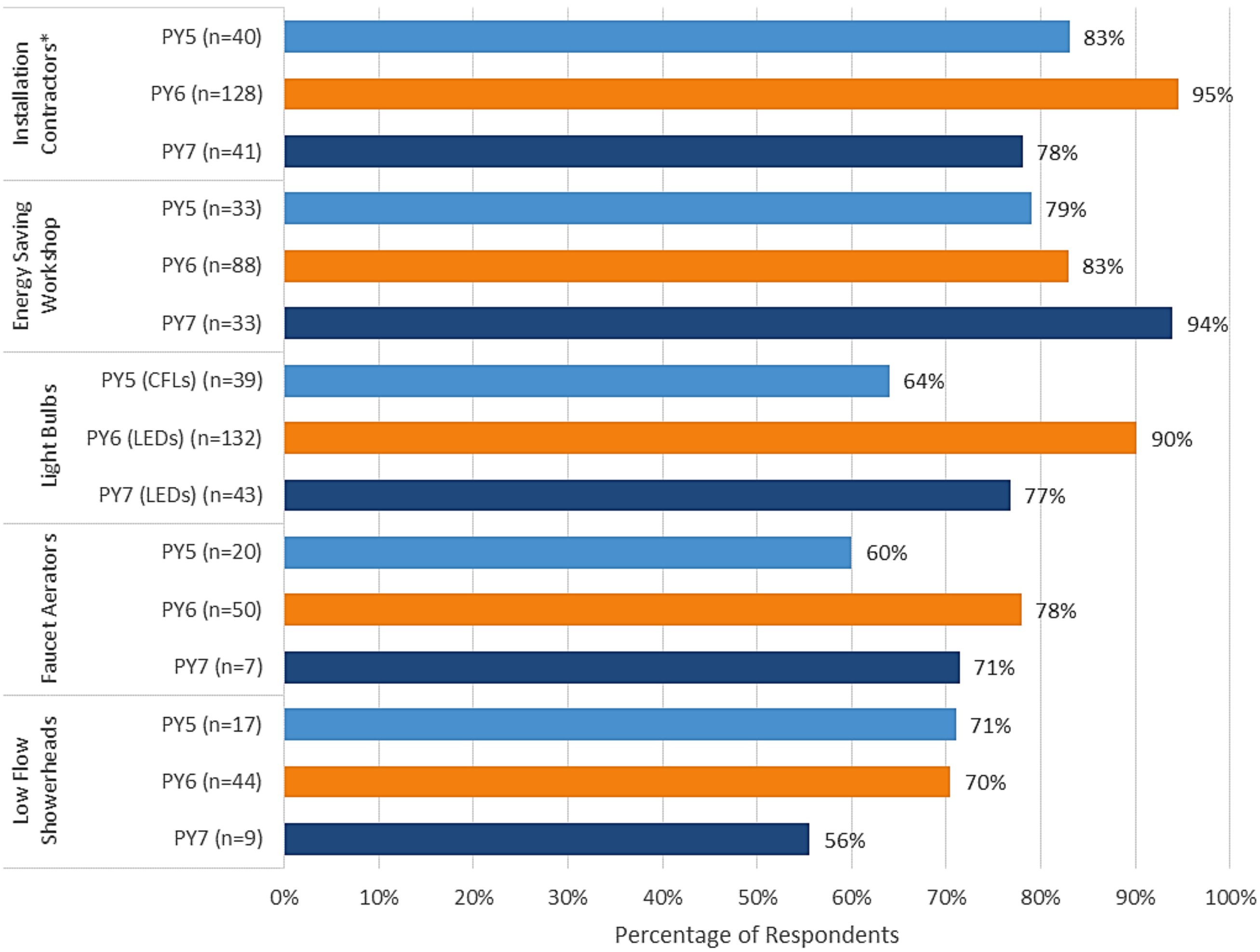

Source: Tenant Leave-Behind Postcard Survey Question 1. "How satisfied were you with…." Energy saving workshops refer to tenant education workshops. The survey referred to the thermostatic shower restriction valve as the "built-in showerhead device that shuts off the water once it's heated."

Cadmus received anecdotal feedback during its inspection site visit to one property. The facility manager stated that tenants, especially older residents with physical and mental disabilities, do not find the low-flow showerheads coupled with thermostatic shower restriction valves satisfactory. Low levels of satisfaction could lead tenants to remove the aerators and the showerheads and could explain why Cadmus found a 75% in-service rate for low-flow showerheads in PY7, a lower rate than other equipment installed in this program except for beverage vending machine controls (Table 11-9).

Figure 11-8 compares PY5, PY6, and PY7 results for respondents (tenants) who said they were *very satisfied*. In PY5, tenant participants received CFLs. In PY6 and PY7, tenant participants received LEDs. The PY6 tenant postcard survey did not include a question about the thermostatic shower restriction valve because this product was not added to the program until Q3 of PY6.

The largest decrease in satisfaction among the tenants reporting they were *very satisfied* was with the installation contractors, which fell from 95% in PY6 to 78% in PY7. This difference is significant (α=0.05). For the remaining questions, although the proportion of *very satisfied* respondents in PY7 is different than in PY6, the differences are not significant (α=0.05).

**Figure 11-8: PY5, PY6, and PY7 Tenant Leave-behind Survey Results Comparison for Very Satisfied Respondents**



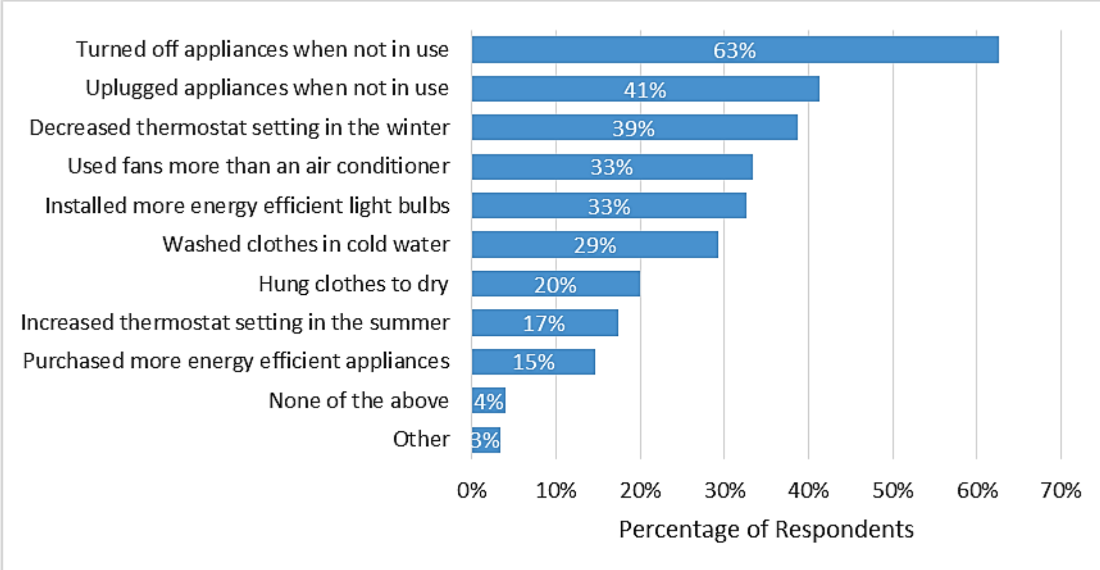

Source: Tenant Leave-Behind Postcard Survey Question 1. "How satisfied were you with…." Includes respondents who say *very satisfied*.
* Indicates where the proportion of *very satisfied* respondents in PY7 is significantly different than PY6 (α=0.05).

### 11.4.8 Tenant Education

The tenant education workshop survey administered by the ICSP asked how beneficial the education workshop and/or handouts were in helping tenants understand the importance of the energy efficiency upgrades. Overall, the respondents found the workshops beneficial, with 71% (n=127) scoring the workshop as *very beneficial*. Eighty-two percent (n=121) scored the individuals conducting the energy education workshop as *excellent,* and 84% (n=89) scored the individuals conducting the energy audits as *excellent*.

The workshop satisfaction survey asked participants to select actions they had taken to reduce their energy use prior to attending the workshop. The action most commonly taken by respondents was turning off appliances when not in use (63%; n=150), followed by unplugging appliances when not in use (41%), and decreasing thermostat setting in the winter (39%). Further details are provided in Figure 11-9.

**Figure 11-9: Tenants' Actions to Reduce Energy Use Before the Tenant Education Workshop**

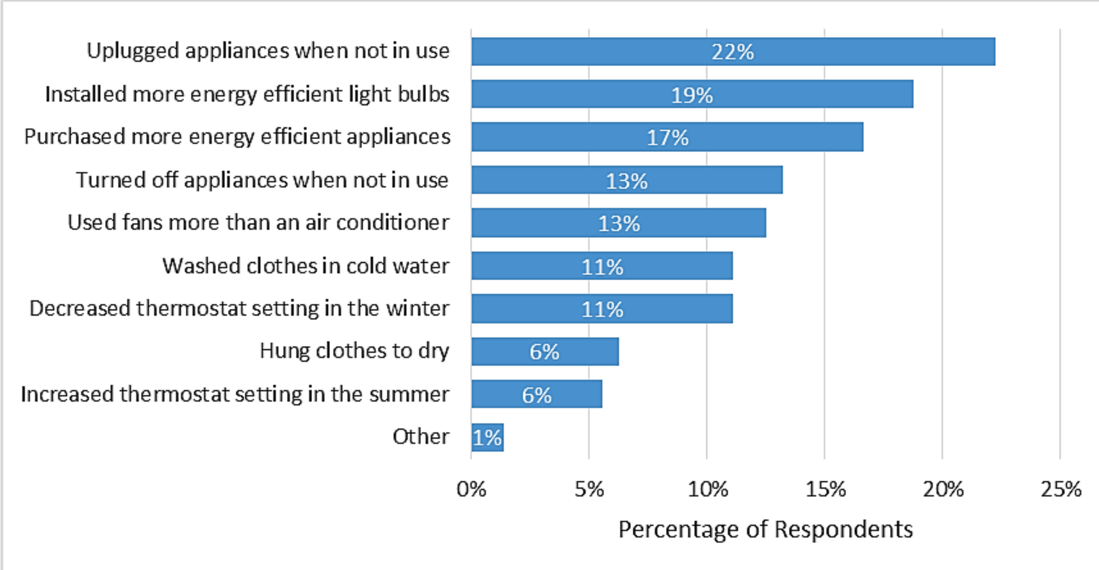



Source: Tenant Education Workshop Satisfaction Survey Question 3: Before this workshop, had you done any of the following things to reduce your energy usage? Select all that apply. (n=150)

The workshop satisfaction survey asked participants to select actions they planned to take to reduce their energy use as a result of the workshop. Most respondents made the same choices as they had to the question that asked about their current actions. Cadmus removed responses that were the same to both questions and found that almost one-quarter (22%; n=144) reported they plan to *unplug appliances when not in use*, 19% plan to *install more energy-efficient light bulbs*, and 17% plan to *purchase more energy-efficient appliances* as a result of the workshop (Figure 11-10).

Finally, when asked what the workshop organizers could improve, a majority of the respondents (58%; n=114) said nothing, 16% said the educational seminar/handouts, and 6% said they needed better notification of impending energy audits.

**Figure 11-10: Tenants' Planned Actions to Reduce Energy use As a Result of the Tenant Education Workshop**




Source: Tenant Education Workshop Satisfaction Survey Question 4: As a result of the workshop, are you planning to implement any of the following things to reduce energy usage? Select all that apply. (n=144)

## 11.4.9 Marketing and Outreach

### 11.4.9.1 PPL Electric Utilities and CSP Marketing

The PPL Electric Utilities program manager and the ICSP indicated during their interviews (n=2), that the change to program eligibility requirements increased participation by nursing home properties. This increase was large enough that there was no need for further program marketing and outreach in PY7 to find additional qualified opportunities. Nevertheless, to speed up participation, in Q2 of PY7 the ICSP sent letters to properties that had not yet decided to participate to remind them of the program end date.

## 11.4.10 Decision-Making Factors in Project Planning

During the interviews with the program manager and implementer (n=2), Cadmus asked about the lessons learned from Phase II that could help PPL Electric Utilities engage decision-makers in the master metered multifamily buildings under the low-income WRAP in Phase III.

In general, a simpler and more consolidated decision-making structure in low-income nursing homes allowed for quicker participation decisions than typically found with program-eligible multifamily building decision-makers. The nursing homes are often owned by a nonprofit organization, whereas low-income master metered multifamily buildings are often owned by the local county or other regional governmental organizations. Nursing homes appear eager to display energy efficiency technologies to prospective tenants.

The interviewees said there are opportunities for energy efficiency upgrades in both master metered multifamily and nursing home buildings. However, upfront costs, tight operating budgets, and the reluctance to take on additional debt were the most important reasons that some building owners and/or operators did not participate in the program after receiving the audit. The participants' lack of available capital was also the most important reason that the ICSP did not install comprehensive retrofits or the more expensive equipment rebated through the program (e.g., HVAC equipment).

The ICSP offered interest-free financing (independent from PPL Electric Utilities) to help decision-makers participate in the program and install rebated equipment. However, only one owner/operator took advantage of financing and the rest did not want to take on additional debt or needed additional approval to do so.

## 11.5 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings, Cadmus suggests that PPL Electric Utilities consider these recommendations in Phase III.

**Conclusion**
Overall, the program processes worked well in PY7 and the program reached Phase II planned savings. PPL Electric and the ICSP made a proactive change in program eligibility requirements in PY6 that allowed low-income nursing homes to participate. Low-income nursing homes were easier to recruit, because they had an autonomous decision-making structure and were eager to showcase energy-efficient technologies for prospective residents. (See Sections 11.2.6 Summary of Evaluation Results and Section 11.4.10 Decision-Making Factors in Project Planning.)

**Recommendation**
In Phase III, consider recruiting low-income nursing home buildings to reach the low-income WRAP planned savings for master metered multifamily buildings. Likewise, consider recruiting nursing homes that are not income-eligible into the Phase III Prescriptive Equipment program.

**Conclusion**
There are remaining energy-saving opportunities in master metered multifamily buildings, especially for comprehensive retrofits that could improve envelope and HVAC system performance. Upfront costs, tight operating budgets, and the reluctance to take on additional debt are barriers that building owners face that prevent comprehensive retrofits in this market. (See Sections 11.4.4 Achievements Against Plan and 11.4.10 Decision-Making Factors in Project Planning.)

**Recommendation**
In Phase III, explore options to increase incentives for HVAC equipment and comprehensive building retrofits in the master metered multifamily market segment, to reduce the gap between the incentives and the actual cost of these retrofits to program participants.

**Conclusion**
The program participant buildings consisted primarily of mid-sized buildings (less than 100,000 sq. ft.) built in the 1970s, 1980s, and 1990s, with 50 or less tenant units. Twenty-six percent of the program participant buildings visited (n=50) had electric heat pumps for heating, and 42% had electric water heaters (n=50). This information can help PPL Electric Utilities target its program incentives and marketing toward the building vintages and the systems most prevalent in the master-metered multifamily sector. (See Section 11.4.6 Participant Building Profile.)

**Conclusion**
Tenant energy education workshops were a valuable tool to help participating building tenants understand the importance of energy efficiency retrofits and the importance of their actions on the energy performance of their buildings. Twenty-two percent of the workshop survey respondents (n=144), reported they plan to *unplug appliances when not in use*, 19% plan to *install more energy-efficient light bulbs*, and 17% plan to *purchase more energy-efficient appliances* as a result of the workshop. The collective effect of these incremental tenant actions may have a large impact on the building’s energy use and demand reduction. This highlights the importance of programs focused on education and behavioral adjustments in the residential sector. (See Section 11.4.8 Tenant Education.)

**Recommendation**

In Phase III, continue to offer tenant education under the low-income WRAP to recommend energy-efficiency actions tenants and householders can take to improve the energy performance of their buildings.

### 11.5.1 Status of Recommendations for Program

Table 11-15 contains the status of each PY7 process recommendation made to PPL Electric Utilities.

**Table 11-15: Master Metered Low-Income Multifamily Housing Program Status Report on Process and Impact Recommendations**

| Recommendations | EDC Status of Recommendation (Implemented, Being Considered, Rejected AND Explanation of Action Taken by EDC) |
|---|---|
| **Master Metered Low-Income Multifamily Housing Program** | |
| In Phase III, consider recruiting low-income nursing home buildings to reach the low-income WRAP planned savings for master metered multifamily buildings. Likewise, consider recruiting nursing homes that are not income-eligible into the Phase III Prescriptive Equipment program. | Implemented. Low-income nursing homes are eligible for WRAP (there is not a separate MF program in Phase III). |
| In Phase III, explore options to increase incentives for HVAC equipment and comprehensive building retrofits in the master metered multifamily market segment, to reduce the gap between the incentives and the actual cost of these retrofits to program participants. | Rejected. As part of the Phase III EE&C Plan, PPL determined that it could not offer higher incentives for HVAC in master metered multifamily buildings. PPL will continually monitor Phase 3 savings and budgets and adjust incentives or programs if necessary. |
| In Phase III, continue to offer tenant education under the low-income WRAP to recommend energy-efficiency actions tenants and householders can take to improve the energy performance of their buildings. | Implemented. |

## 11.6 FINANCIAL REPORTING

A breakdown of the Master Metered Low-Income Multifamily Housing Program finances is presented in Table 11-16.

**Table 11-16: Summary of Master Metered Low-Income Multifamily Housing Program Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs[6] ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs (Sum of rows 2 to 4) | $591 | $1,193 |
| 2 | EDC Incentives to Participants | $412 | $795 |
| 3 | EDC Incentives to Trade Allies | - | - |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $180 | $398 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6, 7, 8, 9, 10 ) | $359 | $1,217 |
| 6 | Design & Development | $0 | $0 |
| 7 | Administration, Management, and Technical Assistance[1] | $359 | $1,217 |
| 8 | Marketing[2] | $0 | $0 |
| 9 | EDC Evaluation Costs | $0 | $0 |
| 10 | SWE Audit Costs | $0 | $0 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | ($0) | ($0) |
| | | | |
| 12 | Total TRC Costs[3] (Sum of rows 1, 5 and 11) | $951 | $2,410 |
| 13 | Total NPV Lifetime Energy Benefits | $1,390 | $3,248 |
| 14 | Total NPV Lifetime Capacity Benefits | $125 | $219 |
| 15 | Total NPV O&M Saving Benefits | $65 | $198 |
| 16 | Total NPV TRC Benefits[4] | $1,581 | $3,664 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | 1.66 | 1.52 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.
[2] Includes the marketing CSP and marketing costs by program CSPs.
[3] Total TRC Costs includes Total EDC Costs and Participant Costs.
[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.
[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[6] Phase II Costs in this table are discounted back to PY5, thus will not match cumulative costs reported in the PY6 Q4 quarterly report

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# 12 E-POWER WISE PROGRAM

The E-Power Wise Program educates low-income customers about energy efficiency to enable them to make informed choices about energy use. The program targets PPL Electric Utilities customers with incomes at or below 150% of the federal poverty level. The program is available to customers in single-family housing and in multifamily housing where each unit is metered (not master metered).

The program uses a train-the-trainer model, in which Resource Action Program, Inc., or RAP, the ICSP, trains community-based organizations (agencies) it identifies to provide energy workshops at locations convenient to the targeted customer segment. These community-based organizations conduct one-on-one energy education sessions and workshops with customers.

The program distributes energy-savings kits through two delivery channels. Eligible customers who go to the agency in person complete an enrollment card and receive energy education and an energy-savings kit. In the direct mail delivery channel, the ICSP sends eligible customers a promotional card that explains they can receive an energy-savings kit. Customers opt in by mailing the enrollment card and then the ICSP sends them a kit.

The objectives of the E-Power Wise Program are these:[157]

- Provide quality energy conservation and efficiency education to low-income customers so they can make informed choices about their energy use
- Provide information about low-cost/no-cost energy efficiency strategies that low-income customers can use in their homes
- Provide low-income customers with energy-efficient products in free take-home and direct mail energy-savings kits
- Obtain participation by 11,400 customers through 2016 and achieve energy savings of approximately 5,600 MWh/yr
- Promote other PPL Electric energy efficiency programs

A summary of cumulative Phase II program metrics can be found in Table 12-1.

The E-Power Wise Program included one new component in PY7, referred to as the Wise Home Pilot.

***Wise Home Pilot.*** The Wise Home Pilot targeted manufactured homes, with the expectation that many are classified as low-income households. WRAP provided the income-qualified homes with electric heat with full home weatherization measures, if needed. Households with non-electric heat received partial home weatherization measures. Results of the Wise Home Pilot component are discussed in Section 12.7.

The Wise Home Pilot included two objectives in addition to the first three listed above. These were to conduct a randomized control trial (RCT) or a pre-post consumption analysis to assess energy savings and to conduct a limited process evaluation to document logistics associated with the delivery of the Wise Home Pilot component, lessons learned, and participant satisfaction.

157 Program objectives are stipulated on PPL Electric Utilities' revised EE&C Plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, p.91.

**Table 12-1: Phase II E-Power Wise Program Summary[1]**

| Sector | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Net-to-Gross Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) | Program Acquisition Cost ($/Annual kWh) [2] | Cost of Conserved Energy (TRC Costs/ Lifetime kWh, at Generation) [3] | Phase II Participants |
|---|---|---|---|---|---|---|---|---|---|
| Residential | - | - | - | - | N/A | - | N/A | N/A | - |
| Low-Income | 6,233 | 6,966 | 5,812 | 1.0 | 3.32 | $1,139 | $0.173 | $0.032 | 11,436 |
| Small C&I | - | - | - | | N/A | - | N/A | N/A | - |
| Large C&I | - | - | - | | N/A | - | N/A | N/A | - |
| Government/ Nonprofit/ Education | - | - | - | | N/A | - | N/A | N/A | - |
| **Total** | **6,233[4]** | **6,966[4]** | **5,812[4]** | **1.0** | **3.32** | **$1,139** | **$0.173** | $0.032 | **11,436** |

[1] This table does not include the Wise Home Pilot.
[2] Total EDC Costs divided by first-year kWh savings.
[3] Total TRC Costs divided by levelized lifetime kWh savings.
[4] The E-Power Wise Program kit's education component has a one-year measure life. The 355.65 MWh/yr and 0.0915 MW verified in PY5 calculations has expired, as well as have the 424.99 MWh/yr and 0.0706 MW verified in PY6.

## 12.1 Program Updates

In PY7, the program increased the number of planned kits distributed by 1,500 kits (for a total of 5,100 kits) from PY6. To meet this planned increase, the program added three new agencies. Additionally, the program modified the content of the train-the-trainer workshops conducted at agencies to focus more on the importance of installing the products in the energy-savings kits. The DVD included in the energy-savings kit was also updated to emphasis the importance of installation.

In PY7, PPL Electric Utilities introduced a new component. The Wise Home Pilot component targeted the manufactured home segment.

### 12.1.1 Definition of Participant

Participants in PY7 are defined as any low-income customer who received an energy-savings kit either through the community-based organization or the direct mail delivery channel of PPL Electric Utilities' E-Power Wise Program between June 1, 2015, and May 31, 2016.

In PY7, a participant can also be defined as a customer who participated in the Wise Home Pilot component (discussed in Section 12.7).

## 12.2 Impact Evaluation Gross Savings

### 12.2.1 Reported Gross Savings

Table 12-2 shows the Phase II cumulative reported results by sector.

**Table 12-2: Phase II E-Power Wise Program Reported Results by Customer Sector [1]**

| Sector | Phase II Participants | Phase II Reported Gross Energy Savings (MWh/yr) | Phase II Reported Gross Demand Reduction (MW) | Incentives Paid ($1,000) |
|---|---|---|---|---|
| Residential | | | | |
| Low-Income | 11,436 | 6,233 | 0.96 | - |
| Small C&I | | | | |
| Large C&I | | | | |
| Government/Nonprofit/Education | | | | |
| **Phase II Total** | **11,436** | **6,233** [2] | **0.96** [2] | **-** |

[1] This does not include the Wise Home Pilot.
[2] The E-Power Wise Program kit's education component has a one-year measure life. The 355.65 MWh/yr and 0.0915 MW that were verified in the PY5 calculations have expired, as have the 424.99 MWh/yr and 0.0706 MW verified in PY6.

### 12.2.2 Database Review

Cadmus reviewed the EEMIS database of all PY7 records for participants' PPL Electric Utilities account numbers, E-Power Wise Program kit numbers, and other data. Cadmus also reviewed records across all previous program years and quarters in Phase II to ensure that the program counted only one kit per household. Additionally, it compared participants' EEMIS records with enrollment data stored in the ICSP's electronic database to ensure that records were traceable between both databases.

EEMIS listed a total of 5,119 participants prior to the database review. Cadmus discovered a number of discrepancies and accounted for them as follows:

- 5 PPL Electric Utilities accounts received multiple kits in Phase II and were present as duplicates in both EEMIS and the ICSP data. Cadmus applied TRM adjusted *ex ante* savings of zero to these records, giving savings to only one kit per customer.
- 5 PPL Electric Utilities accounts received multiple kits in Phase II and were present as duplicates in EEMIS but not duplicates in the ICSP data. Cadmus applied TRM adjusted *ex ante* savings of zero to these records, giving savings to only one kit per customer.
- 11 PPL Electric Utilities accounts returned their kits to the ICSP in PY7 and were present in EEMIS but not in the ICSP data. Cadmus applied TRM adjusted *ex ante* savings of zero to these records.

As a result of the review, Cadmus reduced the total to 5,098 program kits distributed, representing 99.6% accuracy of the database. Table 12-3 presents the database review and number of kits verified in the PY7 analysis. Cadmus accounted for these kits and total savings estimate by assigning them zero TRM-adjusted and *ex post* savings.

**Table 12-3: PY7 E-Power Wise Program Database Review Results**

| Sector | Product | PY7 Kits in EEMIS | Database Accuracy | PY7 Verified Kits |
|---|---|---|---|---|
| Low-Income | Energy-savings kit (including all products) | 5,119 | 99.6% | 5,098 |

### 12.2.3 EM&V Sampling Approach

Each energy-savings kit included a paper survey that asked participants to complete and return responses to questions about installing the products and about their experiences with the products and program. Participants returned the surveys to the ICSP throughout the year. Each quarter, the ICSP sent the survey data to Cadmus. Cadmus used the data in the evaluation and to conduct engineering calculations to compute the program's energy savings in PY7. Phone surveys were not conducted in PY7.

The ICSP distributed 5,098 energy-savings kits during PY7. Of the 2,994 participants who entered the program through the agency-based delivery channel, 386 returned surveys. Of the 2,104 participants who entered through the direct mail delivery channel, 390 returned surveys. Table 12-4 presents the delivery method, sample size, and functions of each of the surveys used in this evaluation.

**Table 12-4: Survey Data Collection for E-Power Wise Program**

| Survey | Survey Delivery Method | Frequency | Population | Sample Size (Returned Surveys) | Impact Evaluation | |
|---|---|---|---|---|---|---|
| | | | | | Product Installation Energy Savings | Behavior Change Energy Savings |
| Agency-Based Participant Kit | Included in kit | All quarters | 2,994 | 386 | Yes | Yes |
| Direct Mail Participant Kit | Included in kit | All quarters | 2,104 | 390 | Yes | Yes |
| **Total** | | | **5,098** | 776 | | |

### 12.2.4 *Ex Ante* Savings Methodology and Findings

Before calculating the E-Power Wise Program realization rate, Cadmus made an adjustment to the reported *ex ante* savings in the Energy Efficiency Management Information System (EEMIS) to align with assumptions specified in the 2015 Pennsylvania TRM and the characteristics of the individual items.[158] This adjustment resulted in adjusted *ex ante* savings for several of the kit products. Cadmus also adjusted the reported savings for ineligible or duplicate kits reported in EEMIS and identified through its database review activities, resulting in a TRM adjusted *ex ante* savings of zero.

Adjustments are made to the population prior to any evaluation activities to account for differences between using deemed placeholders in EEMIS, the TRM assumptions, and the products that were actually distributed to participants. Prior to receiving a kit, participants complete an enrollment card, on which they record their PPL Electric Utilities account number and contact information, and respond to questions about their household and home characteristics. These are data available to determine *ex ante* reported savings. Cadmus used these data from the enrollment cards (customer housing type and heating/water heating fuel type) to compute the *ex ante* adjusted savings.

The results of the adjustments to the population are the *ex ante* adjusted savings used in the equation to determine the program's realization rate. Table 12-5 shows the reported savings and the results of the TRM-adjusted *ex ante* calculations for the products included in each kit.

[158] Pennsylvania Public Utility Commission. *2015 Pennsylvania Technical Reference Manual.* June 2015. Available online: http://www.puc.pa.gov/Electric/pdf/Act129/Act129_TRM-2015_Redlined_v2.pdf

**Table 12-5: Reported and Adjusted *Ex Ante* Savings per Technology and per Unit**

| Product[1] | Reported *Ex Ante* Savings (kWh/yr) | TRM-Adjusted *Ex Ante* Savings (kWh/yr) | Factors |
|---|---|---|---|
| Furnace Whistle | 59.00 | Allentown (59.72), Erie (61.79), Harrisburg (58.80) Philadelphia (58.69), Pittsburgh (58.34), Scranton (60.89), Williamsport (59.47) | ▪ PPL Electric Utilities assumes equivalent full load hours (EFLH) hours for Harrisburg as a placeholder.<br>▪ 2015 TRM Table 2-31 was used to update EFLH by mapping participant zip codes to the nearest city. TRM adjustment uses zip code mapping and whether respondent has electric heating, cooling (central air conditioning) or both. |
| Smart Strip | 66.61 | 58.69 | ▪ PPL Electric Utilities assumes an average default for 7-plug unspecified use and entertainment center from 2015 TRM Section 2.5.3.<br>▪ TRM adjustment uses 7-plug unspecified use from 2015 TRM Section 2.5.3. |
| LED 10.5W | 30.29 | 30.29 | ▪ PPL Electric Utilities assumes 97% in-service rate (ISR) per 2015 TRM Section 2.12.4. No adjustments were made to reported *ex ante* savings. |
| LED2 10.5W | 30.29 | 30.29 | ▪ PPL Electric Utilities assumes 97% ISR per 2015 TRM Section 2.12.4. No adjustments were made to reported *ex ante* savings. |
| Faucet Aerator - Kitchen | 76.00 | Multifamily participants (131.36)<br>Single-family participants (165.93)<br>Unspecified housing (165.93) | ▪ PPL Electric Utilities uses 52% fuel saturation per its RASS study and planning ISR of 85%.<br>▪ TRM adjustment uses PPL Electric Utilities planning ISR, 1.5 gpm per spec sheet, and housing type and water heat fuel type from enrollment cards.<br>▪ 2015 TRM Table 2-64 stipulates different fixed values based on housing types[2] |
| Low-Flow Showerhead | 106.00 | Multifamily participants (212.25)<br>Single-family participants (226.85)<br>Unspecified housing (245.76) | ▪ PPL Electric Utilities uses 52% fuel saturation per its residential appliance saturation survey (RASS) study and planning ISR of 84%.<br>▪ TRM adjustment uses PPL Electric Utilities planning ISR, 1.75 gpm per spec sheet, and housing type and water heat fuel type from enrollment cards. 2015 TRM Table 2-65 stipulates different fixed values based on housing types[2] |
| LED Nightlight | 27.60 | 27.62 | ▪ PPL Electric Utilities assumes 97% ISR per 2015 TRM. No adjustments made to reported *ex ante* savings except for rounding. |
| Energy Education (Initial) | 253.00 | 253.00 | ▪ Behavior-based custom measure protocol (CMP) approved by the statewide evaluator (SWE) in Phase I.[3] No adjustments made to reported *ex ante* savings. |

[1] Savings from all products are attributed to the low-income sector.
[2] The 2015 TRM provides different fixed variables for number of persons in the house and number of showers and faucets based on single-family and multifamily home types. Enrollment data regarding home type was available for both agency-based and direct mail participants. Cadmus used enrollment data to determine home type and associated energy savings. Pennsylvania Public Utility Commission. *2015 Pennsylvania Technical Reference Manual.* June 2015. Available online: http://www.puc.pa.gov/Electric/pdf/Act129/Act129_TRM-2015_Redlined_v2.pdf
[3] Savings from energy education and related behavior activities are derived from survey data using the CMP for E-Power Wise Behavior Savings Calculations. Cadmus updated the CMP in PY7 to conform with updates to the 2015 TRM water heaters, clothes washers, and programmable thermostats algorithms. This update affects the survey-verified savings for survey respondents.

### 12.2.5 *Ex Post* Savings Methodology and Findings

The adjustments to e*x post* savings modified the TRM-adjusted *ex ante* savings by modifying the individual item and energy education savings to reflect the installation rates determined through the participants' returned surveys.

Results of these adjustments are reflected in the *ex post* savings. The *ex post* savings were used in the calculations to determine the savings realization rate.

#### 12.2.5.1 Participant Surveys

Each kit distributed through the program included a paper survey for the participant to complete and mail back to the ICSP. These surveys, which were approved by PPL Electric Utilities, collected the necessary data to calculate installation rates and determine participant actions taken as a result of the program. The PY7 analysis involved a total of 776 paper surveys—386 surveys returned by participants who received the kit from the community-based organization and 390 surveys returned by direct mail participants. In PY7, the overall survey return rate was 15%, a slight decrease from the 17% return rate in PY6. Cadmus used data collected in the returned paper surveys to determine the installation rate and calculate *ex post* per-unit savings for each item contained in the E-Power Wise Program energy-savings kit.

The methodology relied on the individual survey responses and the program enrollment cards. The EM&V CSP based each respondent's verified *ex post* savings on the survey responses indicating whether the respondent installed the products. It also used data from the enrollment cards about fuel types for water and space heating to determine the *ex post* savings. Cadmus calculated realization rates for each stratum (agency delivery channel and direct mail delivery channel) as the ratio of survey verified savings to survey *ex ante* savings. The stratum-level realization rates were applied to *ex ante* savings to calculate stratum-level *ex post* savings. Program-level *ex post* savings were estimated as the sum of stratum-level *ex post* savings.

Because one survey is included in the kit and includes questions about each item, survey responses for products may be correlated within customers. Cadmus accounts for the correlations by rolling savings up to the customer level prior to calculating realization rates and precision. Cadmus calculates confidence and precision for the *ex post* savings and realization rate estimates in each stratum and for the program as a whole.

Refer to *Appendix H: Methodology for Determining Savings From Energy-Savings Kits* for more information on the methodology at the respondent level. Savings calculations for energy education (behavior-based savings) are described in detail in *Appendix I: E-Power Wise Behavior Savings Methodology*.

#### 12.2.5.2 Summary of Survey Findings

Program participants returned 776 surveys. Table 12-6 presents the PY7 installation rates for each item in the energy-savings kit. Note that the in-service rate is a percentage of the participants who answered the question and not of the total number of people surveyed. These installation rates are useful for program planning purposes.

Cadmus calculated the in-service rates of the water products (aerators and showerheads) by dividing the number of respondents who installed the product in a home with electric water heat by the number who answered the question and had electric water heat. The furnace whistle in-service rate was calculated in a similar way, by dividing those who installed the product in a home with electric space heat and/or central air conditioning by the respondents who answered the question and have electric space heat and/or central air conditioning in the home.

**Table 12-6: PY7 Installation Rates for Kit Products Distributed Through E-Power Wise Program**

| Product Installed | Kit Delivery Method | | | |
|---|---|---|---|---|
| | PY7 Agency | | PY7 Direct Mail | |
| | Sample Count (n) | ISR | Sample Count (n) | ISR |
| Kitchen Aerator | 185 | 71%[1] | 256 | 65%[1] |
| Low-Flow Showerhead | 184 | 66%[1] | 256 | 60%[1] |
| 10.5W LED | 385 | 98% | 386 | 97% |
| 10.5W LED[2] | 385 | 92% | 386 | 90% |
| LED Nightlight | 386 | 90% | 388 | 88% |
| Furnace Whistle | 165 | 44%[3] | 224 | 49%[3] |
| Smart Strip | 381 | 76% | 388 | 75% |

[1] Represents the percentage of electric water heat homes where the product was installed, out of the total number of respondents to the specific question who had electric water heat.
[2] This line item represents the second LED bulb in the kit.
[3] Represents the percentage of electric heating fuel type homes or central air conditioning homes where the product was installed, out of the total number of respondents to the specific question who had electric space heat and/or central air conditioning.

Cadmus determined relative per-unit savings for each of the savings-kit items based on the equations listed in the 2015 TRM. Table 12-7 shows the survey-verified savings attributable to all products in the energy-savings kit, with one exception. Verified savings for the furnace whistle can be found in Table 12-8.

**Table 12-7: E-Power Wise Program Survey Verified Product Savings per Distributed Unit**

| Product Installed | PY7 Per-Unit Savings (kWh/yr) |
|---|---|
| Kitchen Aerator | Single-family (195.21)<br>Multifamily (154.54)<br>Unspecified (195.21) |
| Low-Flow Showerhead | Single-family (270.07)<br>Multifamily (252.67)<br>Unspecified (292.57) |
| 10.5W LED | 31.22 |
| 10.5W LED[1] | 31.22 |
| LED Nightlight | 28.47 |
| Smart Strip | Entertainment center (74.46)<br>Unspecified (58.69) |

[1] EEMIS contains separate placeholder values for each 10.5W LED bulb in the kit.

**Table 12-8: E-Power Wise Program Survey – Verified Furnace Whistle Savings per Distributed Unit**

| TRM-Specified Installation Location | Both Heating and Cooling Savings (kWh/yr) | Heating Only Savings (kWh/yr) | Cooling Only Savings (kWh/yr) |
|---|---|---|---|
| Allentown | 126.01 | 89.48 | 36.53 |
| Erie | 130.36 | 101.18 | 29.18 |
| Harrisburg | 124.06 | 82.73 | 41.33 |
| Philadelphia | 123.83 | 79.50 | 44.33 |
| Pittsburgh | 123.08 | 90.68 | 32.40 |
| Scranton | 128.48 | 97.20 | 31.28 |
| Williamsport | 125.48 | 93.83 | 31.65 |

### 12.2.6 Summary of Evaluation Results

Program energy savings results are provided in Table 12-9 and Table 12-10.

**Table 12-9: PY7 E-Power Wise Summary of Evaluation Results for Energy[1] [2]**

| Stratum | PYTD Reported Gross Energy Savings (MWh/yr) | PYTD Adjusted *Ex Ante* Energy Savings (MWh/yr) | Energy Realization Rate (%) | PYTD Verified Gross Energy Savings (MWh/yr) [3] | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Agency | 1,942 | 1,850 | 85% | 1,564 | 0.69 | 4.58% |
| Direct Mail | 1,379 | 1,457 | 98% | 1,431 | 0.61 | 3.94% |
| **Program Total** | **3,321[4]** | **3,307[4]** | **91%** | **2,996 [4]** | **N/A[5]** | **3.04%** |

[1] Values in this table refer to savings at the point of consumption. (Savings for MWh refer to values at the point of consumption.) Due to line losses, savings at the point of generation are systematically larger.
[2] This does not include the Wise Home pilot.
[3] Adjusted *ex ante* multiplied by the realization rate will not equal verified gross energy savings due to rounding.
[4] Total may not equal sum due to rounding.
[5] Observed Cv is not applicable at the program level.

**Table 12-10: PY7 E-Power Wise Summary of Evaluation Results for Demand [1]**

| Stratum | PYTD Reported Gross Demand Savings [2] (MW) | PYTD Adjusted *Ex Ante* Demand Savings [3] (MW) | Demand Realization Rate (%) | PYTD Verified Gross Demand Savings [3] (MW) | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Agency | 0.387 | 0.392 | 35% | 0.136 | 0.99 | 6.32% |
| Direct Mail | 0.275 | 0.285 | 47% | 0.134 | 0.88 | 5.36% |
| **Program Total** | **0.662** | **0.678 [4]** | **40%** | **0.270** | **N/A[5]** | **4.14%** |

[1] This does not include De Facto Pilot.
[2] Reported gross demand reductions do not include the gross-up to reflect T&D losses.
[3] Adjusted *ex ante* and verified gross demand reductions include T&D losses.
[4] Total may not equal sum due to rounding.
[5] Observed Cv is not applicable at the program level.

## 12.3 IMPACT EVALUATION NET SAVINGS

The E-Power Wise Program targets the low-income community, and only income-verified customers participate. These customers seek assistance from community based organizations and receive free energy education, along with a free kit of energy-saving products. Cadmus is of the opinion that the low-income participants would not pay for energy education and would not purchase the energy-saving kits of their own accord in the absence of the program. Therefore, and in keeping with the discussion in the evaluation plan approved by the SWE, Cadmus did not allocate time or budget to conduct surveys to estimate freeridership and spillover. Shown in Table 12-11, Cadmus assumeds there is no freeridership and spillover among the income-qualified E-Power Wise Program participants.

**Table 12-11: PY7 E-Power Wise Sampling Strategy for Net-to-Gross Research**

| Stratum | Stratum Boundaries | Population Size (Number of Energy-Savings Kits) | Assumed Cv or Proportion in Sample Design | Assumed Levels of Confidence & Precision | Target Sample size | Achieved Sample Size | Percent of Sample Frame Contacted to Achieve Sample[1] |
|---|---|---|---|---|---|---|---|
| **E-Power Wise** | Program | 5,098 | N/A | N/A | N/A | N/A | N/A |

[1] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means of all the sample frame how many were called to get the completes.

The E-Power Wise Program was assigned an NTG ratio of 1.0, as shown in Table 12-12.

**Table 12-12: PY7 E-Power Wise Summary of Evaluation Results for NTG Research**

| Target Group or Stratum (if appropriate) | Estimated Freeridership | Estimated Participant Spillover | NTG Ratio | Observed Coefficient of Variation or Proportion | Relative Precision |
|---|---|---|---|---|---|
| **E-Power Wise** | N/A | N/A | 1.0 | N/A | N/A |

# 12.4 PROCESS EVALUATION

## 12.4.1 Research Objectives

Cadmus conducted the PY7 process evaluation to address these research objectives:

- Identify areas of program success
- Identify areas that may benefit from program improvements
- Assess agency satisfaction with program

## 12.4.2 Evaluation Activities

For the E-Power Wise Program, the PY7 process evaluation activities were these:

- Interviews with program staff and implementer (n=2)
- Interviews with agencies (n=5)
- Analysis of process-related questions from customer surveys returned from the energy-savings kits (n=776)

The PY7 process evaluation activities were consistent with the evaluation plan, with the addition of two informal interviews to explore changes in program delivery.

## 12.4.3 Methodology

### 12.4.3.1 Program Staff and Implementer Interviews

Cadmus interviewed the E-Power Wise Program managers from PPL Electric Utilities and the ICSP to review program design changes, areas of the program that were working well, and any areas where the program had experienced challenges.

### 12.4.3.2 Agency Interviews

The community-based organizations, or agencies, distributed the energy-savings kits to income-qualified clients. The ICSP provided Cadmus with the complete list of 20 participating agencies. Cadmus interviewed one staff member from each of five selected agencies to learn about their experiences, opinions, and overall satisfaction with the program.

Each agency was provided an inventory of energy-savings kits to distribute. Recognizing that agencies have varying staff capacity to administer and distribute the energy-savings kits, the ICSP provided agencies a goal for the number of kits to distribute, customized to available resources, and worked closely with agency staff to coordinate the inventory of kits. Cadmus stratified the agencies according to the percentage of kits each agency distributed from their inventory. Distribution activity levels were defined as high (85% to 100% of the inventory was distributed), medium (70% to 84%), and low (30% to 69%). A sample of agencies was randomly selected from each stratum for interviews.

Table 12-13 lists the agency sampling strategy for the E-Power Wise Program for PY7. (A detailed methodology is included in *Addendum A. Agency Interview Methodology*.)

**Table 12-13: PY7 E-Power Wise Process Evaluation Sampling Strategy**

| Stratum | Stratum Boundaries [1] | Population Size | Assumed Proportion or Cv in Sample Design | Assumed Levels of Confidence & Precision | Target Sample Size | Number of Records Selected for Sample Frame | Achieved Sample Size | Percentage of Sample Frame Contacted [2] | Evaluation Activity |
|---|---|---|---|---|---|---|---|---|---|
| PPL Electric Program and ICSP Staff | Staff | 2 | N/A | N/A | 2 | 2 | 2 | 100% | Process, Program Staff Interview |
| Agency Interview | | | | | | | | | |
| High Activity Agencies | 85%–100% | 6 | N/A | N/A | 2 | 6 | 2 | 67% | Process |
| Medium Activity Agencies | 70%–84% | 7 | N/A | N/A | 2 | 7 | 2 | 71% | Process |
| Low Activity Agencies | 30%–69% | 7 | N/A | N/A | 1 | 7 | 1 | 14% | Process |
| **Total** | | **22** | **N/A** | **N/A** | **7** | **22** | **7** | 50% | **Process** |

[1] Percentage of kit inventory distributed.
[2] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means the percentage of the sample frame called to complete interviews.

### 12.4.3.3 Surveys Included in Kits

In each energy-savings kit, the ICSP included a survey that asked basic questions about installing the products and experience with the program and materials. Customers who returned the surveys to the ICSP were automatically entered into a monthly raffle for a $100 gift card.

Each quarter, the ICSP sent all survey data to Cadmus. In total, the ICSP sent data for 776 surveys (of 5,098 surveys distributed), which represented 15% of the total participation. Cadmus reviewed the data for consistency and clarity and included all returned surveys in its analysis (this is considered a convenience sample). Associated biases could affect the results if, for example, respondents acted and answered differently than non-respondents. Cadmus determined that the 15% response rate was reasonable and higher than for many surveys and, therefore, assumed that any possible bias would have minimal impact.

Table 12-14 shows PY5, PY6, and PY7 survey return rates.

**Table 12-14: E-Power Wise Survey Return Rate by Year and Distribution Channel**

| | PY5 | | | PY6 | | | PY7 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Agency | Direct Mail | Program Total | Agency | Direct Mail | Program Total | Agency | Direct Mail | Program Total |
| Total Participants | 1,600 | 1,115 | 2,715 | 2,325 | 1,275 | 3,600 | 2,994 | 2,104 | 5,098[1] |
| Returned Surveys | 199 | 188 | 387 | 390 | 215 | 605 | 386 | 390 | 776 |
| **Survey Return Rate** | **12%** | **17%** | **14%** | **17%** | **17%** | **17%** | **13%** | **19%** | **15%** |

[1] During verification activities, Cadmus identified and removed 21 accounts that received multiple kits or could not be traced between the ICSP and EEMIS databases.

## 12.4.4 Achievements Against Plan

Table 12-15 shows the program's Phase II planned energy savings and incentives.

**Table 12-15: E-Power Wise Program Savings**

| | PY5 Verified | PY6 Verified | PY7 Only | | | Phase II: PY5–PY7 | | |
|---|---|---|---|---|---|---|---|---|
| | | | Planned | Verified | Percentage of Planned | Planned [1] | Verified | Percentage of Planned |
| MWh/yr | 1,525 | 2,071 | 2,261 | 2,996 | 132% | 5,611 | 5,812[2] | 101% |
| MW | 0.26 | 0.39 | 0.29 | 0.27 | 93% | 0.73 | 0.47[2] | 64% |
| Participation | 2,715 | 3,600 | 5,100 | 5,098[3] | 100% | 11,400 | 11,413 | 100% |

[1] Planned savings are based on PPL Electric Utilities' revised EE&C plan (Docket No. M-2012-2334388) approved by the Pennsylvania Public Utility Commission on June 5, 2015, Table K7, pp. 88.
[2] The E-Power Wise Program energy-savings kit's education component has a one-year measure life. The 355.65 MWh/yr and 0.0991 MW verified in PY5 calculations have expired, as well as have the 424.99 MWh/yr and 0.0765 MW verified in PY6. These savings were not included in the Phase II total verified savings.
[3] EEMIS reported that 5,119 kits were distributed in PY7. During verification activities, Cadmus identified and removed 21 accounts that received multiple kits or could not be traced between databases.

Two possible reasons the program exceeded its planned MWh/yr savings for Phase II are these:

- The installation rate for the LED bulbs was high (for the agency delivery channel, 98% for the first bulb and 92% for the second bulb; for the direct mail delivery channel 97% for the first bulb and 90% for the second bulb)
- The ICSP exceeded its Phase II planned participation by 13 kits.

### 12.4.5 Program Delivery

Overall, Cadmus found that the ICSP had continued to deliver and manage the program very well. The PPL Electric Utilities and ICSP program managers said they spoke each week and worked together to ensure that kit distribution remained steady throughout the program year. Agency staff members reported they were very satisfied with the communications from the ICSP program manager.

In PY6, the ICSP reconfigured the agency management structure to be more flexible to the needs of individual agencies. In PY7, the PPL Electric Utilities and ICSP program managers continued to balance kit distribution with the agencies' administrative capacity, and this had worked well for the participating agencies. The managers seek agencies with varying capacity to administer and distribute the energy-savings kits for future program participation. In PY7, agencies continued to receive an incentive for each kit they distribute to offset the administrative costs of the training and kit distribution (referred to as the "kit incentive amount" in Figure 12-1).

Cadmus asked the agencies which products should be removed or added to the kit; some suggested removing the furnace whistle. Agencies reported that clients frequently ask questions about the furnace whistle because they do not understand how to install or use it.

According to PPL Electric Utilities and the ICSP, the Phase III program will offer two different energy-savings kits depending on the water heater fuel type in the home. Participants with electric water heaters will receive a kit with faucet aerators and showerheads. PPL Electric Utilities and the ICSP also said that offering two different kits will require agencies to more closely manage their inventory. The ICSP said it planned to focus time in developing training materials and would conduct additional outreach so agencies were aware of and prepared for this program change in Phase III.

#### 12.4.5.1 Key Performance Indicators

In addition to program savings and energy-savings kits distributed, PPL Electric and the ICSP identified a key performance indicator they used to measure program performance, which was the number of agencies distributing kits for the program. Table 12-16 shows these key performance indicators with the PY7 results.

**Table 12-16: PY7 E-Power Wise Program Key Performance Indicators**

| Key Performance Indicator | Metric | Goal | PY7 Result |
|---|---|---|---|
| Agency Participation | Number of agencies distributing kits for the program | Increase number of agencies participating in program to reach all of PPL Electric Utilities territory | Increased by three agencies in PY7 |

Cadmus' review found that the program did well in enlisting additional agencies to participate and modifying each agency's kit distribution plans to facilitate smooth program tracking.

### 12.4.6 Participant Profile

In PY7, 5,098 participants received an energy-savings kit through the E-Power Wise Program—2,994 through an agency and 2,104 through direct mail. Eighty-two percent of the participants lived in single-family housing (including mobile homes, rowhouses or townhomes, and duplexes). Fifty-nine percent had electric water heating in their homes, 45% heated their homes with electricity, and 18% cooled their homes with central air conditioning or a heat pump.

### 12.4.7 Satisfaction

#### 12.4.7.1 Agency Satisfaction

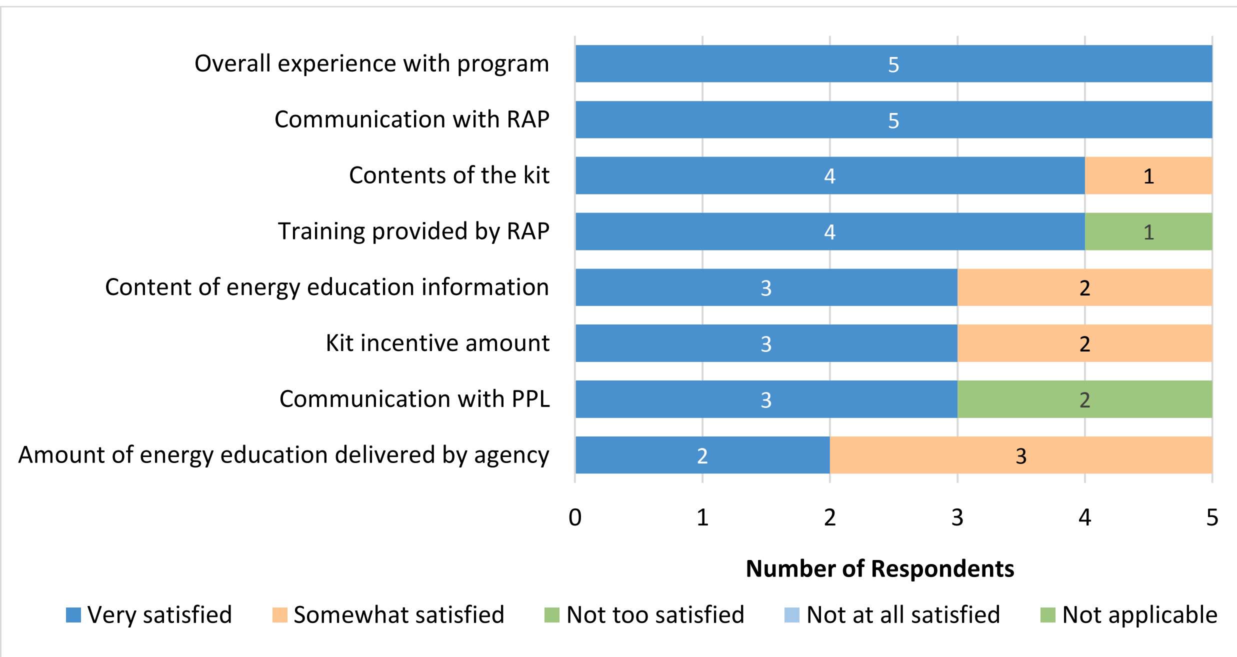
Overall, all five interviewed agencies were *very satisfied* with the E-Power Wise Program. Figure 12-1 shows the satisfaction levels for various components of the program. Agencies reported high levels of satisfaction with these program components:

- Content of the energy education information
- Communication with the ICSP
- Contents of the kit
- Training provided by the ICSP

Two out of five agencies said they did not speak directly with PPL Electric Utilities regarding the program and therefore had no comment on their level of satisfaction with communication from utility staff. The remaining three agencies said they were *very satisfied* with communication from PPL Electric Utilities.

Agencies provided the lowest satisfaction rating with the amount of energy education their own organization delivered to clients. However, it should be noted that their satisfaction was still relatively high. Of the five agencies, two said they were *very satisfied* and three said they were *somewhat satisfied*.

**Figure 12-1: Agency Satisfaction with E-Power Wise Program Components**

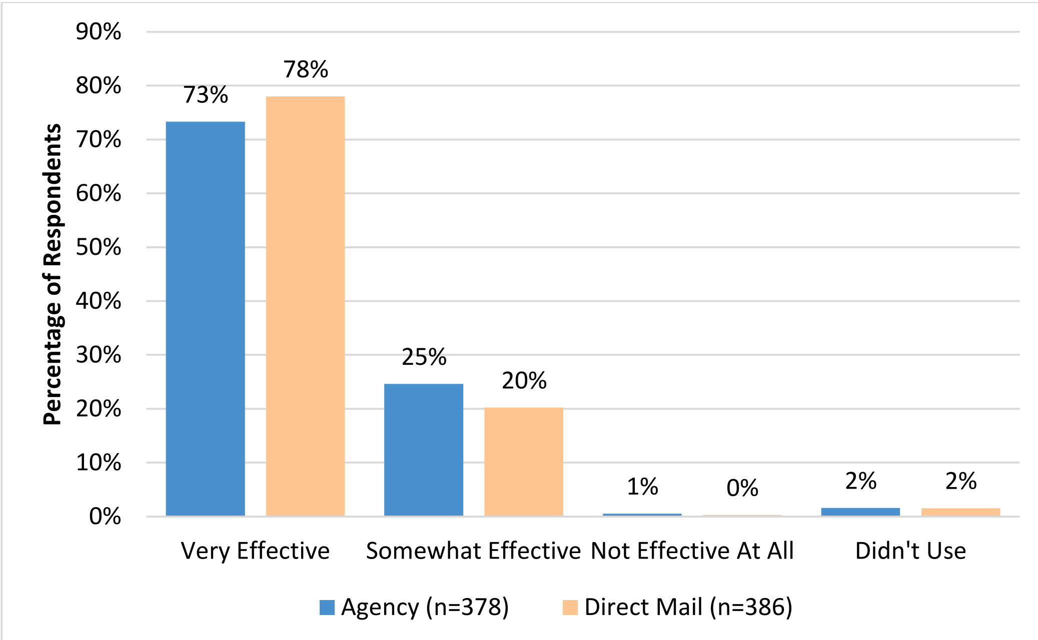



Source: Agency interview guide QE1, "I am going to ask you about your satisfaction with several features of the E-Power Wise Program. Please tell me whether you are very satisfied, somewhat satisfied, not too satisfied, or not at all satisfied with the following statements." (n=5)

#### 12.4.7.2 Effectiveness of Quick Start Guide

The survey asked participants to rate the effectiveness of the Quick Start Guide, the energy education program manual included in the kit that presents energy efficiency tips and installation guidelines. Figure 12-2 shows that approximately three-quarters of participants (73% of agency participants and 78% of direct mail participants) found the Quick Start Guide *very effective* in helping them become more energy-efficient. The difference in responses between the agency and direct mail delivery channels was not statistically significant.

**Figure 12-2: Effectiveness of the Quick Start Guide**




Source: Survey Q25, "How effective was the PPL Electric Utilities E-Power Wise Quick Start Guide in helping you become more energy-efficient?" (n=764)

## 12.4.8 Marketing and Outreach

### 12.4.8.1 Program Marketing

Four of the five agencies interviewed said they used their own outreach channels to promote the E-Power Wise Program. Three agencies said they used flyers or brochures to advertise the program to their clients. The others said they promoted the program through direct community outreach (e.g., an employment expo, a health fair for seniors, food pantries, and family fun nights). One agency said it conducted minimal additional outreach about the program but mentioned the program in an annual budgeting feature included in its organization's client newsletter.

## 12.4.9 Agency-Delivered Kits

The Agency staff Cadmus interviewed said they most commonly distributed the kits through one-on-one meetings between agency staff and clients. Only one agency said it had conducted workshops at its location that were specifically about the energy-savings kits. As in past program years, most agencies said they had challenges getting clients to participate in workshops and, therefore, they focused on one-on-one meetings.

In PY6, a common concern expressed by agency staff was program saturation. In PY7, Cadmus asked if agencies had continued to have this concern in PY7. Three agencies (n=5) said saturation was still a concern because they frequently see the same clients over time. However, the two other agencies said this was not a problem; one of these agencies reported having a waiting list of 80 clients who had not previously participated in the program.

## 12.4.10 Agency-Delivered Energy Education

During both one-on-one meetings with clients and in workshops, agency staff reviewed the kit products and discussed installation instructions. Agency staff also reviewed additional energy-savings tips described in the Quick Start Guide (i.e., turning down the temperature on the water heater, washing clothes in cold water, and adjusting the thermostat to save energy in the summer and winter).

Agencies reported that clients were most interested in these energy efficiency topics:

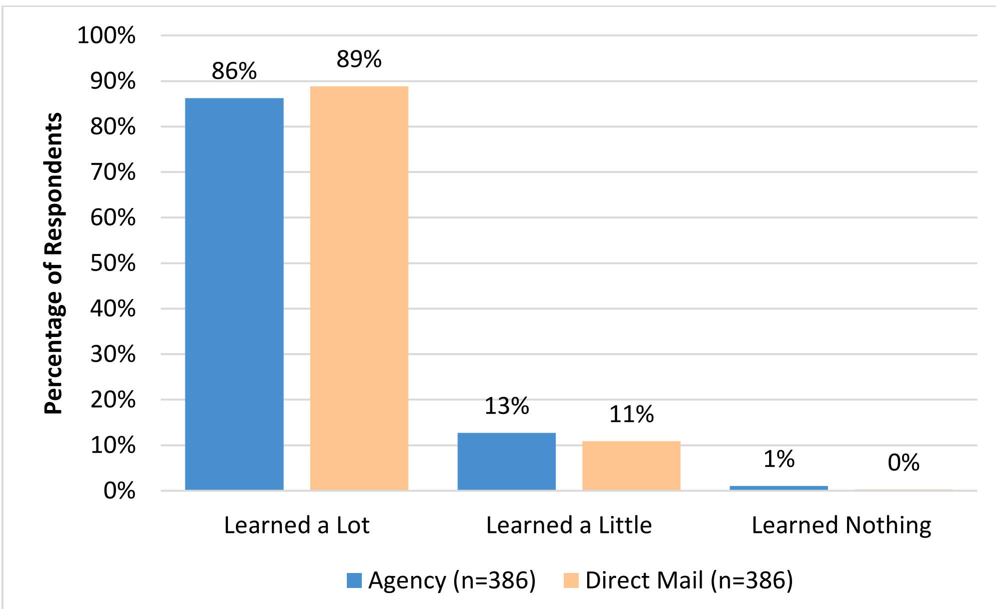
- General ways to save money and reduce energy use as well as specific ways to save on heating and cooling costs
- Faucet aerators and showerhead installation, use, and impacts.
- Plug load

According to the agencies, clients had the most questions about these topics:

- How and why their energy bills differed from their neighbors
- The impact of showers on their energy use and shower-using behaviors to reduce energy use
- How to use furnace whistles and smart strips

As shown in Figure 12-3, the majority of participants (86% of agency participants and 89% of direct mail participants) said they *learned a lot* of about saving energy through the program. The difference between the agency and direct mail delivery channels was not statistically significant.

**Figure 12-3: Participant Knowledge Gained Through E-Power Wise Program**




Source: Survey Q26, "Now that you have completed the PPL Electric Utilities E-Power Wise Quick Start Guide, how much have you learned about saving energy and money in your home?" (n=772)

## 12.5 CONCLUSIONS AND RECOMMENDATIONS

Based on findings of this evaluation, Cadmus suggests that PPL Electric Utilities consider the following conclusions and recommendations for Phase III. These conclusions and recommendations are intended to help PPL Electric Utilities capture additional low-income savings through the E-Power Wise Program.

**Conclusion**

The installation rates for the furnace whistles (44%-49% based on delivery channel) remain lower than the water saving and plugged in measures (see Section 12.2.5.2, Summary of Survey Findings). Agencies reported that clients frequently ask questions about the furnace whistle because they do not understand how to install or use it, which has resulted in low installation rates (see Section 12.4.5, Program Delivery). Furthermore, furnace whistles generate a small proportion of energy savings (just 3% of *ex post* savings from the agency delivery channel and 4% of savings from the direct mail delivery channel).

**Recommendation**
Consider removing the furnace whistle from the energy-savings kit and explore offering a rebate for furnace filters instead (TRM savings apply). The purpose of the furnace whistle is to alert a homeowner that the furnace filter is dirty and needs to be changed. Therefore, including a rebate offer or coupon in the kit could result in purchases of additional furnace filters.

**Conclusion**
Despite comparable in-service rates, the agency realization rate was lower than the direct mail delivery channel (see Section 12.2.5.2, Summary of Survey Findings). This difference was primarily driven by lower electric water heater fuel saturation among agency participants (70% of direct mail participants had electric water heat versus 52% of agency participants). In Phase III, the program will offer two different energy-savings kits based on the water heater fuel type (electric or fossil fuel). Only those participants with electric water heaters will receive a kit with faucet aerators and showerheads. This approach will ensure that only those households that can generate electric savings from faucet aerators and showerheads receive these products. For more details about the kits in Phase III, see Section 12.4.5 (Program Delivery).

**Recommendation**
Offering two kits may offer logistical challenges for participating agencies and the ICSP, and will likely require that the ICSP work more closely with agencies to manage inventory. To monitor progress and identify any early issues with the two-kit delivery system, Cadmus suggest adding questions to the agency interviews as a part of the PY8 evaluation to gather feedback from agencies.

**Conclusion**
One-on-one meetings with clients continue to be agencies' preferred method for kit delivery, which is in line with findings from PY5 and PY6. The majority of agencies in PY5, PY6, and PY7 indicated that they most commonly distributed the kits through one-on-one meetings between agency staff and clients, with a minority of agency interviewees indicating that they occasionally distribute kits through workshops. Most agencies said they had challenges getting clients to participate in workshops and, therefore, they focused on one-on-one meetings. For more details about how agencies delivery energy kits and education to their clients, see Section 12.4.9 (Agency-Delivered Kits) and 12.4.10 (Agency-Delivered Energy Education).

**Recommendation**
Ensure that the program provides sufficient training and materials geared toward one-on-one interactions between clients and agencies.

### 12.5.1 Status of Recommendations for Program

Table 12-17 contains the status of each PY7 process recommendation made to PPL Electric Utilities.

**Table 12-17: E-Power Wise Program Status Report on Process and Impact Recommendations**

| Recommendations | EDC Status of Recommendation (Implemented, Being Considered, Rejected AND Explanation of Action Taken by EDC) |
|---|---|
| **E-Power Wise Program** | |
| Consider removing the furnace whistle from the energy-savings kit and explore offering a rebate for furnace filters instead | Being considered and will likely be implemented. |
| Monitor progress and identify any early issues with the two-kit delivery system; Add questions to the agency interviews as a part of the PY8 evaluation to gather feedback from agencies. | Implemented. |
| Ensure that the program provides sufficient training and materials geared toward one-on-one interactions between clients and agencies. | Being considered and will likely be implemented. |

## 12.6 FINANCIAL REPORTING

A breakdown of the E-Power Wise Program finances is presented in Table 12-18.

**Table 12-18: Summary of E-Power Wise Program Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs[6] ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs (Sum of rows 2 to 4) | $0 | $0 |
| 2 | EDC Incentives to Participants | $0 | $0 |
| 3 | EDC Incentives to Trade Allies | $0 | $0 |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $0 | $0 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6, 7, 8, 9, 10 ) | $503 | $1,037 |
| 6 | Design & Development | $0 | $0 |
| 7 | Administration, Management, and Technical Assistance[1] | $503 | $1,037 |
| 8 | Marketing[2] | $0 | $0 |
| 9 | EDC Evaluation Costs | $0 | $0 |
| 10 | SWE Audit Costs | $0 | $0 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | $0 | $0 |
| | | | |
| 12 | Total TRC Costs[3] (Sum of rows 1, 5 and 11) | $503 | $1,037 |
| 13 | Total NPV Lifetime Energy Benefits | $1,495 | $3,108 |
| 14 | Total NPV Lifetime Capacity Benefits | $50 | $198 |
| 15 | Total NPV O&M Saving Benefits | $69 | $133 |
| 16 | Total NPV TRC Benefits[4] | $1,614 | $3,440 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | 3.21 | 3.32 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.
[2] Includes the marketing CSP and marketing costs by program CSPs.
[3] Total TRC Costs includes Total EDC Costs and Participant Costs.
[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.
[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[6] Phase II Costs in this table are discounted back to PY5, thus will not match cumulative costs reported in the PY6 Q4 quarterly report

# ADDENDUM A. AGENCY INTERVIEW METHODOLOGY

## 12.6.1 Interview Methodology

Cadmus received the complete list of 20 participating agencies from the ICSP. Cadmus stratified the sample (high, medium, and low) by randomly selecting agencies according to how many kits an agency delivered compared to the number of kits it received from the ICSP. Cadmus then flagged agencies that were contacted in PY6 and gave priority to the agencies that had not been contacted in Phase II.

Cadmus called agencies at different times of day and different days of the week to increase the probability of contact and up to five times each for a total of 24 calls.

Table 12-19 summarizes the agency sampling strategy for the E-Power Wise Program for PY7, sorted by activity level.

**Table 12-19: PY7 E-Power Wise Program Agency Sampling Strategy**

| Agency | Kits Shipped | Kits Distributed (as of Q3) | Percentage of Inventory Distributed | Activity Level | Contacted in PY6 (Yes, No) |
|---|---|---|---|---|---|
| Agency 1 | 270 | 239 | 89% | High | No |
| Agency 2 | 331 | 287 | 87% | High | No |
| Agency 3 | 230 | 193 | 84% | High | Yes |
| Agency 4 | 551 | 510 | 93% | High | Yes |
| Agency 5 | 130 | 114 | 88% | High | Yes |
| Agency 6 | 255 | 213 | 84% | High | Yes |
| Agency 7 | 188 | 144 | 77% | Medium | No |
| Agency 8 | 121 | 92 | 76% | Medium | No |
| Agency 9 | 201 | 150 | 75% | Medium | No |
| Agency 10 | 140 | 100 | 71% | Medium | No |
| Agency 11 | 70 | 40 | 57% | Medium | No |
| Agency 12 | 100 | 67 | 67% | Medium | Yes |
| Agency 13 | 100 | 71 | 71% | Medium | Yes |
| Agency 14 | 20 | 9 | 45% | Low | No |
| Agency 15 | 30 | 13 | 43% | Low | No |
| Agency 16 | 100 | 42 | 42% | Low | No |
| Agency 17 | 30 | 9 | 30% | Low | No |
| Agency 18 | 50 | 10 | 20% | Low | No |
| Agency 19 | 165 | 85 | 52% | Low | Yes |
| Agency 20 | 20 | 9 | 45% | Low | Yes |

## 12.7 WISE HOME PILOT

The E-Power Wise Program included one new component in PY7, referred to as the Wise Home Pilot. PPL Electric Utilities designed the pilot to target manufactured home parks in an effort to determine the percentage of customers among this housing type who qualify as low-income.

The pilot offered two kinds of weatherization: a full treatment that included air sealing and duct sealing and a partial treatment that included air sealing but not duct sealing. Both treatment types included the direct installation of weather strips, window insulation, door caddies, outlet gaskets, pipe insulation, window air conditioner covers, LEDs, and advanced power strips. Technicians also installed aerators and showerheads in homes with electric water heaters.

PPL Electric Utilities asked Resource Action Program (RAP) to piggyback the pilot onto its responsibilities as the ICSP for the E-Power Wise Program. Residents of manufactured homes qualify for both the E-Power Wise Program and the Wise Home Pilot.

The Wise Home Pilot intended to help manufactured homes households save energy as well as establishd the following objectives:

- Provide low-income customers with energy-efficient equipment to help reduce their energy consumption and costs
- Conduct randomized control trials (RCTs) and pre-post analyses to assess energy savings in four customer subpopulations defined by heating and cooling fuel and system types
- Conduct a limited process evaluation to document logistics associated with delivery, lessons learned, and participants' satisfaction with the pilot
- Promote other PPL Electric Utilities energy efficiency programs
- Estimate percentage of low-income customers who live in manufactured homes in PPL Electric Utilities' service territory

A summary of pilot metrics can be found in Table 12-20.

**Table 12-20: E-Power Wise's Wise Home Pilot Summary**

| Program | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Net-to-Gross Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) [1] | Program Acquisition Cost [1], [2] ($/Annual kWh) | Cost of Conserved Energy [3] (TRC $/kWh) | Phase II Participants |
|---|---|---|---|---|---|---|---|---|---|
| Wise Home Pilot | 1,688 | 1,688 | 121 | 1.0 | 1.17 | $98 | $0.81 | 0.088 | 110 |
| **Pilot Total** | **1,688** | **1,688** | **121** | **1.0** | **1.17** | **$98** | **$0.81-** | **0.088** | **110** |

[1] Expenditures are tracked at the program level, not by component.
[2] Total EDC Costs divided by kWh savings.
[3] Total TRC Costs divided by levelized lifetime kWh savings.

PPL Electric Utilities reported savings of 1,688 MWh/yr and 0 MW for the Wise Home Pilot. Cadmus, the evaluation, measurement, and verification (EM&V) CSP, verified consumption savings of 121 MWh/yr and demand savings of 0 MW. These savings represented the pilot's first-year savings, which were estimated based on changes in average daily consumption after homes were weatherized and the length of the year (365 days). Additional details are provided in Section 12.7.2.5.

Total energy savings averaged 1,101 kWh/yr per treated home and the cost averaged $890, resulting in $0.81/annual kWh saved. The cost per treated home was high because program expenditures included marketing and recruiting for the randomized control trial, analysis and assigning customers into groups. Furthermore, because of scheduling difficulties, not all customers who were selected for treatment received weatherization services.

### 12.7.1 Program Updates

In PY7, PPL Electric Utilities introduced the Wise Home Pilot, a new component that targeted the manufactured home segment. The pilot offered two types of treatments both of which received direct-install measures:

- The **full home treatment** included an assessment and, depending on the condition of the home, the installation of air and duct sealing under and in above-ground areas of the home.
- The **partial home treatment** included the installation of air and duct sealing to the above-ground areas of the home; no blower door test or inspection of the ducts under the home were required.

PPL Electric Utilities planned to use a randomized control trial (RCT) to measure electric savings resulting from the full or partial home treatments. The initial design, as well as details on challenges that PPL Electric Utilities faced and subsequent updates to the pilot design during its implementation are described in Section 12.7.1.

#### 12.7.1.1 Initial Design

In the initial design, Cadmus calculated the sample sizes required to achieve statistically significant savings results and recommended that PPL Electric Utilities recruit and enroll 600 customers then randomize them into three groups—two treatment groups and a control group, with 200 in each.

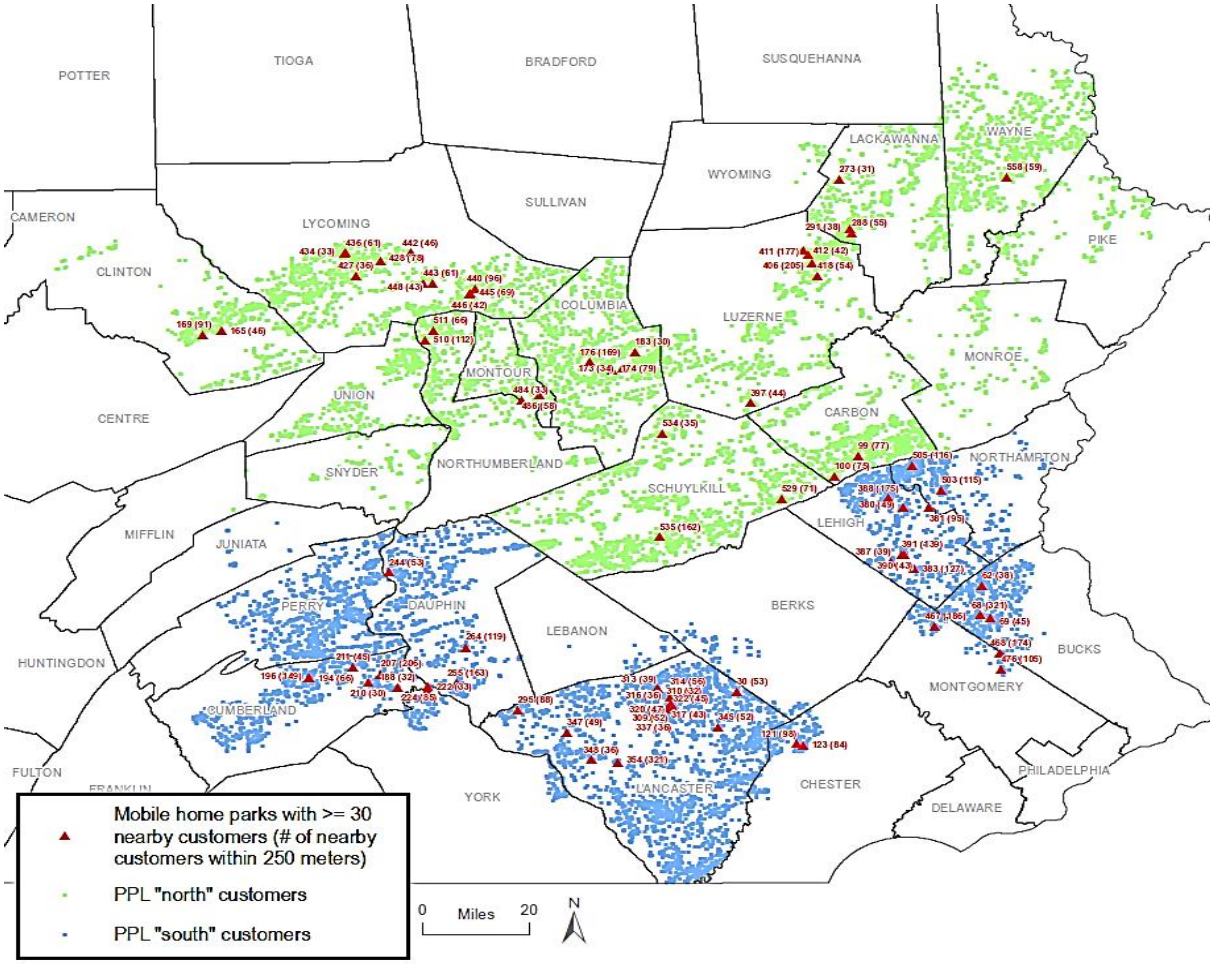
To determine where the pilot should focus recruitment efforts, Cadmus conducted a preliminary analysis of customers and their monthly energy consumption in each manufactured home park in PPL Electric Utilities' service territory. The territory was divided by the Blue Mountains into north and south regions. Based on this analysis and cost considerations, PPL Electric Utilities limited the pilot to two subregions: a northern subregion that consisted of Luzerne and Lackawanna counties and a southern subregion of Lehigh, Berks, Northampton, Bucks, Montgomery, Schuylkill, Carbon, and Monroe counties.

Cadmus used geocoding in ArcGIS to map addresses within 250 meters of each manufactured home park.[159] Figure 12-4 presents the location of manufactured home customers—green dots represent customer homes in the northern region, blue dots represent homes in the southern region, and red triangles represent parks with at least 30 customers. Cadmus randomly selected manufactured home parks from the two subregions and provided this list to PPL Electric Utilities for recruitment efforts.

Using the list of manufactured home parks, PPL Electric Utilities technicians solicited customer participation using on-site recruitment visits and opt-in surveys. Cadmus used a customer's self-reported survey responses to verify the home used electric forced air heat and was eligible for the pilot.

159 Cadmus initially used a list of parks provided by PPL Electric Utilities but later inferred the likely locations of parks based on clusters of homes.

**Figure 12-4: Manufactured Home Parks**



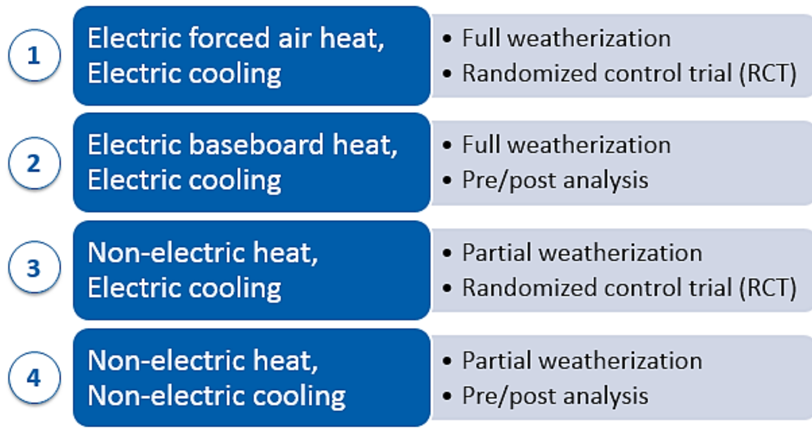

## 12.7.1.2 Updated Pilot Design

Initially, PPL Electric Utilities focused the pilot on installing air and duct sealing and on providing direct-install measures to customers with electric forced air heat. However, during the outreach period in October 2015, it experienced low customer response and enrollment rates and found that far fewer customers used electric forced air heat than expected. Of the roughly 330 customers enrolled, only 25% used electric heat at all, let alone electric forced air heat. As a result, PPL Electric Utilities considered other options for the pilot and study design.

After reviewing the characteristics of enrolled customers, Cadmus revised the study design to account for expected differences in baseline energy consumption for homes with electric heating and cooling and homes with electric cooling but not electric heating. Cadmus also accounted for heat sources—forced air heat, baseboard heat, or neither. Cadmus then proposed a study design with four study groups. Two were large enough for Cadmus to develop RCTs to measure electric energy savings resulting from treatments. In the two small study groups, Cadmus designed treatment-only studies that applied pre-post analyses to evaluate energy savings.

Figure 12-5 depicts the Wise Home Pilot's four study groups and analysis designs.

**Figure 12-5: Study Group and Analysis Designs**




#### 12.7.1.3 Definition of Participant

In the final study and pilot design, a participant is defined as a customer who met these conditions:

- Received electricity service from PPL Electric Utilities
- Lived in the manufactured home at the existing locations for at least 12 months
- Owned the home or had obtained written permission from the owner to weatherize the home
- Resided in permanently established manufactured home (i.e., not wheeled, like a recreational vehicle [RV])

Homes were eligible to participate if the customers had previously obtained weatherization services through the Universal Services Program (USP) or Act 129 WRAP or had received an E-Power Wise Program energy conservation kit.

### 12.7.2 Impact Evaluation Gross Savings

#### 12.7.2.1 Reported Gross Savings

Table 12-21 shows reported savings results by sector.

**Table 12-21: E-Power Wise's Wise Home Pilot Reported Results by Customer Sector**

| Sector | Phase II Participants | Phase II Reported Gross Energy Savings (MWh/yr) | Phase II Reported Gross Demand Reduction (MW) | Incentives Paid ($1,000) |
|---|---|---|---|---|
| Low-Income | 110 | 1,688 | 0 | - |
| **Phase II Total** | **110** | **1,688** | **0** | **-** |

In PY7, Cadmus performed these impact evaluation activities:

- Database review
- Billing analysis

These activities are discussed in detail in the following sections.

#### 12.7.2.2 Database Review

Cadmus reviewed data uploaded into EEMIS, the program tracking database, and conducted range checks for valid responses related to quantity and associated savings. The majority of data were within reasonable ranges, with only four apparent data entry errors in reported savings. There were a number measures in the EEMIS data with reported quantities and savings values that were considerably higher than feasible, given average energy consumption in a single home. These are apparent data entry errors. Cadmus identified errors by comparing the measure-level reported savings to average customer-level annual consumption. If the reported savings for a measure were greater than 15% of the annual consumption, Cadmus flagged it as a data entry error. Cadmus identified 78 measures with apparent data entry errors in the EEMIS data using average annual consumption (2,450 kWh, based on Study Group 2, which had the highest annual consumption). The measures were retained in the final realization rate estimate. A discussion of their impact is included in Section 12.2.5.

**Table 12-22: Database Review**

| Quantity | Study Group 1 | Study Group 2 | Study Group 3 | Study Group 4 |
|---|---|---|---|---|
| **Expected Average Daily Consumption per Home (Without Weatherization) [1]** | **38.4** | **44.8** | **26.2** | **28.0** |
| Estimated Annual Consumption in Non-Weatherized Home | 14,010 | 16,334 | 9,556 | 10,213 |
| 15% of Annual Consumption | 2,101 | 2,450 | 1,433 | 1,532 |
| **Number of Measures Reported with Greater than 15% Savings** | 44 | 27 | 7 | 0 |

[1] Cadmus estimated average daily consumption in homes without weatherization based on observed consumption in the control groups for Study Groups 1 and 3 and observed consumption plus savings in the weatherized homes from Study Groups 2 and 4.

Cadmus did not make any *ex ante* adjustments for the Wise Home Pilot.

#### 12.7.2.3 EM&V Sampling Approach

Cadmus calculated target sample sizes for each study group. The initial recruitment met the target sample size for Study Group 3 (non-electric heat and electric cooling) but not for Study Group 1 (electric forced air heat and electric cooling). Accordingly, PPL Electric Utilities attempted to enroll 32 additional customers in November 2015 and January 2016 to meet the target sample size. Based on initial recruiting efforts, Cadmus did not establish sample size targets for Study Group 2 (electric baseboard heat, electric cooling) and Study Group 4 (baseload) because it expected enrollments for these groups to remain small.

Table 12-23 lists the study groups and evaluation activites (RCT or pre-post) used to evaluate savings for each group.

**Table 12-23: PY7 Wise Home Pilot Impact Evaluation Sampling Strategy**

| Study Group | | Treatment | Population [1] | Target Levels of Confidence & Precision | Target Sample Size | Achieved Sample Size | Evaluation Activity |
|---|---|---|---|---|---|---|---|
| 1 | Electric Forced Air Heat, Electric Cooling | Full | Unknown | N/A | 106 | 90 | RCT |
| 2 | Electric Baseboard Heat, Electric Cooling | Full | Unknown | N/A | 12 | 26 | Pre-Post |
| 3 | Non-Electric Heat, Electric Cooling | Partial | Unknown | N/A | 186 | 300 | RCT |
| 4 | Non-Electric Heat, Non-Electric Cooling | Partial | Unknown | N/A | 18 | 22 | Pre-Post |
| **Program Total** | | | **49,306** | **N/A** | **322** | **438** | |

[1] Population sizes in each study group are unknown. Customers were assigned to study groups based on data collected during enrollment. Total population informed by customer list provided by PPL Electric Utilities.

After customers were enrolled, Cadmus assigned them to study groups based on enrollment data from the initial recruitment effort and redesign of the study. For Study Groups 1 and 3, Cadmus randomized customers into treatment and control groups according to whether homes had electric cooling and either electric forced air heat or non-electric heat. Table 12-24 shows the number of participants assigned to the treatment and control groups in each study group after the final recruitment and randomization efforts in January 2016.

**Table 12-24: Study Group Participants by Designation**

| Study Group | | Treatment | Control | Total |
|---|---|---|---|---|
| 1 | Electric Forced Air Heat, Electric Cooling | 45 | 45 | **90** |
| 2 | Electric Baseboard Heat, Electric Cooling | 26 | 0 | **26** |
| 3 | Non-Electric Heat, Electric Cooling | 150 | 150 | **300** |
| 4 | Non-Electric Heat, Non-Electric Cooling (Baseload) | 22 | 0 | **22** |
| Total | | **243** | **195** | **438** |

### 12.7.2.4 *Ex Ante* Savings Methodology and Findings

PPL Electric Utilities calculated *ex ante* savings using engineering savings estimates for each measure and recorded them in the EEMIS database. The ICSP reported savings according to the specific measures installed in each home. Cadmus did not make any *ex ante* adjustments for the Wise Home Pilot.

### 12.7.2.5 *Ex Post* Savings Methodology and Findings

*Billing Analysis*

Cadmus received energy consumption data from PPL Electric Utilities for all homes in the treatment and control group. Cadmus used a billing analysis to evaluate energy savings based on differences in consumption before and after the home weatherization between treatment and control groups, where applicable. Cadmus used a difference-in-differences regression analysis approach to estimate savings in the RCT study groups and a pre-post regression analysis approach for the other two study groups.

**Data cleaning.** Cadmus analyzed customer billing data from the 12 months before a customer's home was weatherized (the pre-treatment period). Because the evaluation so closely followed the installation dates, no customer had a full 12 months of post-treatment billing data. Cadmus used as much available data as possible, removing any monthly observations that did not reflect a full month's worth of billing data to control for imprecise meter reads, outliers, and missing data.[160] Table 12-25 shows the reasons for attrition and number of records for each data-cleaning step.

160 Customer accounts with no data were labeled as "inactive" in the data provided to Cadmus. Because no posttreatment consumption data existed, any pretreatment consumption data was not relevant; therefore, savings could not be calculated for those customers.

**Table 12-25: Attrition of Monthly Consumption Data**

| Reasons for Attrition | Study Groups 1 & 3 | Study Groups 2 & 4 | Total |
|---|---|---|---|
| **Initial count of monthly data records across all customers** | **9,102** | **1,111** | **10,213** |
| Customer's home not treated | N/A [1] | 464 | 464 |
| Incomplete billing months | 729 | 51 | 780 |
| Omitted months that were more than 365 days before or after installation date | 1,114 | 87 | 1,201 |
| Outside date range (Oct. 2014 – July 2016) | 2 | 0 | 2 |
| **Final count of monthly observations used in analysis** | **7,257** | **509** | **7,766** |
| [1] Cadmus retained RCT customers not treated through the pilot to preserve balance between randomly assigned treatment and control groups. See Section 12.2.5.2 for more details. | | | |

**Checking balance.** After randomization, Cadmus checked that the treatment and control groups in the RCT were balanced—that is, the treatment and control groups within Study Groups 1 and 3 were equivalent in terms of average daily energy consumption during the 12 months prior to enrolling in the pilot. Cadmus used a t-test to test for a difference in means between the treatment and control groups and found no significant differences in consumption in the period before enrollment.

Before evaluating savings, Cadmus again checked the balance between the treatment and control groups by comparing the average daily energy consumption in the pretreatment period—more specifically defined according to installation dates—and used a t-test to test for a difference in means between the treatment and control groups. As shown in Table 12-26, this balance check showed that the treatment and control customers' mean average daily consumption was balanced in Study Group 1, with no stastically significant difference (p-value > 0.10). However, the balance check showed there was a difference between the treatment and control groups for Study Group 3 (p-value < 0.10).

**Table 12-26: T-Tests to Confirm Balance in RCT Treatment and Control Groups**

| Statistic | Study Group 1 | Study Group 3 |
|---|---|---|
| Treatment Group Average Daily Consumption (kWh) Before Treatment | 40.5 | 30.3 |
| Control Group Average Daily Consumption (kWh) After Treatment | 38.9 | 27.8 |
| Difference (kWh) | 1.7 | 2.5 |
| Percentage Difference | 4.1% | 8.2% |
| t-value | -0.5 | -1.7 |
| p-value (Pr>\|t\|) | 0.7 | 0.09 |

To ensure that the imbalance in Study Group 3 would not risk biasing the savings analysis results, Cadmus conducted an analysis to verify that customer and time (month-year) fixed effects controlled for the pre-installation differences in energy consumption. In this analysis, Cadmus regressed average daily consumption in the pre-installation periods on customer and month-year fixed effects to estimate the average daily consumption conditional on these variables. In cases where the independent variables did control for pre-installation differences, it was expected that the residuals, or differences between estimated and observed average daily consumption, in the treatment and control groups would each sum to zero.

Cadmus used separate t-tests to test for differences in mean residuals between treatment and control groups for Study Groups 1 and 3 and found they were not significantly different from zero or from each other, implying that customer and month-year fixed effects were sufficient to control for pre-installation differences in the savings analysis. Because Cadmus used these independent variables in the savings analysis model to estimate changes in the energy consumption for before and after weatherization for both treatment and control groups, the estimation of savings accounted for any time-invariant difference in pre-treatment consumption.

No balance check was required for Study Groups 2 and 4.

**Savings analysis.** Cadmus estimated energy savings in the RCT study groups (Study Groups 1 and 3) using a difference-in-differences approach that employed customer and month-year fixed effects, as recommended in the Uniform Methods Protocol and the State and Local Energy Efficiency Action Networks EM&V guidance for behavior-based pilot evaluation.[161] The resulting savings estimates were expected to be unbiased because of the randomization of homes into treatment and control groups.

Cadmus defined the post-treatment indicator variable for each treated customer according to the date his or her home was weatherized. Although some treatment group customers did not have their homes weatherized through the pilot, as discussed in Section 12.7.4.5, it was necessary to keep all customers assigned to the treatment group in the analysis sample. Removing customers who did not receive treatment would violate the randomization of the RCT study design, creating a risk of over- or under-estimating the resulting savings estimates. Cadmus accounted for customers who did not receive treatment predicting installation dates based on their enrollment dates and actual weatherization dates for treatment group customers living in the same or a nearby city.

Cadmus combined data for customers in the treatment and control groups from the two RCT study groups to improve the precision of the savings estimates because the sample size in each group was small. It used one difference-in-differences model to estimate changes in energy consumption. Cadmus also combined data for customers in Study Groups 2 and 4 in a pre-post regression analysis.

To control for differences in the types of home heating and cooling systems between customers in different study groups, the model specifications interacted one or both of cooling degree day (CDD) and heating degree day (HDD) variables with treatment group indicator variables. For example, the key difference between the RCT treatment groups was that Study Group 1 customers had electric heat whereas Study Group 3 customers did not. Therefore, the model included an interaction between HDDs and Study Group 1's treatment group to control for energy-consumptive behavior that customers with electric heating would be expected to exhibit on cold days that customers without electric heating would not.

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[161] Stewart, James, and A. Todd. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* "Chapter 17: Residential Behavior Protocol." U.S. Department of Energy, National Renewable Energy Laboratory. August 2014. Available online: http://energy.gov/sites/prod/files/2015/02/f19/UMPChapter17-residential-behavior.pdf.

SEE Action. "Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations." 2012. State and Local Energy Efficiency Action Network's (SEE Action) Customer Information and Behavior (CIB) Working Group and Evaluation, Measurement, and Verification (EM&V) Working Group. Accessed October 31, 2016: https://www4.eere.energy.gov/seeaction/publication/evaluation-measurement-and-verification-emv-residential-behavior-based-energy-efficiency

Cadmus also estimated models for the study groups separately to understand differences in the treatment effects between Study Groups 1 and 3. Although the results were not significant, the average of savings point estimates was similar to the average savings estimated using the combined model.

After fitting the regression model, Cadmus estimated the treatment groups' annual savings due to the pilot by multiplying the estimated treatment effect—that is, average daily savings per customer—by 365 days and summing across treatment group customers.

As previously discussed, some customers assigned to the treatment groups did not receive weatherization. It was expected that changes in their energy consumption would not reflect energy savings resulting from the pilot treatment. Therefore, the energy savings estimated from the regression analysis was an average for the entire treatment group, including customers who received weatherization and customers who did not. To determine the energy savings associated with the weatherized homes only, Cadmus divided the overall average savings by the percentage of treatment group customers who received weatherization.[162]

Energy savings (the treatment effect) were large enough relative to random variation in annual energy consumption and, thus, the regression analysis could detect them despite small study groups.

**Site inspections summary.** The ICSP conducted an audit of the home to verify the date it was built, the type of materials used in its construction, and its heating and cooling systems. If the home's specifications qualified for the pilot, the technician installed energy efficiency products according to the schedule detailed in Table 12-27.

The primary technician for Franklin Energy, one of the ICSPs, reported that some homes may have received more products, primarily kitchen aerators and shower heads, than PPL Electric Utilitiesexpected to install. EEMIS data supports this observation.

**Table 12-27: PY7 Wise Home Pilot Summary of Evaluation Results for Energy**

| Product | Study Group 1 | Study Group 2 | Study Group 3 | Study Group 4 |
|---|---|---|---|---|
| Duct sealing | ✓ | ✓ | ✓ | |
| Caulk | ✓ | ✓ | ✓ | |
| Weather strips | ✓ | ✓ | ✓ | |
| Window insulation | ✓ | ✓ | ✓ | |
| Door caddies/corner pads | ✓ | ✓ | ✓ | |
| Outlet gaskets | ✓ | ✓ | ✓ | |
| Pipe insulation | ✓ | ✓ | ✓ | |
| Air conditioner cover | ✓ | ✓ | ✓ | |
| Kitchen aerators | ✓ | ✓ | | |
| Shower heads | ✓ | ✓ | | |
| Advanced power strips | ✓ | ✓ | ✓ | ✓ |
| LED light bulbs | ✓ | ✓ | ✓ | ✓ |
| Carbon monoxide (CO) detectors | ✓ | ✓ | ✓ | ✓ |

Cadmus did not conduct verification site visits for this program.

162 This method does not change the total estimated savings.

### 12.7.2.6 Summary of Evaluation Results

Program energy savings results are provided in Table 12-28, and energy savings by study group are provided in Table 12-29. The point estimate of average daily savings from the regression analysis for the combined Study Groups 1 and 3 was 3.46 kWh per weatherized home per day, with an 85% confidence interval between 7.34 kWh and 9.17 kWh. The point estimate of average daily savings per weatherized home from the regression analysis for the combined Study Groups 2 and 4 was 1.97 kWh per weatherized home per day, with an 85% confidence interval between 1.10 kWh and 2.84 kWh.

Demand savings were neither reported nor verified for the Wise Home Pilot.

**Table 12-28: PY7 Wise Home Pilot Summary of Evaluation Results for Energy**

| Stratum | PYTD Reported Gross Energy Savings [1] (MWh/yr) | PYTD Adjusted *Ex Ante* Energy Savings (MWh/yr) | Energy Realization Rate (%) | PYTD Verified Gross Energy Savings (MWh/yr) [2] | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| Study Groups 1 and 3 | 1,046 | 1,046 | 10% | 101 | 0.44 | 47% |
| Study Groups 2 and 4 | 642 | 642 | 3% | 20 | 0.31 | 33% |
| **Wise Home Pilot Total** | **1,688** | **1,688** | **7%** | **121** | **N/A** | **40%** |

[1] Values in this table refer to savings at the point of consumption. (Savings targets for MWh refer to values at the point of consumption.) Due to line losses, savings at the point of generation are systematically larger.
[2] Adjusted *ex ante* multiplied by the realization rate will not equal verified gross energy savings due to rounding.

The total savings within Study Groups 1 and 3 and Study Groups 2 and 4 can be divided into individual groups by the number of participants in each group shown in Table 12-29.

**Table 12-29: PY7 E-Power Wise's Wise Home Summary of Evaluation Results for Energy (By Study Group)**

| Study Group | | PYTD Reported Gross Energy Savings[1] (MWh/yr) | PYTD Adjusted *Ex Ante* Energy Savings (MWh/yr) | Energy Realization Rate (%) | PYTD Verified Gross Energy Savings (MWh/yr)[2] | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|---|
| 1 | Electric Forced Air Heat, Electric Cooling | 923 | 923 | 4% | 39 | 0.44 | 65.4% |
| 2 | Electric Baseboard Heat, Electric Cooling | 637 | 637 | 2% | 13 | 0.31 | 44.2% |
| 3 | Non-Electric Heat, Electric Cooling | 123 | 123 | 50% | 62 | 0.44 | 64.7% |
| 4 | Non-Electric Heat, Non-Electric Cooling | 5 | 5 | 146% | 7 | 0.31 | 44.2% |
| **Wise Home Pilot Total** | | **1,688** | **1,688** | **7%** | **121** | **N/A** | **40%** |

[1] Values in this table refer to savings at the point of consumption. (Savings targets for MWh refer to values at the point of consumption.) Due to line losses, savings at the point of generation are systematically larger.
[2] Adjusted *ex ante* multiplied by the realization rate will not equal verified gross energy savings due to rounding.

The low pilot realization rate of 7% reflects discrepancies between reported savings totals and verified savings totals. The reported savings totals include the apparent data entry errors discussed earlier. If *ex ante* and *ex post* savings associated with the data entry errors are removed from the totals, then the realization rate increases to 57% for the pilot as a whole and within Study Groups 1, 2, and 3 individually, as shown in Table 12-30. Further, despite the low realization rate, the pilot is cost-effective because the energy savings were substantial, even if much lower than the reported savings.

**Table 12-30: Realization Rates by Study Group Accounting for Data Entry Errors**

| Study Group | | Realization Rate (All Data) | Realization Rate (Omitting Data Entry Errors) |
|---|---|---|---|
| 1 | Electric Forced Air Heat, Electric Cooling | 4% | 54% |
| 2 | Electric Baseboard Heat, Electric Cooling | 2% | 26% |
| 3 | Non-Electric Heat, Electric Cooling | 50% | 68% |
| 4 | Non-Electric Heat, Non-Electric Cooling | 146% | 146% |
| **Wise Home Pilot Total** | | **7%** | **57%** |

## 12.7.3 Impact Evaluation Net Savings

As part of the E-Power Wise Program, the Wise Home Pilot targeted low-income customers. Cadmus assumed that participants would not weatherize their home or install the energy-saving products on their own in the absence of the program. Therefore, and in keeping with the discussion in the approved evaluation plan, there are no free riders among this program's population nor was there any spillover, as depicted in Table 12-31 and Table 12-32.

**Table 12-31: PY7 Wise Home Pilot Sampling Strategy for NTG Research**

| Stratum | Stratum Boundaries | Population Size (Number of Unique Households) | Assumed CV or Proportion in Sample Design | Assumed Levels of Confidence & Precision | Target Sample size | Achieved Sample Size | Percent of Sample Frame Contacted |
|---|---|---|---|---|---|---|---|
| **Wise Home Pilot** | Program | N/A | N/A | N/A | N/A | N/A | N/A |

**Table 12-32: PY7 Wise Home Pilot Summary of Evaluation Results for NTG Research**

| Stratum | Estimated Freeridership | Estimated Participant Spillover | NTG Ratio | Observed Coefficient of Variation or Proportion | Relative Precision |
|---|---|---|---|---|---|
| **Wise Home Pilot** | N/A | N/A | 1.0 | N/A | N/A |

## 12.7.4 Process Evaluation

### 12.7.4.1 Research Objectives

Cadmus conducted a process evaluation of the Wise Home Pilot to provide recommendations for achieving the following objectives:

- Document logistics of pilot delivery
- Identify pilot delivery challenges
- Assess participant satisfaction

### 12.7.4.2 Evaluation Activities

To achieve its objectives, Cadmus conducted the following process evaluation activities:

- Stakeholder interviews with program managers and implementers (n=3)
- Technician interview (n=1)
- Participant enrollment surveys (n=243)

- Leave-behind postcard surveys (n=40)
- Participant satisfaction follow-up surveys (n=44)[163, 164]

### 12.7.4.3 Process Evaluation Sampling Plan

Table 12-33 presents the sampling strategy for the Wise Home Pilot. Cadmus interviewed all program managers and implementers and attempted to interview as many technicians as possible. Field technicians left behind postcard surveys to assess satisfaction. Cadmus conducted additional surveys online and by phone.

**Table 12-33: PY7 Wise Home Pilot Process Evaluation Sampling Strategy**

| Stratum | Population Size [1] | Assumed Proportion or CV in Sample Design | Assumed Levels of Confidence/ Precision | Target Sample Size | Achieved Sample Size | Percent of Population Frame Contacted to Achieve Sample[2] | Used For Evaluation Activities (Impact, Process, NTG) |
|---|---|---|---|---|---|---|---|
| Program Manager Interviews [3] | 1 | N/A | N/A | 1 | 1 | 100% | Process |
| Implementer Interviews | 2 | N/A | N/A | 2 | 2 | 100% | Process |
| Technician Interviews [4] | 1 | N/A | N/A | 1 | 1 | 100% | Process |
| Enrollment Surveys | 49,306 | N/A | N/A | 600 | 243 | 100% | Process |
| Leave-Behind Postcard Surveys | 243 | N/A | N/A | 30 | 40 | 100% | Process |
| Satisfaction Follow-Up Surveys [5] [6] | 110 | N/A | N/A | 60 | 44 | 100% | Process |

[1] Population size refers to the total number of customers enrolled in the program, including customers in the treatment and control groups.
[2] Sample frame denotes contacts that have a chance to be selected into the sample. Percent contacted is the percentage of the sample frame called to complete surveys.
[3] Cadmus interviewed two program managers at once.
[4] Only one primary technician applied treatments to homes; the rest were sub-technicians.
[5] Administered online and via telephone, as described in Section 12.7.4.4.
[6] Not all participants received treatments, as described in Section 12.7.4.4.

### 12.7.4.4 Methodology

*Program Staff and ICSP Interviews*

Cadmus interviewed PPL Electric Utilities program managers and the ICSPs to understand the pilot processes as well as discuss elements of the pilot that proved successful or challenging.

Cadmus contacted each technician three times.

163 In the follow-up online and phone surveys, Cadmus asked the same satisfaction questions from the postcards that technicians' left behind for customers. The results of these questions have been aggregated. Accordingly, the frequency of responses exceed the individual sample sizes described in 12.7.4.2 for each survey.

164 One survey respondent did not have his or her home weatherized despite being assigned to the treatment group. Cadmus omitted the responses of this customer to more accurately assess satisfaction among customers who did receive direct-install measures.

### *Participant Opt-In Enrollment Card Surveys*

PPL Electric Utilities collected data on enrolled customers from the completed opt-in surveys on the enrollment cards depicted in Figure 12-6.

**Figure 12-6: PY7 Customer Opt-In Enrollment Card**

I.D. Number ______________________
Name (first and last) ______________________
Home Address ______________________
______________________
Name of manufactured home park (if applicable) ______________________
______________________
Phone Number (daytime) ______________________
Phone Number (alternate) ______________________
Email Address ______________________

1. Do you rent or own your home?
   - O Rent O Own
2. What size of home do you live in? (Check one that applies)
   - O Single Wide Home O Double Wide Home
   - O Something else ______________________
3. In what year was your home built? ______________________
4. If you don't know what year your home was built, about how old is your home? ________ years
   (if less than one year, how many months? _________)
5. What is your primary heating system? (Check one that applies)
   - O Baseboard electric
   - O Through the wall units, sometimes known as ductless heat pumps
   - O Electric air source heat pump
   - O Electric forced air furnace
   - O Gas forced air furnace
   - O Unknown O Something else ________________
6. What kind of air conditioning do you have? (Check one that applies)
   - O None
   - O Window air conditioners
   - O Through the wall units, sometimes known as ductless heat pumps
   - O Central, ducted AC system
   - O Unknown O Something else ________________
7. What temperature do you set your thermostat for heating in the winter?
   ________ degrees
8. What temperature do you set your thermostat for cooling in the summer?
   ________ degrees
9. How do you heat your water? (Check one that applies)
   - O Electric water heater
   - O Gas water heater
   - O Unknown O Something else ________________

Cadmus analyzed the enrollment data for each question, as described in the next section.

### *Participant Online and Phone Surveys*

Cadmus conducted follow-up surveys in July 2016 with a sample of Wise Home Pilot participants from the treatment groups of all four study groups. The primary objectives of the survey were to assess participants satisfaction with equipment installed through the pilot and ascertain their behavior before and after technicians installed equipment. Surveys also solicited participant demographic data, including annual income and household size, both of which dictate a household's qualification under the federal poverty guidelines.

The sample excluded customers who completed a PPL Electric Utilities survey in the past three months or who requested to not be contacted.[165]

Potential sources of bias in the surveys include nonresponse, recall, and social desirability biases. Cadmus attempted to mitigate biases by using survey design and data collection best practices. Cadmus designed surveys to include questions that were not leading, ambiguous, or double-barreled, and provided clear interviewing and programming instructions so they could be implemented consistently across interviewers.

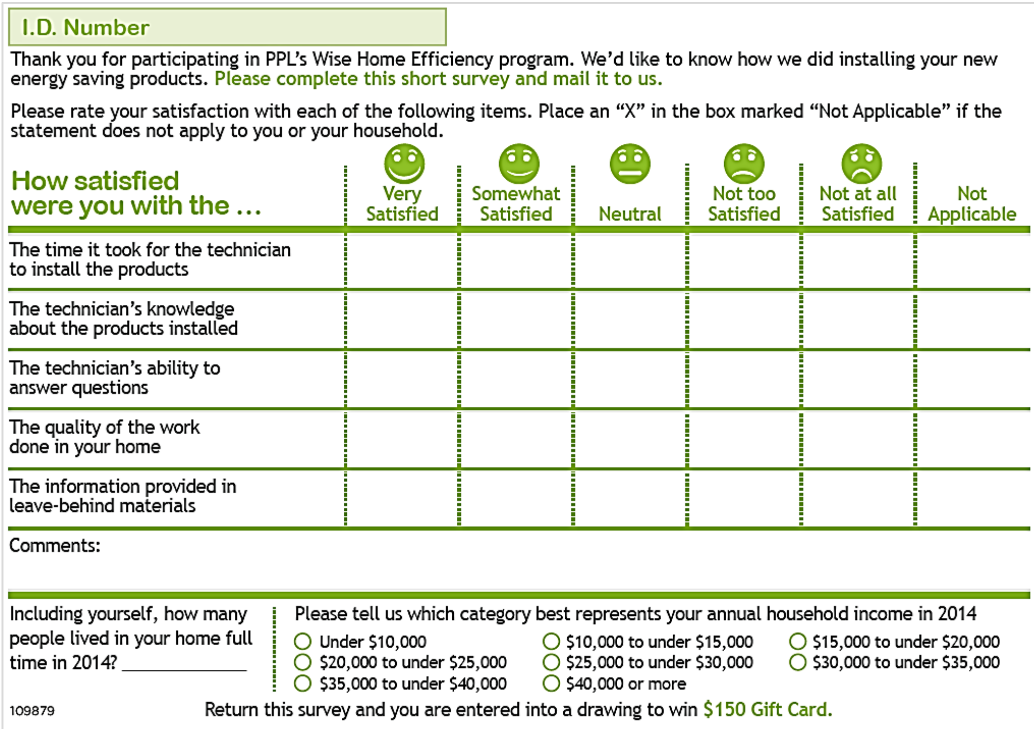
Cadmus offered both online and telephone surveys to broaden participation and sample size. Both survey instruments asked identical questions. To distribute the participant survey, Cadmus first sent links to the online survey to participants with valid e-mail addresses up to three times. Next, for those who did not complete an online survey, Cadmus called each participant three times. Cadmus placed phone calls at different times of day and scheduled callbacks whenever possible to maximize the probability of contact.

[165] PPL Electric Utilities requested that customers who had completed a survey in the past three months be excluded.

Forty percent of customers who had their homes treated through the pilot responded to the survey (n=110). See Section 12.7.4.6 for further details.

Technicians also left behind a survey, depicted in Figure 12-7, for customers to complete and return.

**Figure 12-7: PY7 Satisfaction Survey Leave-Behind Postcard**



I.D. Number

Thank you for participating in PPL's Wise Home Efficiency program. We'd like to know how we did installing your new energy saving products. Please complete this short survey and mail it to us.

Please rate your satisfaction with each of the following items. Place an "X" in the box marked "Not Applicable" if the statement does not apply to you or your household.

| How satisfied were you with the … | Very Satisfied | Somewhat Satisfied | Neutral | Not too Satisfied | Not at all Satisfied | Not Applicable |
|---|---|---|---|---|---|---|
| The time it took for the technician to install the products | | | | | | |
| The technician's knowledge about the products installed | | | | | | |
| The technician's ability to answer questions | | | | | | |
| The quality of the work done in your home | | | | | | |
| The information provided in leave-behind materials | | | | | | |

Comments:

Including yourself, how many people lived in your home full time in 2014? ____________

Please tell us which category best represents your annual household income in 2014

- ◯ Under $10,000
- ◯ $10,000 to under $15,000
- ◯ $15,000 to under $20,000
- ◯ $20,000 to under $25,000
- ◯ $25,000 to under $30,000
- ◯ $30,000 to under $35,000
- ◯ $35,000 to under $40,000
- ◯ $40,000 or more

109879 Return this survey and you are entered into a drawing to win $150 Gift Card.

## 12.7.4.5 Program Delivery

Franklin Energy and (RAP), the ICSPs, installed energy efficiency measures according to each customer's study group assignment and the needs of the home. After treating each home, field technicians left behind a satisfaction survey for the customer to complete and return (see Figure 12-7). Homes assigned to control groups received no equipment through the pilot in PY7.

Less than half of all customers assigned to the Wise Home Pilot's treatment groups had any kind of energy efficiency products directly installed in their homes. Table 12-34 contains the participant attrition for each of the Wise Home Pilot's four study groups.

**Table 12-34: Treatment Group Attrition**

| Study Group | Treatment Size (Recruited) | Direct Installs Completed | Declined/ No Response | Percentage Completed |
|---|---|---|---|---|
| 1 | 45 | 32 | 13 | 71% |
| 2 | 26 | 18 | 12 | 69% |
| 3 | 150 | 50 | 100 | 33% |
| 4 | 22 | 10 | 12 | 45% |
| **Total** | **243** | **110** | **137** | **45%** |

Franklin Energy's weatherization technician noted in the interview that the delays between enrolling customers and scheduling appointments contributed to customers changing their minds about participating and choosing to decline to participate. Additionally, it could not successfully contact all participants who originally opted into the pilot to set up appointments to weatherize their homes. Challenges delivering this pilot are summarized in Section 12.7.4.9.

*Key Performance Indicators*

In addition to energy savings and participation targets, PPL Electric Utilities and the ICSP identified one key performance indicator that they track internally to measure how well the pilot is performing. Table 12-35 shows this key performance indicator with the PY7 results.

**Table 12-35: PY7 Wise Home Pilot Key Performance Indicators**

| Key Performance Indicator | Metric | Goal | PY7 Result |
|---|---|---|---|
| **Customer satisfaction with pilot overall** | Satisfaction rating determined from participant telephone or online surveys conducted by Cadmus | 80% of respondents satisfied with the program | Met goal: 66% were *very satisfied* and 30% were *somewhat satisfied* |

## 12.7.4.6 Participant Profile

Upon enrolling in the pilot (and prior to the installation of energy efficiency measures in their homes), 238 participants completed a short survey, depicted in Figure 12-6, regarding home ownership characteristics. Table 12-38 contains the response frequencies to the survey questions.

**Table 12-36: PY7 Response Frequencies from Opt-In Enrollment Cards**

| Question | Responses |
|---|---|
| Do you rent or own your home? (n=237) | 93% rent, 7% own |
| What size of home do you live in? (n=237) | 62% single wide<br>37% double wide<br>1% something else |
| What is your primary heating system? (n=235) | 39% something else<br>29% gas forced air furnace<br>11% electric baseboard<br>11% electric forced air furnace<br>7% electric air source heat pump<br>1% ductless heat pump<br>3% unknown |
| What kind of air conditioning do you have? (n=234) | 51% central, ducted A/C system<br>33% window A/C<br>6% none<br>5% ductless heat pump<br>4% something else<br>0% unknown |
| How do you heat your water? (n=236) | 89% electric water heater<br>8% gas water heater<br>3% something else<br>0% unknown |

More than half of respondents who stated their primary heating system was “something else” had oil heat. Others heated with propane, kerosene, or electric space heaters.

Twelve percent of participants who responded to the follow-up telephone or online satisfaction survey (n=41) reported they had earned a four-year college degree, and another 24% of respondents had completed some college, including technical/business school or earning a two-year degree. Almost half of respondents (46%) had earned a high school diploma but had not pursued further education and the remaining 17% of respondents had not completed high school.

Eighty-eight percent of respondents (n=42) were aged 45 or older, with almost half of respondents aged 65 or older. About 71% of respondents lived alone or with one other person while the remaining 29% of respondents lived in homes of three or more people.

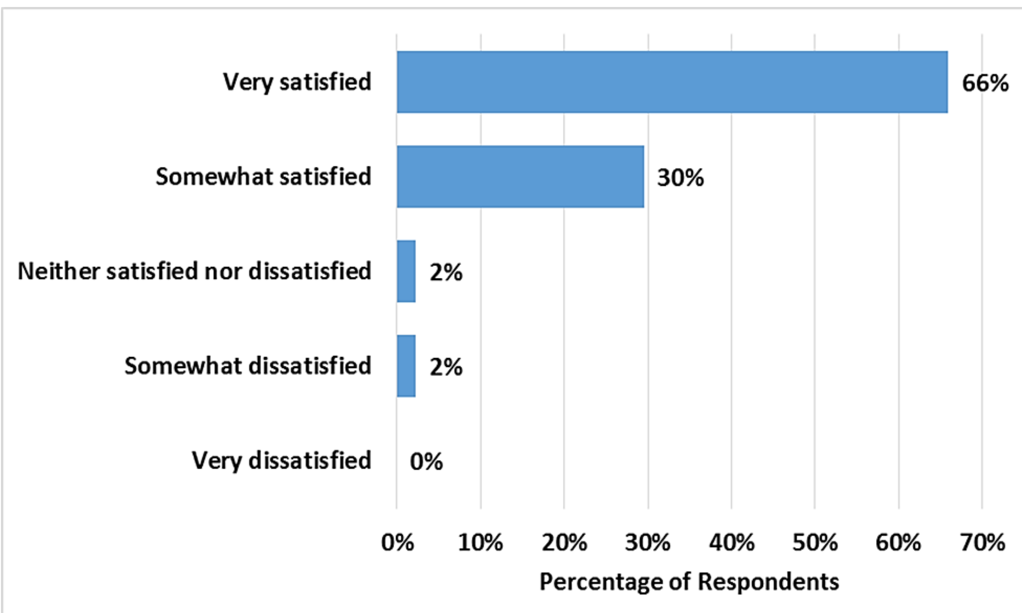
Roughly two-thirds of all respondents (n=34) earned $25,000 or less annually.[166] This trend remained fairly consistent between age groups, with 67% of respondents aged 65 or older and 60% of respondents younger than 45 earning $25,000 or less per year. Only two respondents (5%) earned $50,000 or more annually, both of whom were aged 65 or older. Among those who answered the necessary questions (n=32), 53% of respondents were considered low-income according to the federal poverty guidelines, indicating PPL Electric Utilities had succeeded in targeting low-income customers through the Wise Home Pilot.

### 12.7.4.7 Satisfaction

Cadmus administered surveys through leave-behind postcards, telephone, and online to assess pilot awareness, determine satisfaction levels, understand motivation for participation, and collect demographic information of participants.

Ninety-three percent of telephone survey respondents (n=44) reported they were *very satisfied* (66%) or *somewhat satisfied* (30%) when asked to think of their overall experience with the Wise Home Pilot, as shown in Figure 12-8.

**Figure 12-8: Treatment Group Participant Satisfaction with Wise Home Energy**

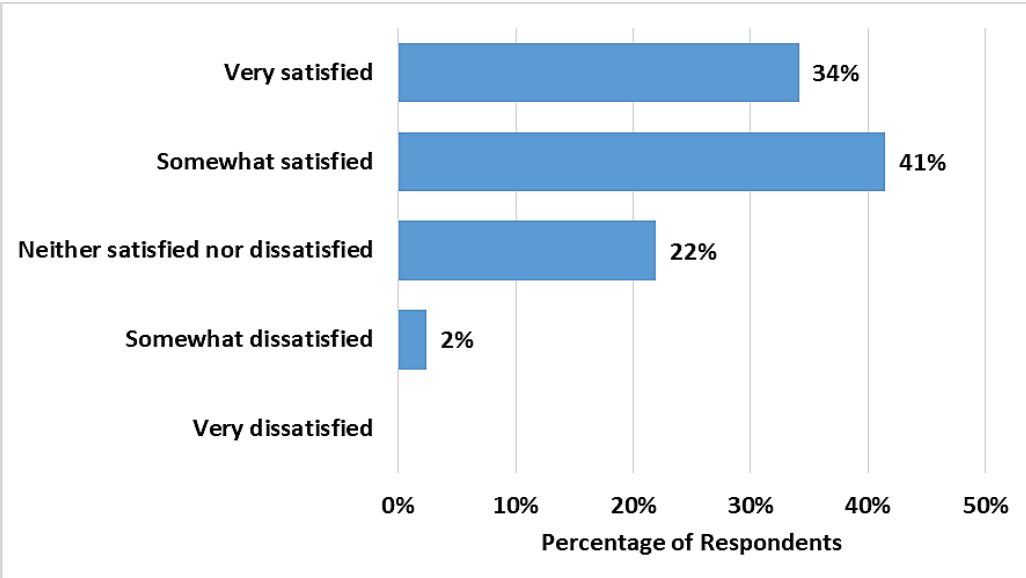



Question F1. “Thinking about your overall experience with the weatherization program, how would you rate your satisfaction?” (n=44)

166 The remaining respondents either did not know their annual income or preferred not to answer the question.

Roughly 75% of respondents (n=41) reported they were *very satisfied* (34%) or *somewhat satisfied* (41%) with their homes' comfort and temperature control after the installation of energy efficiency services and products through the Wise Home Pilot, as shown in Figure 12-9. Before weatherization, 44% were satisfied with their home's comfort and temperature control.[167]

**Figure 12-9: Treatment Group Participant Satisfaction with Home Weatherization**



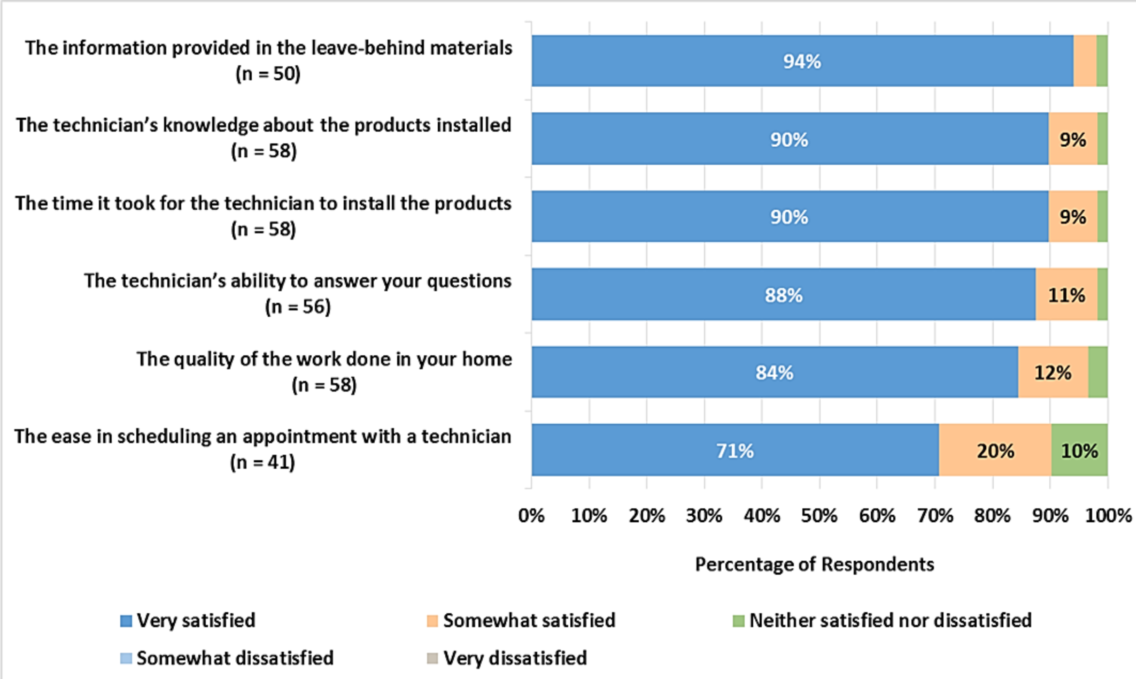

Source: Cadmus survey question E15. "Overall, since the weatherization of your home, how would you rate your satisfaction with your home's comfort and temperature control?" (n=41)

Respondents rated their satisfaction, from *very dissatisfied* to *very satisfied*, with elements of the pilot pertaining to the technician who performed the home weatherization, as shown in Figure 12-10.

Respondents were typically most satisfied with the information contained in the leave-behind materials; 94% indicated they were *very satisfied*. Respondents were least satisfied with the ease in scheduling an appointment with a technician; 71% indicated they were *very satisfied*.

[167] Respondents were less often *very satisfied* (17%) or *somewhat satisfied* (27%) with their home comfort prior to the weatherization of their homes.

**Figure 12-10: Satisfaction with Elements of Weatherization Process**

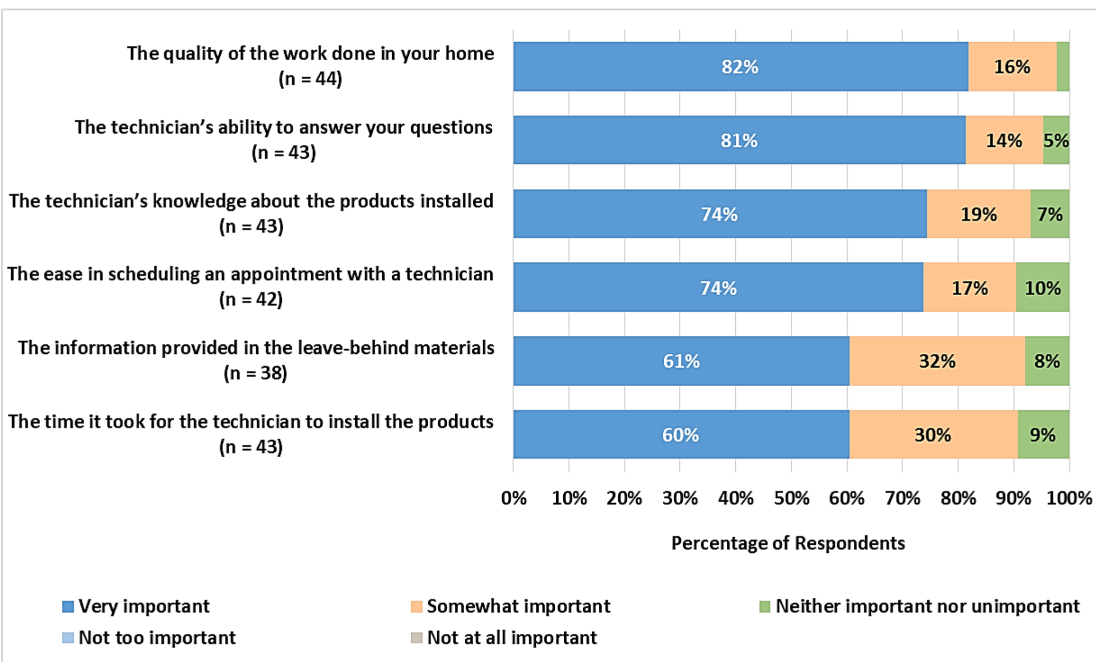



Source: Survey question E2, "Please rate your satisfaction for each of the following statements…". Postcard survey questions 1-5, "How satisfied were you with the…". Frequencies reflect aggregated online/telephone participant survey responses and leave-behind postcard survey responses.

### *Importance of Wise Home Pilot Elements*

Respondents rated, from *not at all important* to *very important*, the importance of various elements of the home weatherization that pertained to the technician, as shown in Figure 12-11.

**Figure 12-11: Importance of Elements of Weatherization Process**




Source: Cadmus survey question E4. "Please rate how important to you each of the following statements are."

Respondents indicated that the quality of work and the technician's ability to answer questions were most important; 82% said these were *very important*. Conversely, 59% of respondents indicated the information provided in the leave-behind materials and the time it took for the technician to install the products were least important.

Although overall satisfaction ratings were very high, respondents were typically less satisfied with some elements of the pilot that they considered to be very important. As shown in Figure 12-11, respondents rated these as *very important*—the quality of the work (82%), the technician's ability to answer questions (81%), and the ease in scheduling an appointment (74%). However, for the previous questions (as shown in Figure 12-10), respondents reported their lowest levels of satisfaction with these same three elements—the quality of the work (84%), the technician's ability to answer questions (88%), and the ease in scheduling an appointment (71%).

Respondents most frequently cited LED light bulbs and various insulation products, including duct sealing and weatherstripping, as the most important products installed during the home weatherization, as shown in Table 12-37.

**Table 12-37: Most Important Product(s) or Information Provided**

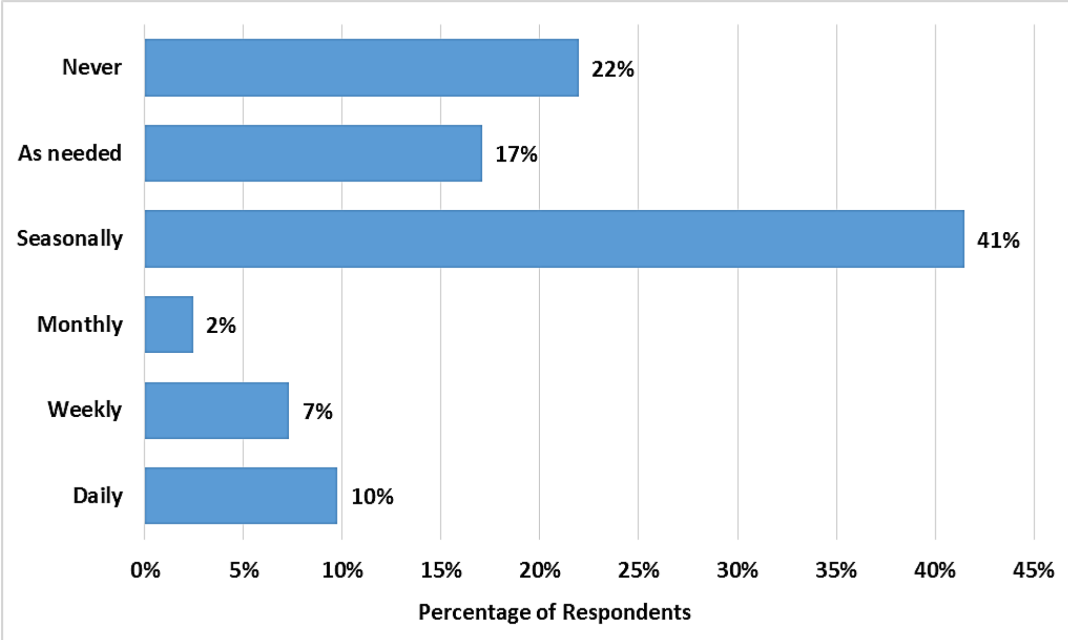
| Product or Information | Count |
|---|---|
| Insulation, weather-stripping, duct sealing | 14 |
| LED light bulbs | 14 |
| Water heater pipe wraps | 5 |
| Low-flow shower heads | 4 |
| Carbon monoxide (CO) monitor | 3 |
| Advanced power strip | 2 |
| Other | 5 |
| (None, N/A) | 6 |
| **Total** | **53** |

Source: Cadmus survey question E5. "Which of the products and information the technician provided was most important to you?" Open-ended/multiple response. (n=44)

### *Behavior*

Twenty-two percent of telephone survey respondents (n=41) said they never manually changed the temperature on their thermostats since the home weatherization occurred, and another 17% of respondents only adjusted the thermostat as needed, as shown in Figure 12-12. Respondents most frequently adjusted their thermostats seasonally.

**Figure 12-12: Manual Thermostat Change Frequency**

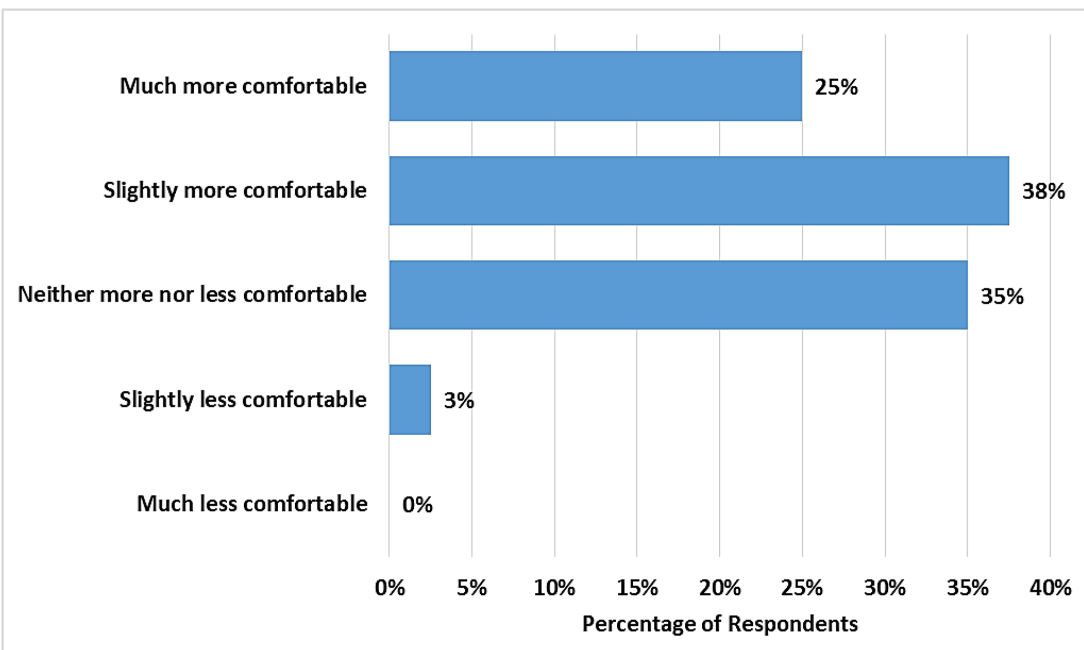



Question E12. "Since the weatherization of your home, how frequently do you manually change the temperature on your thermostat?" (n=41)

When asked if they had started manually changing the temperatures on their thermostats more often after the home weatherization occurred, all respondents (n=39) indicated they had not. They either changed them less often (41%) or as often (59%) as before. These actions indicated positive shifts in energy-saving behaviors that reduce household consumption and overall demand.

Figure 12-13 shows how respondents' comfort levels changed after the weatherization of their homes.

**Figure 12-13: Comparison of Comfort Before and After Weatherization**




Question E14. "Since your home was weatherized, has your level of comfort changed?" (n=40)

Only 3% of respondents (n=40) said they were *slightly less comfortable* since their homes were weatherized. No respondents said they were *much less comfortable*. Sixty-three percent of respondents said they felt *slightly more comfortable* (38%) or *much more comfortable* (25%).

About 84% of survey respondents claimed their monthly energy bills had either not changed or decreased slightly since their homes were weatherized through the pilot.

On a scale of 1 to 10, survey respondents rated the likelihood they would recommend the pilot to a friend, relative, or colleague an average of 8.8 (n=42).

#### *Reasons for Dissatisfaction*

Eight respondents (n=44) offered feedback that PPL Electric Utilities could use to improve participants' experiences with the Wise Home Pilot.

- One respondent recommended making it easier to schedule an appointment with the technician.
- One respondent asked for more information on programs to help reduce the household energy bill and claimed the technician could not answer.
- One respondent said, *"The only thing that was installed was some insulation around our rear door."*[168]
- One respondent asked for one more door strip, both indicating a desire for additional or more thorough product installations.
- One respondent noted that the technician did not show up to install the weatherization products.

Overall, Cadmus found during calls to potential survey respondents that 14% said a technician never followed up with them or never showed up to the home to perform the weatherization.

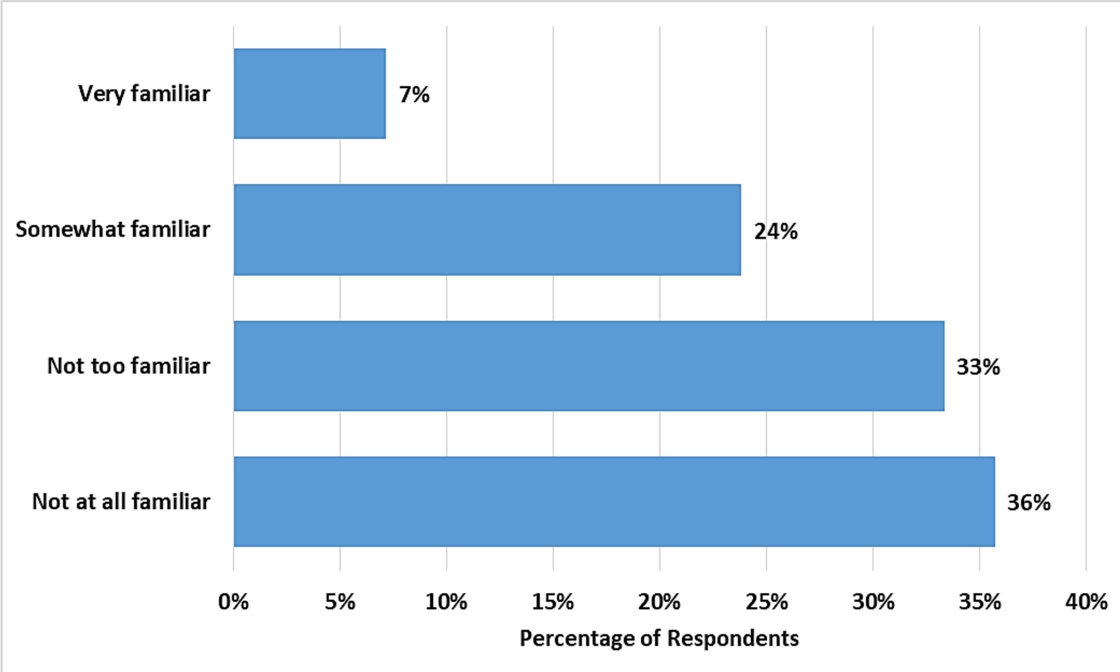
#### *Awareness and Motivation*

As shown in Figure 12-14, 7% of respondents (n=42) reported they were *very familiar* with other rebates and programs offered by PPL Electric Utilities, and another 24% reported they were *somewhat familiar*. The majority of respondents, however, reported they were *not at all familiar (36%)* or *not too familiar* (33%) with other PPL Electric Utilities rebates and programs.

Among the 27 respondents who indicated they were *not too* or *not at all familiar* with other PPL Electric Utilities rebates and programs, eight respondents (30%) recalled the Appliance Recycling Program. The remaining responses were not specific, primarily consisting of *none* or *I don't know* (30%) or *programs included in the monthly billing materials* (19%). One respondent (4%) mentioned LIHEAP (Low-Income Home Energy Assistance Program) by name, and another respondent (4%) referred to a pilot involving insulation and water heater replacement, which most closely relates to the Winter Relief Assistance Program (WRAP).

[168] According to data in the EEMIS database, this participant received weather strip(s), door caddie(s), LED light bulb(s), power strip(s), and caulking.

**Figure 12-14: Awareness of Other PPL Electric Utilities Rebates and Programs**




Question H1. "How familiar are you with other energy-efficiency rebates or programs from PPL Electric Utilities that help you with ways to use less energy and save money?" (n=42)

### 12.7.4.8 Marketing and Outreach

PPL Electric Utilities used direct mailers as its primary method of contacting customers about the Wise Home Pilot. Cadmus had previously conducted an analysis to ascertain customers in manufactured home parks by geographic regions in PPL Electric Utilities' service territory and by their monthly energy consumption. PPL Electric Utilities also targeted potential participants through information sessions at manufactured home parks, employing park managers to post fliers and notices, and conducted follow-up phone calls with interested homeowners. PPL Electric Utilities acknowledged that using branding from the E-Power Wise Program may have been less effective than it would have been using its own branding, as PPL Electric Utilities branding may have been more recognizable.

### 12.7.4.9 Challenges

*Recruitment and Enrollment*

PPL Electric Utilities struggled to attract customers to participate in the Wise Home Pilot. Both PPL Electric Utilities and the ICSPs (RAP and Franklin Energy) acknowledged the difficulty in reaching out to a primarily low-income and/or elderly demographic that were often subject to attempts of fraudulent activity.[169] Because customer distrust played a large role in recruitment difficulties, PPL Electric Utilities attempted to build trust with the target customer base through multiple channels of communication, including direct mailers, phone calls, and in-person visits to manufactured home parks to publicize the program. PPL Electric Utilities also paid manufactured home park managers to drop off flyers at residents' homes.

The fact that the Wise Home Pilot was free was expected to more readily attract customers from the target demographic groups but may have triggered skepticism instead, leading to the decision not to

[169] For example, third-party energy companies try to convince homeowners to switch utility providers by promising lower rates and offering free goods.

participate. RAP noted that even during installation of energy-efficient products in the home, participants still expressed disbelief that the pilot was free. It administers many direct-to-customer programs, and its representative was *"surprised by the level of skepticism and amount of pushback from customers."* Nevertheless, participants reported high levels of satisfaction so RAP thinks the pilot provided value.

PPL Electric, Cadmus, and Franklin Energy coordinated efforts to target and screen participants and to control participation to retain the study's enrollment targets in each of the four study groups. Because responses and participation did not meet targets, PPL Electric Utilities expanded the customer roster three times and conducted four rounds of direct mailing. Despite the expanded effort, the pilot still did not reach its desired level of 600 participants, as shown in Table 12-33. Franklin Energy reported that if the initial outreach effort had been much larger, it believed the pilot would have achieved its participation target and achieved it sooner. However, it acknowledged the outreach may have been time-consuming and not as cost-effective to target a larger market.

#### *Heating Criteria and Revisions to Study Groups*

After it sent direct mailers to customers, PPL Electric Utilities learned that dramatically fewer customers used electric heating in their manufactured homes than it had expected. This forced it and Cadmus to revise the focus of the pilot with Cadmus. Ultimately, PPL Electric Utilities redistributed participants from one main study group to four separate study groups according to customer homes' heating and cooling systems, as described in Section 12.7.1, and offered more partial treatments in place of fewer full treatments.

#### *Delivery Delays*

The revision to the pilot's scope in response to the low enrollment delayed the pilot's implementation, which resulted in home weatherization occurring in the winter rather than summer. Technicians had fewer hours of daylight during which they could visit participants' homes. In addition, weatherization home visits occurred near the holidays, reducing the probability that a homeowner would be present and available or willing to accommodate a site visit. Technicians had difficulty scheduling visits in an efficient and cost-effective manner because of the large size of PPL Electric Utilities' service territory and the small number of participants, especially without knowing beforehand which products and services would be installed at each home.

RAP stated it could have emphasized more strongly to PPL Electric Utilities certain difficulties with scheduling, such as extreme weather conditions and insufficient numbers of participants in particular locales.

#### *Installation Challenges*

Franklin Energy's primary field technician reported he had the most difficulty installing advanced power strips, typically because heavy furniture had to be moved to access electrical outlets. Participants reportedly sometimes declined the installation of power strips because they required too much moving of furniture/equipment to install. Installing air conditioner covers proved *"kind of uncomfortable"* because some homes had gardens in front of the air conditioner units. Installing duct sealing was not difficult, but determining exactly where to install duct sealing and accessing the particular spot was occasionally challenging. Participants sometimes declined shower heads because of the low-flow design.

The technician characterized the process of collecting data during the home audit not as "difficult" but as "confused." He said participants did not understand some of the questions he asked regarding home specifications, so he used common sense to ensure the answers were correct. He did not collect data regarding the insulation used underneath the trailer. Explaining what he was doing to customers was time-consuming, but he also perceived the explanation was a good thing because it was educational.

The technician observed that participants occasionally did not fully understand what the pilot entailed. Participants expressed skepticism that the products and services were free and curiosity about what would happen next. Homeowners reportedly asked the technician if he could also change the windows or if he could come back to help with the air conditioning unit. He said he had no answers for them except to give them PPL Electric Utilities' phone number to ask about the services.

The technician said he did not receive instruction to promote other PPL Electric Utilities programs during his visits to participants' homes. He also said he did not know any programs offhand, so he learned about them by searching on Google so he could have answers prepared in case anyone asked. The technician reported that some participants asked about refrigerator and air conditioner programs that PPL Electric Utilities offered, but he did not have any information about them.

### 12.7.5 Conclusions and Recommendations

Based on the findings, Cadmus suggests that PPL Electric Utilities consider the following recommendations, should PPL Electric Utilities offer a pilot or program of this nature in the future.

**Conclusion**
The actual number of manufactured homes that use electric forced air heating was substantially lower than anticipated, requiring an unanticipated study redesign, delaying the implementation of the pilot for several months. PPL Electric Utilities asked customers interested in the pilot to indicate the energy sources for the heating and cooling in their homes, and Cadmus used statistical sampling to try to identify homes that likely had electric forced air heating (see Section 12.7.4.9).

**Recommendation**
PPL Electric Utilities took ample precautionary measures to screen customers prior to participation. The possibility exists that customers may have misreported or simply did not know their homes' heating and cooling types. Similar programs in the future may benefit from an additional low-cost screening step, such as a phone call, that attempts to verify self-reported information from customers.

**Conclusion**
PPL Electric Utilities made concerted efforts to connect and establish trust with customers by visiting manufactured home parks and speaking with customers and park managers in person. PPL Electric Utilities offered the Wise Home Pilot free of charge to customers. However, stakeholder interviews revealed that frequent scams promoting free programs have cultivated distrust among the program's target demographic. Thus, the program's participation rate may have suffered from an inherent lack of trust in free programs (see Section 12.7.4.9).

**Recommendation**
PPL Electric Utilities could include information about future low-income programs in monthly energy bills to tap into additional direct, known, and trusted avenues of communication with customers.

**Conclusion**
Some participants did not understand what the pilot entailed and occasionally expected more than what it offered. Delays in implementation may have led to customers misremembering or forgetting what the pilot entailed. These issues occasionally placed technicians in uncomfortable situations and may have suppressed customer satisfaction rates (see Section 12.7.4.9).

**Recommendation**
In its efforts to market the Wise Home Pilot to customers, PPL Electric Utilities tried to thoroughly explain the benefits of the pilot. It can be difficult to provide details about free products while trying not to

promise too much to potential participants. PPL Electric Utilities could provide clearer information on the conditional nature of pilot offerings during recruitment to manage customer expectations.

**Conclusion**

Technicians had little knowledge of other PPL Electric Utilities programs and could not inform participants about other programs (see Section 12.7.4.8).

**Recommendation**

PPL Electric Utilities could provide a training session for technicians and subcontractors to enhance their knowledge of other PPL Electric Utilities offerings. This would help technicians answer customer questions and satisfy PPL Electric Utilities' desire to generate awareness of its other programs.

### 12.7.5.1 Status of Recommendations for Program

Table 12-38 contains the status of each PY7 process recommendation made to PPL Electric Utilities.

**Table 12-38: Wise Home Pilot Status Report on Process and Impact Recommendations**

| Recommendations | EDC Status of Recommendation (Implemented, Being Considered, Rejected AND Explanation of Action Taken by EDC) |
|---|---|
| **Wise Home Pilot** | |
| Include additional low-cost screening step, such as a phone call, to verify self-reported customer information, e.g., heating and cooling equipment and fuel type. | Being considered and will likely be implemented. |
| Include information about low-income programs in customers' monthly energy bills. | Will be implemented as part of the Phase III marketing strategy. |
| Provide more clear information regarding the conditional nature of program and pilot offerings. | Will be implemented. |
| Train technicians about other program offerings to inform participants. | Will be implemented. |

### 12.7.6 Financial Reporting

A breakdown of Wise Home Pilot finances is presented in Table 12-39.

**Table 12-39: Summary of E-Power Wise Program Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs[6] ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs (Sum of rows 2 to 4) | $0 | $0 |
| 2 | EDC Incentives to Participants | $0 | $0 |
| 3 | EDC Incentives to Trade Allies | $0 | $0 |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $0 | $0 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6, 7, 8, 9, 10 ) | $98 | $84 |
| 6 | Design & Development | $0 | $0 |
| 7 | Administration, Management, and Technical Assistance[1] | $98 | $84 |
| 8 | Marketing[2] | $0 | $0 |
| 9 | EDC Evaluation Costs | $0 | $0 |
| 10 | SWE Audit Costs | $0 | $0 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | $0 | $0 |
| | | | |
| 12 | Total TRC Costs[3] (Sum of rows 1, 5 and 11) | $98 | $84 |
| 13 | Total NPV Lifetime Energy Benefits | $113 | $97 |
| 14 | Total NPV Lifetime Capacity Benefits | $0 | $0 |
| 15 | Total NPV O&M Saving Benefits | $1 | $1 |
| 16 | Total NPV TRC Benefits[4] | $115 | $98 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | 1.17 | 1.17 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.
[2] Includes the marketing CSP and marketing costs by program CSPs.
[3] Total TRC Costs includes Total EDC Costs and Participant Costs.
[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.
[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[6] Phase II Costs in this table are discounted back to PY5, thus will not match cumulative costs reported in the PY6 Q4 quarterly report

# ADDENDUM A. PARTICIPANT SURVEY METHODOLOGY – WISE HOME PILOT

### 12.7.7 Contact Instructions

PPL Electric Utilities provided contact instructions for conducting surveys. Customers cannot be contacted for a survey if they have completed a survey in the three months prior to survey data collection or if they opted out of a survey. Telephone survey calls cannot take place on Sundays or national holidays.

Cadmus first e-mailed the online survey to all respondents with valid e-mail addresses up to three times each. Cadmus then called all respondents with valid phone numbers who did not complete the online survey up to three times each. Phone calls occurred up to three times per participant at different times of day and different days of the week to increase the probability of contact.

### 12.7.8 Sample Cleaning and Attrition

Cadmus screened the sample and removed records of any customers called in the past three months (whether for a Cadmus or PPL Electric Utilities survey) and who previously requested not to be contacted again. Cadmus also removed records with incomplete information. This cleaning and survey sample preparation process reduced the available sample.

Cadmus contacted all remaining records from the participant population. Table 12-40 lists the total number of records Cadmus contacted to conduct the survey along with the outcome (final disposition) of each record.

**Table 12-40: Survey Sample Attrition Table**

| Description of Call Outcomes | Number of Records |
|---|---|
| **Population** | **438** |
| Removed incomplete, missing, or bad phone number and e-mail address | 0 |
| Removed because on “do not call” list | 4 |
| Removed because in control group | 194 |
| **Survey Sample Frame** | **240** |
| Removed because missing group designation | 2 |
| **Used for Sample** | **238** |
| Not attempted | 0 |
| Records Attempted | 238 |
| Non-working number | 19 |
| Wrong number, business | 5 |
| PPL Electric or market research employee | 2 |
| Did not participate, doesn’t recall participating, or technician never came | 34 |
| Refusal | 46 |
| No answer/answering machine/phone busy | 85 |
| **Completed survey** | **44** |

# 13 CONTINUOUS ENERGY IMPROVEMENT PROGRAM

The Continuous Energy Improvement (CEI) Program targets school districts, for which PPL Electric Utilities provides technical support for schools to develop and implement a strategic energy management plan (SEMP). In the middle of PY5, PPL Electric Utilities identified eight school districts to participate in the program. Strategic Energy Group (SEG), the ICSP, assisted each district in selecting one school or facility to participate in the first (or pilot) year and to develop a SEMP to implement during PY6. These districts expanded the CEI Program to all schools in their district in PY7.

Each district also identified an energy manager, who could be a facility manager, energy expert, teacher, or administrator. The districts collaborated during monthly meetings, workshops, and conference calls led by the ICSP and shared best practices. By the end of the program, each district had developed an energy reduction goal, a methodology for measuring energy savings, and a plan to continually improve its energy performance. During PY7, all schools in the school district implemented a SEMP, relying on the experience gained at the first pilot building during PY6.

The SEMP included improvements in equipment and operation and maintenance (O&M) and changes in the energy-related behaviors of staff, faculty, and students. Most equipment upgrades were eligible for a rebate through other PPL Electric Utilities programs, such as the Prescriptive Equipment Program and the Custom Incentive Program.

The objectives of the CEI Program were these:

- Encourage customers to identify energy-saving opportunities by focusing on behavioral changes and fostering sustainability through individual engagement
- Assist school districts in defining an energy vision, resources, and goals of their own energy efficiency program
- Demonstrate how the program fits into the school district’s structure and use a systematic approach to quantify the success of energy management
- Raise employee and student engagement surrounding activities that directly influence the amount of energy consumed by systems and the schools
- Promote other PPL Electric Utilities energy efficiency programs
- Provide partial funding to offset a portion of the salary for school energy champion personnel
- Achieve participation with eight school districts through 2016, with a total reduction of approximately 3,150 MWh/yr

A summary of cumulative Phase II program metrics can be found in Table 13-1.

**Table 13-1: Phase II Continuous Energy Improvement Program Summary**

| Program | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Net-to-Gross Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) | Program Acquisition Cost ($/Annual kWh) | Cost of Conserved Energy (TRC Costs/ Lifetime kWh, at Generation) | Phase II Participants |
|---|---|---|---|---|---|---|---|---|---|
| Continuous Energy Improvement | 4,808 | 4,783 | 4,697 | 1.0 | 1.25 | $993 | $0.21 | $0.063 | 45 |
| **Total** | **4,808** | **4,783** | **4,697** | **1.0** | **1.25** | **$993** | **$0.21** | $0.063 | **45** |

## 13.1 PROGRAM UPDATES

Initially, the CEI Program planned to have 10 school districts in PPL Electric Utilities' territory participate during PY6 and PY7; however, two school districts dropped out just after the program started in PY6. The ICSP continued with eight school districts but retained the same planned energy savings as for 10 schools.

The ICSP did not recruit more school districts for PY7 because the program was designed for two program years of participation.

### 13.1.1 Definition of Participant

A participant in the CEI Program is defined as a job. As described in the energy efficiency and conservation (EE&C) plan,[170] the energy efficiency opportunities were implemented in one school in each participating district in PY6 then expanded to the other schools in the district in PY7. Forty-four schools[171] implemented SEMPs in PY7. Table 13-2 lists the number of participating schools with SEMPs in the eight school districts.

**Table 13-2: Number of Participating Schools per District in PY7**

| District [1] | Number of Participating Schools |
|---|---|
| District 1 | 5 |
| District 2 | 3 |
| District 3 | 1 |
| District 4 | 8 |
| District 5 | 5 |
| District 6 | 11 |
| District 7 | 6 |
| District 8 | 5 |
| **Total** | **44** |
| [1] Districts are not named to maintain anonymity. | |

## 13.2 IMPACT EVALUATION GROSS SAVINGS

### 13.2.1 Reported Gross Savings

Table 13-3 shows the reported energy savings and demand reduction for the participating schools in the CEI Program in PY7.

170 PPL Electric Utilities' revised EE&C Plan (Docket No. M-2012-2334288) approved by the Pennsylvania PUC on June 5, 2015, p.178.

171 Note that this differs from the number of jobs that are listed in the program database. Forty-five jobs are listed, however two of these jobs are from a single school. Hence, the number of schools referred to in this report is 44.

**Table 13-3: Phase II Continuous Energy Improvement Program Reported Results by Customer Sector**

| Sector | Phase II Participants | Phase II Reported Gross Energy Savings (MWh/yr) | Phase II Reported Gross Demand Reduction (MW) | Incentives Paid ($1,000) |
|---|---|---|---|---|
| Residential | - | - | - | - |
| Low-Income | - | - | - | - |
| Small C&I | - | - | - | - |
| Large C&I | - | - | - | - |
| Government/Nonprofit/Education | 45 | 4,808 | 0.55 | - |
| **Phase II Total** | **45[1]** | **4,808** | **0.55** | - |

[1] EEMIS shows a total of 53 participants. Eight of these refer to PY6 savings for the eight pilot schools uploaded by the ICSP in PY7. The actual number of PY7 participant records is 45.

### 13.2.2 Database Review

Cadmus inspected records for eight districts and 44 schools to verify customer information and electric and demand savings data (Table 13-4). The ICSP reported data for all 44 participating schools in the energy efficiency management information system (EEMIS) database as required. The ICSP also provided documentation for 44 participating schools.

**Table 13-4: PY7 CEI Program Impact Evaluation QAQC Database Review**

| Stratum | Population Size | Assumed Levels of Confidence & Precision | Target Sample Size | Achieved Sample Size | Used For Evaluation Activities (Impact, Process, NTG) |
|---|---|---|---|---|---|
| Schools | 44 | N/A | Census | 44 | Process, impact |

### 13.2.3 EM&V Sampling Approach

Cadmus included all eight school districts in the impact evaluation, as shown in Table 13-5. In PY7, 44 schools were enrolled in the CEI Program. Cadmus conducted separate documentation reviews and billing analyses for each school.

**Table 13-5: PY7 CEI Program Sampling Strategy**

| Stratum | Population Size | Target Levels of Confidence & Precision | Target Sample Size | Achieved Sample Size[1] | Evaluation Activity |
|---|---|---|---|---|---|
| Schools | 44 | N/A | Census | 42 | Documentation review, billing analysis |

[1] Two schools were removed as part of the *ex post* adjustments. See 13.2.5 Ex Post Savings Methodology and Findings.

### 13.2.4 *Ex Ante* Savings Methodology and Findings

In PY7, the energy savings and demand reduction for the 44 participating schools were reported in PPL Electric Utilities' database (Table 13-7 and Table 13-8 show the Program Year to Date [PYTD] Reported Gross savings in Section 13.2.6 Summary of Evaluation Results). Cadmus made two adjustments to the ex *ante* savings:

- One school required an update to its yearly savings estimate after the ICSP uploaded its data into EEMIS. PPL Electric provided this update to Cadmus. Demand savings for this school remained unchanged.
- In PY7, the ICSP uploaded PY6 savings estimates for the eight pilot schools in EEMIS. Because these savings were previously reported for PY6, Cadmus adjusted the *ex ante* savings to zero for PY7.

### 13.2.5 *Ex Post* Savings Methodology and Findings

PPL Electric Utilities provided hourly interval billing data, which Cadmus used to quantify annual energy savings and demand reduction. Cadmus conducted a billing analysis, which conformed to the International Performance Measurement and Verification Protocol (IPMVP) Option C, whole facility report.[172] Cadmus specified separate regression models for each participating school. Cadmus could not evaluate savings at two schools because of these facility changes:

- One school building was no longer being used as an elementary school prior to the beginning of PY7. Cadmus determined that because of this it could not evaluate this school.
- The ICSP noted that one school underwent renovations after the baseline period. Because renovations confounded savings estimates, Cadmus determined that it could not evaluate this school.

Cadmus also specified separate models for energy savings and demand reduction.

#### 13.2.5.1 Energy Savings Methodology

For the energy savings models, Cadmus aggregated hourly interval data to daily energy use. Cadmus used daily data that coincided with the date range of monthly billing data used by the ICSP. For some schools, Cadmus opted to define the baseline differently than the ICSP, in order to capture a full 12 months of baseline data and to ensure that the baseline period did not have any savings related to early adoption of CEI Program activities. The baseline models included weather, season, daylight hours, and variables relating to the school's schedule (indicating school days, weekend days, holidays, and in-service days). Cadmus computed energy savings as the difference between predicted savings and actual consumption in the billing data provided by PPL Electric.

Some CEI Program participants applied for rebates from other PPL Electric Utilities' programs, such as the Prescriptive Equipment Program. Of the 42 schools evaluated, 28 (67%) had savings from capital projects. To avoid double-counting these savings, Cadmus subtracted the rebated equipment's *ex ante* savings from the regression analysis savings estimate (whole facility savings). A total of 610 MWh/yr in savings was subtracted across all schools because of cross-program participation.

Cadmus estimated the relative precision for whole facility savings but not for CEI Program savings. CEI Program savings are the difference between whole facility savings and capital project savings; however, standard errors were not available for capital project savings.[173] The magnitude of capital project savings was small compared to whole facility savings. Cadmus anticipated that capital project uncertainty would have little effect on total uncertainty; therefore, the precision estimates for CEI Program savings will be approximately equal to the precision estimates for whole facility savings.

#### 13.2.5.2 Demand Reduction Methodology

Cadmus estimated the demand reduction savings of the 42 schools that could be evaluated with a customer fixed effects panel regression (that included all schools). The model used hourly interval data with an indicator variable to signify each hour in the coincident peak demand period as defined by the

172 International Performance Measurement and Verification Committee. *International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings*. January 2012. Available online: http://www.coned.com/energyefficiency/PDF/EVO%20-%20IPMVP%202012.pdf.

173 Note that the precision for capital projects would need to account for two sources of error: 1) error due to sampling, and 2) error around the engineering savings estimate. The sampling precision is available for projects rebated through other PPL programs, however the precision around the engineering savings estimate is not available and would be difficult to quantify.

2015 Pennsylvania TRM.[174] The demand savings model included variables to account for the effects of each school in addition to several variables used in the energy savings models. The baseline period was defined as the peak months during the year before the school districts joined the program. The test period was defined as the peak months during the year of participation.

Cadmus restricted the demand model to weekdays to coincide with the definition of peak demand in the 2016 Pennsylvania TRM. Cadmus applied the average savings during the peak demand period to all 42 schools. This differs from the method used by the ICSP, which calculated demand reduction by applying a coincidence factor to the annual energy savings for each school.

### 13.2.5.3 Energy Savings Findings

Both Cadmus and the ICSP used a regression model to estimate energy savings. Cadmus defined the baseline for the regression as a period of at least 12 months before the pilot school began participation (PY6). The test period is defined as the year of participation (PY7). Cadmus verified savings of 4,697 MWh/yr and a 98.2% realization rate. *Ex post* savings were different than *ex ante* savings due primarily to differences in the definition of the baseline period, which were:

- For 7 schools, the ICSP's baseline period had fewer than 12 months.
- For 9 schools, the ICSP's baseline period overlapped with the pilot school participation period.

In total, Cadmus adjusted the baselines for 13 schools in the CEI Program, shown in Table 13-6. Cadmus' verified savings for 10 of the 13 schools were different than reported savings.[175] Of these 10 schools:

- 5 schools had baselines that were shorter than 12 months
- 7 schools had baselines that overlapped with the pilot-school program period

Interviews with the ICSP suggested that when the pilot school began participation, district energy managers were not discouraged from sharing program activities with other schools in the same district. Nevertheless, the ICSP-defined baselines for seven schools extend into the pilot school participation period. By including program activities—which were expected to reduce energy consumption at the facility—in the baseline, the regression model risks under-predicting consumption at the facility, thereby underestimating savings.

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174 Table 1-3 of the 2016 Pennsylvania TRM defines the coincident peak demand period as 2:00 p.m. to 6:00 p.m. during June through August, excluding weekends and holidays. Pennsylvania Public Utility Commission. *Pennsylvania Technical Reference Manual.* June 2016.

175 Statistically significant at the 85% confidence level.

**Table 13-6: Schools where Cadmus Adjusted the ICSP Baseline**

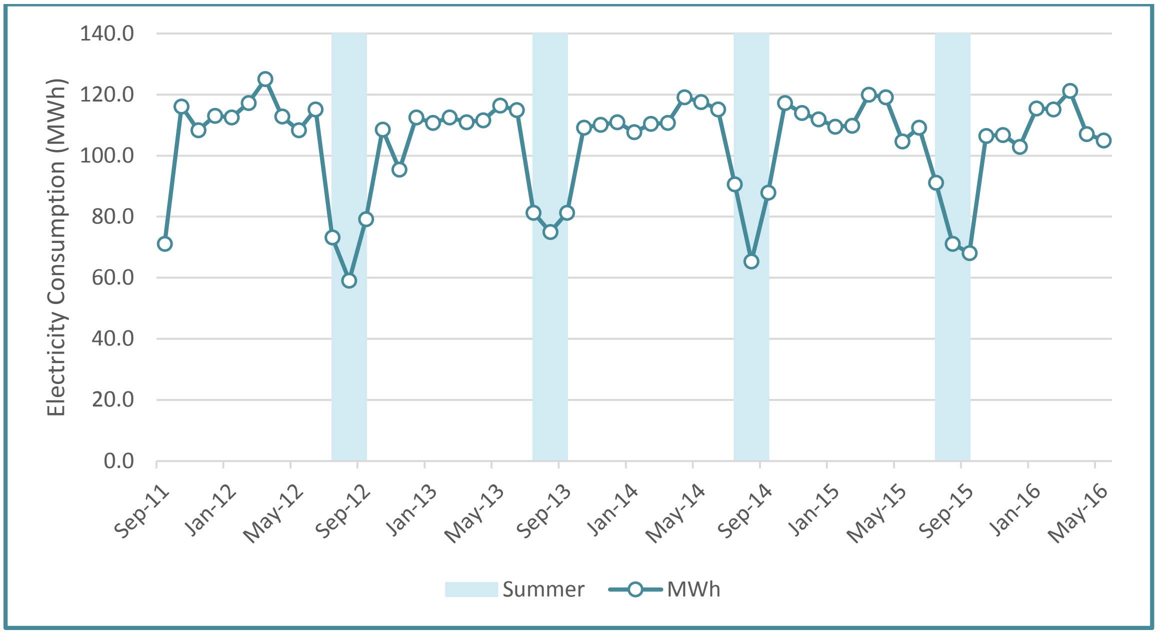
| | Baseline Shorter than 12 months | Baseline Overlaps with Pilot Period | Verified Savings Differ from Reported Savings[1] |
|---|---|---|---|
| School 1 | ✓ | ✓ | ✓ |
| School 2 | ✓ | ✓ | |
| School 3 | ✓ | | |
| School 4 | | ✓ | |
| School 5 | ✓ | | ✓ |
| School 6 | | ✓ | ✓ |
| School 7 | ✓ | ✓ | ✓ |
| School 8 | | ✓ | ✓ |
| School 9 | | ✓ | ✓ |
| School 10 | | ✓ | ✓ |
| School 11 | ✓ | | ✓ |
| School 12 | ✓ | | ✓ |
| School 13 | | ✓ | ✓ |
| **Program Total** | **7** | **9** | **10** |

[1] Differences between verified and reported savings are noted if they are statistically significant at the 85% confidence level.

For two schools, the ICSP left summer months out of the baseline. These schools had large reported savings compared to the verified savings.[176] Excluding summer months from the baseline can lead to overestimation of savings because the reduced consumption during summer could be incorrectly attributed to program activity rather than reduced use of the facility. Table 13-1 highlights an example of the change in energy consumption at one participating school during summer months (indicated by the shaded regions), thereby demonstrating the importance of including these months in a baseline model.

176 Statistically significant at the 85% confidence level.

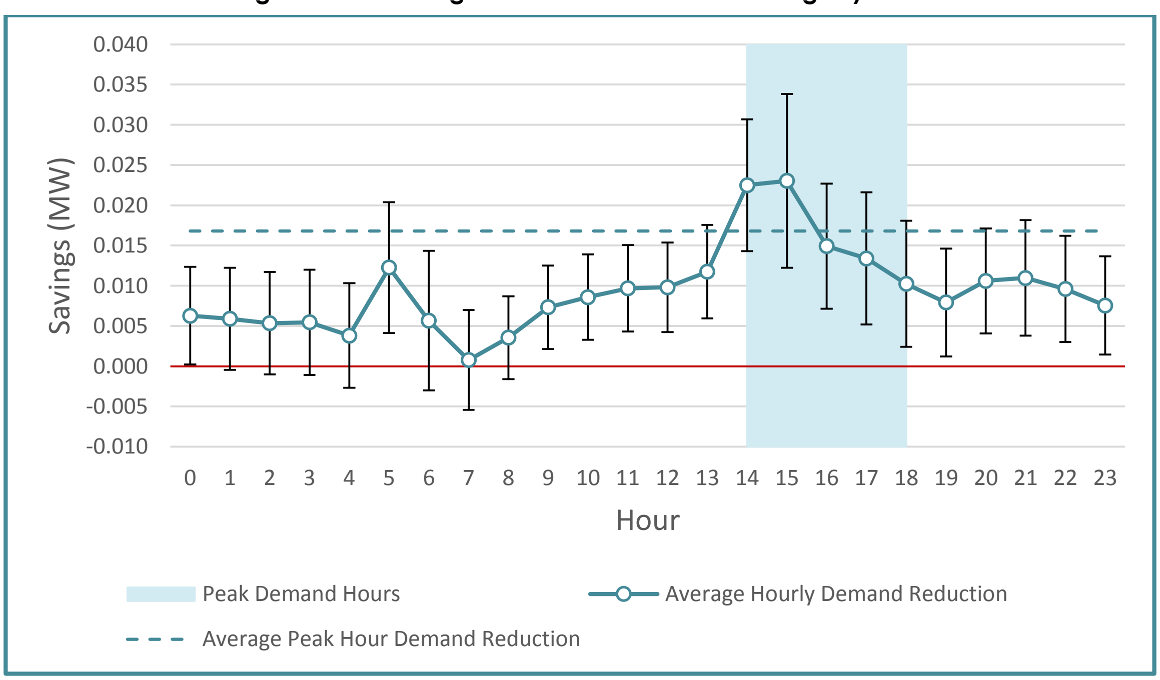
**Figure 13-1: Seasonality of Energy Consumption**




### 13.2.5.4 Demand Reduction Findings

Cadmus estimated the hourly savings during the peak demand period. The peak period demand savings profile is shown in Figure 13-2. The blue shading corresponds to peak hours, as defined by the 2015 Pennsylvania TRM, and the profile shows the demand savings reduction for every hour in the day for the 42 schools. Using this hourly breakdown, Cadmus identified when demand reduction savings occurred through the day during the peak demand months. The average weekday demand reduction savings is 0.227 MW. Thirty-seven percent of these savings (0.084 MW) occurred during peak demand hours (2 p.m. through 6 p.m.). The average peak hours demand reduction per school was 0.1682 MW, as indicated by the dashed line.

**Figure 13-2: Average Peak Period Demand Savings by Hour**



#### 13.2.5.5 Site Visits

The regression analysis did not require site visits, therefore, Cadmus did not conduct site visits in PY7 for the CEI Program.

### 13.2.6 Summary of Evaluation Results

Table 13-7 summarizes the results of the impact evaluation by district. Cadmus verified savings of 4,697 MWh/yr and a 98.2% realization rate. Total electricity consumption across all 42 evaluated schools in absence of the program was 56,667 MWh/yr. The verified savings are 8.3% of the total energy consumption across all facilities during the program period.

**Table 13-7: PY7 CEI Program Summary of Evaluation Results for Energy[1]**

| Stratum | PYTD Reported Gross Energy Savings (MWh/yr) | PYTD Adjusted *Ex Ante* Energy Savings (MWh/yr) | Energy Realization Rate (%) | PYTD Verified Gross Energy Savings (MWh/yr) [2] | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 85% C.L.[3] |
|---|---|---|---|---|---|---|
| District 1 | (223) | (223) | 101% | (225) | N/A | 15.25% |
| District 2 | 340 | 340 | 79% | 269 | N/A | 10.22% |
| District 3 | 492 | 466 | 120% | 562 | N/A | 8.88% |
| District 4 | 862 | 862 | 97% | 839 | N/A | 2.77% |
| District 5 | 634 | 634 | 84% | 532 | N/A | 18.13% |
| District 6 | 1,246 | 1,246 | 115% | 1,430 | N/A | 6.97% |
| District 7 | 1,315 | 1,315 | 90% | 1,189 | N/A | 3.53% |
| District 8 | 142 | 142 | 71% | 101 | N/A | 79.37% |
| **Program Total** | **4,808** | **4,783** | **98%** | **4,697** | **N/A** | **3.83%** |

[1] Values in this table refer to savings at the point of consumption. (Savings targets for MWh refer to values at the point of consumption.) Due to line losses, savings at the point of generation are systematically larger.
[2] Adjusted *ex ante* multiplied by the realization rate will not equal verified gross energy savings due to rounding.
[3] Relative precision estimates represent uncertainty of the whole-facility estimates and do not account for uncertainty of capital project estimates.

Table 13-8 summarizes the reported and verified demand reduction. Cadmus verified 0.768 MW of demand reduction and a 131% realization rate. The demand reduction savings have a relative precision of 46.6% at 85% confidence. The most likely cause of this high precision is a large amount of variance across schools and peak time periods in the program treatment effect. Additionally, the regression model may not be explaining some of the variation in hourly energy consumption.

**Table 13-8: PY7 CEI Summary of Evaluation Results for Demand**

| District | PYTD Reported Gross Demand Savings [1] (MW) | PYTD Adjusted *Ex Ante* Demand Savings [2] (MW) | Demand Realization Rate (%) | PYTD Verified Gross Demand Savings [2] (MW) | Sample Coefficient of Variation (Cv), Error Ratio (ER), or Proportion | Relative Precision at 85% C.L. |
|---|---|---|---|---|---|---|
| District 1 | (0.026) | (0.027) | -198% | 0.054 | N/A | 46.57% |
| District 2 | 0.039 | 0.041 | 216% | 0.089 | N/A | 46.57% |
| District 3 | 0.056 | 0.060 | 239% | 0.143 | N/A | 46.57% |
| District 4 | 0.099 | 0.105 | 85% | 0.089 | N/A | 46.57% |
| District 5 | 0.073 | 0.077 | 23% | 0.018 | N/A | 46.57% |
| District 6 | 0.143 | 0.152 | 118% | 0.179 | N/A | 46.57% |
| District 7 | 0.151 | 0.160 | 67% | 0.107 | N/A | 46.57% |
| District 8 | 0.016 | 0.017 | 517% | 0.089 | N/A | 46.57% |
| **Program Total** | **0.550** | **0.585** | **131%** | **0.768** | **N/A** | **46.57%** |

[1] Reported gross demand reductions do not include the gross-up to reflect transmission and distribution (T&D) losses.
[2] *Ex ante* and verified gross demand reductions include T&D losses.

## 13.3 IMPACT EVALUATION NET SAVINGS

Freeridership is a measure of the energy savings that participants would have achieved on their own in the absence of the program; these savings are subtracted from verified gross savings. Participant spillover, on the other hand, credits the additional savings participants achieved on their own, where their experience with the program was highly influential in their decision to install energy-efficient equipment without the incentive of rebates. Participant spillover adds to gross savings.

Net savings are determined only for future program planning purposes. Energy savings and demand reduction compliance targets are met using verified gross savings.

### 13.3.1 Net-to-Gross Ratio Methodology

Cadmus completed a telephone survey with eight energy managers, one from each participating school district. It also conducted 15 telephone surveys with energy champions from the participating schools that had them. These surveys were completed during May and June 2016 and also included questions to inform the process evaluation. For details on the survey methodology, see *Addendum A. Participant Survey Attrition and Final Disposition*.

Cadmus used participant responses about the program's influence to determine the CEI Program's freeridership. No savings are attributed to spillover, as all energy savings impacts at participating schools are captured using the billing analysis. Cadmus did not measure spillover from non-participants.

### 13.3.2 Net-to-Gross Ratio Sampling

Cadmus interviewed participants, as shown in Table 13-9, to determine the program's influence on their decision to participate in the CEI Program and implement continuous energy improvement activities.

**Table 13-9: CEI Sampling Strategy for PY7 NTG Research**

| Stratum | Stratum Boundaries | Population Size | Assumed CV or Proportion in Sample Design | Assumed Levels of Confidence & Precision | Target Sample Size | Achieved Sample Size | Percent of Sample Frame Contacted[1] |
|---|---|---|---|---|---|---|---|
| School District | School District | 8 | N/A | N/A | 8 | 8 | 100% |
| School | School | 18[2] | N/A | N/A | 18 | 15 | 100% |
| **Program Total** | | **26** | **N/A** | **N/A** | **26** | **23** | |

[1] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means the percentage of the sample frame called to complete surveys.
[2] Multiple schools had the same energy champion (sharing the district energy manager) so this is the number of unique contacts.

## 13.3.3 Net-to-Gross Ratio Findings

Table 13-10 shows a summary of the NTG ratio for the CEI Program participants.

**Table 13-10: PY7 CEI Summary of Evaluation Results for NTG Research**

| Stratum | Estimated Freeridership | Estimated Participant Spillover | NTG Ratio | Observed Coefficient of Variation or Proportion | Relative Precision |
|---|---|---|---|---|---|
| School District | 0% | 0% | 1.0 | N/A | N/A |
| **Program Total** | **0%** | **0%** | **1.0** | **N/A** | **N/A** |

### 13.3.3.1 Freeridership Findings

Cadmus determined there were no free riders in this program. All participants reported that the ICSP influenced their decision to participate and to develop the tools used to support their SEMPs. Additionally, all participants reported that the program was *very* or *extremely influential* in their decision to implement operational or behavioral activities.[177]

### 13.3.3.2 Spillover Findings

As previously mentioned, because a billing analysis was used to estimate energy savings, PY7 spillover savings are included in the PY7 savings estimates for the schools within the districts. Cadmus did not measure spillover from non-participants.

In PY6, the ICSP reported that some districts rolled out CEI activities to schools other than the pilot school, rather than waiting until PY7. For that reason, Cadmus looked at changes in energy consumption at all non-pilot schools during PY6. For each non-pilot school, Cadmus conducted a billing analysis to estimate savings. The "spillover" period starts when the district's pilot school began participation in the CEI Program in PY6 and ends when the non-pilot school began participation in PY7. Cadmus used an indicator variable in the regression model to denote this period and included statistically significant interactions

177 All respondents gave a 4 or 5 response when asked about operational or behavioral energy-efficiency projects in response to the following: "Please rate how influential the CEI Program was on your school district's decision to implement the following types of projects using a scale from 1, meaning no influence, to 5, meaning the CEI Program was extremely influential."

between the period indicator and other known drivers of energy consumption, such as weather, season, daylight hours, and variables relating to the school's schedule.

Cadmus estimated savings from rolling out activities in PY6 for seven of the eight districts and four appeared to have savings. However, the ICSP did not track CEI activities at the non-pilot schools in PY6, nor was a control group used in the analysis that could rule out naturally occurring market effects. Therefore, it is inconclusive whether these savings are attributable to "spillover," i.e., rolling out activities to other schools earlier than planned. With comprehensive documentation that shows non-pilot schools engaged in activities related to the CEI Program, these changes in consumption could be attributed to "spillover." Cadmus estimates 408 MWh/yr of potential spillover savings in PY6. Table 13-11 shows the PY6 savings by district.

**Table 13-11: PY6 Estimated Spillover by District**

| Stratum | Number of Non-Pilot Schools | PY6 Spillover Savings (MWh/yr) |
|---|---|---|
| District 1 | **4** | -78.9 |
| District 2 | **2** | -630.0 |
| District 3 | **0** | N/A[1] |
| District 4 | **7** | 217.7 |
| District 5 | **4** | 233.1 |
| District 6 | **9** | 396.8 |
| District 7 | **5** | 303.1 |
| District 8 | **3** | -35.1 |
| **Program Total** | **34** | **407.6** |

[1] One district was not estimated because the pilot school was the only school in the district.

## 13.4 PROCESS EVALUATION

### 13.4.1 Research Objectives

The purpose of this evaluation is to assess CEI Program processes and recommend improvements in program operation efficiency, delivery infrastructure, and customer response, including adoption of the program. The PY7 evaluation focused on these research objectives:

- Assess program processes and make recommendations for improving program operation
- Assess the program's effectiveness in generating awareness and disseminating information
- Assess the program's effectiveness in encouraging school districts to implement energy efficiency projects
- Evaluate participant satisfaction with the program and identify any opportunities and barriers recommended by participants

### 13.4.2 Evaluation Activities

The PY7 process evaluation activities were:

- Program staff and implementer interviews (n=2)
- Participant surveys (n=23)
  - School district energy managers (n=8)
  - School energy champions (n=15, representing 3 districts)
- Database and QA/QC review of records

### 13.4.3 Methodology

For the PY7 process evaluation, Cadmus' evaluation relied on interviews with program staff and the ICSP, and surveys with program participants. The participant surveys focused on the school's experiences with the program and included questions about participation in and awareness of other PPL Electric Utilities programs.

Cadmus reached out to all district energy managers and school energy champions. Five of the eight districts had one energy manager who also served as the energy champion for all schools in the district. Cadmus attempted to contact all 18 school-level champions and conducted interviews with 15. The research activities were consistent with the evaluation plan—to complete surveys with all school energy champions and district energy managers and interview program managers at PPL Electric Utilities and the ICSP (Table 13-12).

**Table 13-12: PY7 CEI Program Process Evaluation Sampling Strategy**

| Stratum | Stratum Boundaries | Number of Unique Contacts | Assumed Proportion or CV in Sample Design | Assumed Levels of Confidence & Precision | Target Sample Size | Achieved Sample Size | Percent of Population Frame Contacted [1] | Evaluation Activities |
|---|---|---|---|---|---|---|---|---|
| PPL Electric Utilities Program and ICSP Staff | Staff | 2 | N/A | N/A | Census | 2 | 100% | Process |
| School District Energy Manager | District Energy Managers | 8 | N/A | N/A | Census | 8 | 100% | Process, NTG |
| School Energy Champion | School Energy Champions | 18[2] | N/A | N/A | Census | 15 | 100% | Process |

[1] Sample frame is a list of contacts that have a chance to be selected into the sample. Percent contacted means the percentage of sample frame called complete surveys.
[2] Multiple schools have the same energy champion so this is the number of unique contacts.

#### 13.4.3.1 Program Staff and Implementer Interviews

Cadmus conducted interviews with program management staff at PPL Electric Utilities and the ICSP in March 2016. The interviews discussed program objectives, program design changes, key performance indicators, and implementation successes and challenges.

#### 13.4.3.2 Participant Surveys

Eighteen schools (in three districts) had energy champions. The remaining 24 schools shared a district-wide energy manager. Cadmus completed a telephone survey with eight energy managers, one from each participating school district. It also conducted 15 telephone surveys with the energy champions from the 18 participating schools that had them. Cadmus attempted to reach respondents up to five times over several days, at different times of the day, and scheduled callbacks whenever possible. Three energy champions were not reached after four attempts.

The primary objectives of the surveys were to assess satisfaction with the program, gather details about implementing the SEMP, and assess the program's influence on decision-making. The same survey that provided data for the process evaluation was also used to collect information to assess the program's net impacts.

### 13.4.4 Achievements Against Plan

Forty-four schools enrolled in the program, and Cadmus verified the savings for 42 (as explained previously, two were not evaluable because one facility no longer operated as an elementary school and the other underwent renovations after the baseline period).

Table 13-13 shows the program's planned energy savings and achievements. Verified energy savings for PY7 were 4,697 MWh/yr, which exceeded the planned savings of 2,567 MWh/yr by 183%. Verified energy savings for Phase II exceeded planned savings by 149%. Verified demand reduction for PY7 was 0.768 MW, which exceeded the planned savings of 0.42 MW by 183%. Verified demand reduction for Phase II exceeded planned savings by 139%. Note that the Phase II verified savings are equivalent to the PY7 verified savings because the baseline period is the year before program engagement, and therefore PY7 savings include any savings from continued PY6 activities.

**Table 13-13: CEI Program Savings**

| | PY6 Verified [1] | PY7 Only | | | Phase II: PY5–PY7 | | |
|---|---|---|---|---|---|---|---|
| | | Planned | Verified | Percentage of Planned | Planned [2] | Verified | Percentage of Planned |
| MWh/yr | 1,208 | 2,567 | 4,697 | 183% | 3,150 | 4,697 | 149% |
| MW | 0.718 | 0.42 | 0.768 | 183% | 0.52 | 0.723 | 139% |
| Participation | 8 districts | 8 districts | 8 districts | 100% | 8 districts | 8 districts | 100% |

[1] There were no savings in PY5 because the participants were chosen but did not implement activities until PY6.
[2] Planned savings are based on PPL Electric's revised EE&C plan (Docket No. M-2012-2334288) approved by the Pennsylvania PUC on June 5, 2015, Table U6, p.183.

There are two reasons why the program exceeded its planned energy and demand savings for PY7:

- The eight participating school districts had higher consumption than PPL Electric Utilities assumed when designing the program plans for savings; therefore, there were many opportunities for the schools to save energy.
- Some schools implemented capital projects that did not receive a rebate, and these capital projects were present during both the baseline and the performance periods.

### 13.4.5 Program Delivery

PPL Electric and ICSP staff reported that the program was operating well, and the participants said that they were happy with the ICSP and the program. The program expanded to all schools in the eight districts in PY7. Program staff said schools were taking ownership of the program and doing well implementing their SEMPs on their own. District energy managers had biweekly meetings with the ICSP to discuss any issues, and the ICSP had a monthly meeting with the person in charge of the monitoring, targeting, and reporting (MT&R) model to ensure that the data were understood and were accurate.

The ICSP mentioned two challenges in implementation:

- The expansion from the pilot to the rest of the schools in the district took more time than anticipated to get started. The ICSP said there was insufficient communication in the beginning of PY7 to the schools to help them be successful, but that the problem was resolved. The schools did not report that communication was insufficient.
- Participation in CEI was limited to schools in the eight pilot districts that had also been benchmarked in PY4, PY5, or PY6 as part of PPL Electric's Act 129 School Benchmarking Program. Eighty-nine schools participated in the Benchmarking Program, and of those, 44 schools were in the pilot districts. The benchmarking program used EPA's Portfolio Manager software to track school energy use. The schools were supposed to update this information monthly, and use that data to inform their energy

use models. Over time, the login information and passwords to Portfolio manager, were misplaced. The schools were then no longer able to update their energy data or access their old energy use data.

Despite these challenges with the expansion, there were few reported barriers implementing the program as a whole (Section 13.4.8)

#### 13.4.5.1 Key Performance Indicators

In addition to energy savings targets, PPL Electric Utilities has a performance metric for participant satisfaction in the CEI Program, as shown in Table 13-14. Cadmus assesses customer satisfaction annually through participant surveys.

**Table 13-14: CEI Program Key Performance Indicators**

| Key Performance Indicator | Metric | Target | PY7 Result |
|---|---|---|---|
| Customer Satisfaction | Percentage of satisfied customers | 80% or more of customers participating in any PPL Electric Utilities program are satisfied with their experience. | 87% of respondents said they were *very satisfied,* and 13% said they were *somewhat satisfied.* |

PPL Electric Utilities and its ICSP exceeded planned energy and demand savings and the satisfaction metric for this program. All participants reported that they were satisfied with their program experience.

### 13.4.6 Participant Profile

Forty four district schools participated in the CEI Program in PY7, as shown in Table 13-15.

**Table 13-15: Number of Participating Schools in Each District**

| School District Number | Number of Schools |
|---|---|
| District 1 | 5 |
| District 2 | 3 |
| District 3 | 1 |
| District 4 | 8 |
| District 5 | 5 |
| District 6 | 11 |
| District 7 | 6 |
| District 8 | 5 |
| **Overall** | **44** |

The 44 participating schools represented five different facility types:

- 8 high schools
- 3 intermediate schools
- 7 middle schools
- 25 elementary schools
- 1 career and technical institute

### 13.4.7 Marketing and Outreach

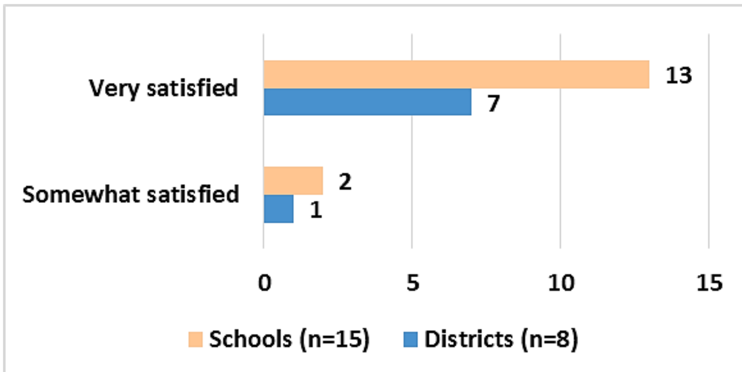
PPL Electric Utilities and the ICSP conducted marketing activities in PY5 to recruit school districts for this two year program which began in PY6. There were no recruitment or marketing activities in PY7 because all participating school districts were required to start the program in PY6.

### 13.4.8 Satisfaction

#### 13.4.8.1 Program Satisfaction

Program satisfaction was very high in PY7. All but three respondents (87%; n=23) were *very satisfied* with the program overall. Three respondents were *somewhat satisfied;* one of these three said that the program needed more student involvement. Satisfaction among the district energy managers was unchanged from PY6 (one said *somewhat satisfied* and seven said *very satisfied*). Figure 13-3 shows program satisfaction.

**Figure 13-3: Program Satisfaction**




Source: Question H7 (schools) and I15 (districts). "Thinking about your overall experience with the program, how would you rate your satisfaction? Are you …" (n=15, n=8)

The survey asked which aspects of the program were working particularly well. Half of the district energy managers (4; n=8) said they enjoyed the MT&R meetings with the ICSP. The ICSP holds optional meetings monthly to go over the MT&R models and address participant concerns. The school-level respondents (8; n=12) said they particularly enjoyed receiving the information about their energy use, which they could share with the students and teachers.

When asked about challenges with the program, six district energy managers referred to difficulties involving the school community and two said their time was limited. Five reported difficulties both with the school community and with time, the same number as in PY6. Two district energy managers made these comments:

- "Lack of commitment from everyone. On the surface [the CEI Program] sounds great but when they get involved it is a lot of work. Sometimes good ideas are difficult to implement because it affects more than one person or department."
- "Teachers are pretty busy so having time is challenging."

Challenges for school energy champions involved gaining buy-in from teachers, students, and administrators and the lack of time for carrying out continuing energy improvement activities. Eleven said they faced challenges in implementing the activities. These challenges and suggestions by respondents for overcoming them are shown in Table 13-16.

**Table 13-16: Challenges Faced by Schools and Suggestions for Improvement**

| Challenge | Suggested Solution |
|---|---|
| Buy-in from teachers and administrators | Express energy savings in dollar amounts |
| | Emphasize that little changes have a big cumulative effect |
| | Get administrators involved |
| Time to conduct continuous energy improvement activities | Plan ahead to guarantee the time |
| | Focus on behavior change as a continued effort instead of a major overhaul |
| | Make announcements to school over the public address (PA) system to communicate faster and easier |
| | Pay the energy champion instead of having it be a volunteer position |
| Lack of information | Identify high energy users by performing more audits |
| | Do more frequent audits to identify big systems that may not be working |
| | Update the school's electrical system to allow for more upgrades |
| Maintaining momentum | Communicate the MT&R data |
| | Schedule more school events |
| Source: Question H2 (Schools): “What challenges have you had implementing this program in the school buildings?” (n=11) and Question H3: “What would be the best way to overcome these challenges?” (n=11) | |

The ICSP said that some district or school staff members were unable to continue to invest as much time as they wanted because the positions were unpaid, and it recommended increasing the budget so these district energy managers could attend more energy team meetings.

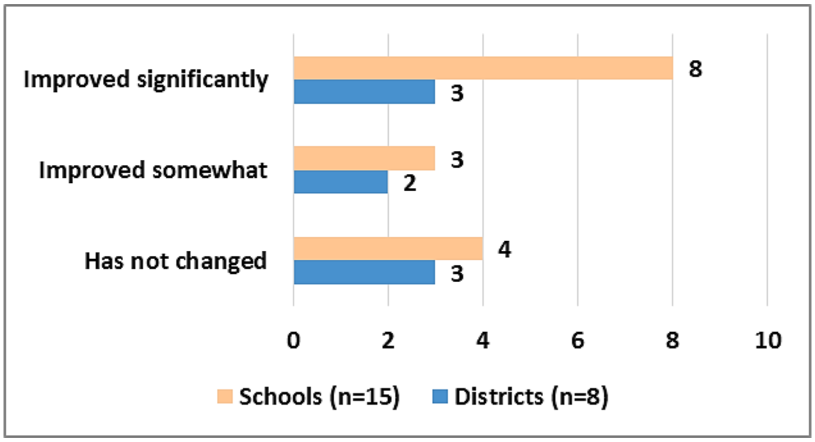
PPL Electric program staff agreed with the suggestion by district and school representatives to conduct more audits to identify areas of opportunity.

Cadmus also asked district energy managers the likelihood of expanding the program to all schools in the district without the $25,000 yearly district incentive. In PY6, only two respondents said that they would be *very likely* to participate without an incentive, and only four said that they would be *somewhat likely.* This indicated that participants would not have enrolled in the program without an incentive. After the districts rolled out the program to all schools (in PY7), four of the eight district energy managers said it was *very likely* and one said it was *somewhat likely* they would have expanded the program to additional schools if PPL Electric Utilities had not provided an incentive.

### 13.4.8.2 Satisfaction with PPL Electric Utilities

All respondents (100%; n=23) reported high overall satisfaction with PPL Electric Utilities as a provider of electric service to their schools and school districts. In PY6, seven respondents reported high satisfaction, and one did not know. Cadmus asked respondents how their opinions of PPL Electric Utilities had changed after PY7 program participation (Figure 13-4). Eight school energy champions (n=15) and three district energy managers (n=8) said their opinion had *improved significantly*, three school energy champions and two district energy managers said it had *improved somewhat*, and four school energy champions and three district energy managers said it *had not changed*.

**Figure 13-4: Opinion of PPL Electric Utilities After Program Participation**

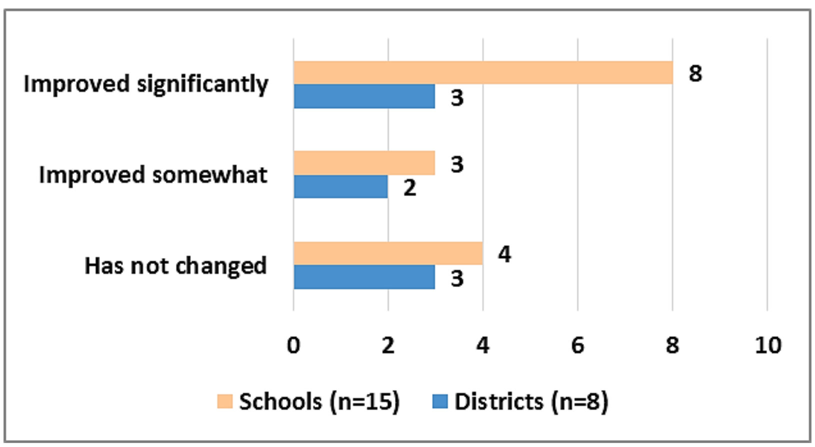



Source: Question H8 (schools) and I16 (districts): "After participating in the program this year, has your opinion of PPL Electric Utilities…" (n=15, n=8)

### 13.4.8.3 Satisfaction with the ICSP

Participant's satisfaction with the ICSP was high in PY7. Twelve respondents (n=15) said they were *very satisfied* with the CEI ICSP, two said they were *somewhat satisfied,* and one said *neither satisfied nor dissatisfied*. Seven school energy champions did not work with the energy advisors and were unable to answer the question. In PY6, all eight district energy managers said they were *very satisfied.* PY7 responses shown in Figure 13-5. Seven of the eight district energy managers said they were *very satisfied* in PY7.

**Figure 13-5: Satisfaction with CEI Program Energy Advisor in PY7**




Source: Question H5 (schools) and I6 (districts): "How would you describe your experience with the CEI Advisors…(n=15, n=8)

### 13.4.9 Adoption of Continuous Energy Improvement Strategies and Objectives

The purpose of assessing the adoption of continuous energy improvements was to determine the extent to which participants implemented the minimum strategic energy management (SEM) activities defined by the Consortium for Energy Efficiency (CEE). [178] SEM programs, like CEI, are holistic energy efficiency programs that focus on behavior change. Although the CEI Program was not specifically designed to conform to the CEE's definition of the minimum elements of SEM, the CEE definition is a useful standard for various implementation strategies and objectives. Lastly, Cadmus assessed whether adoption of the CEE minimum SEM elements could have a relationship with achieved energy savings.

Cadmus used the participant surveys to assess which program elements were more frequently implemented and why. The survey was designed and administered using these CEE definitions of minimum elements of SEM:

- Customer commitment consists of development and communication of the planned savings and implementation and frequency of meetings of the energy team.
- Planning and implementation measured the use of energy maps, energy management assessments, employee engagement, and reassessment of goals and the SEMP.
- The system for measuring and reporting energy performance criteria included energy measurement and tracking techniques, updates with the CEI Program ICSP, and frequency of communicating progress to others within the school district.

Detailed methodology for scoring SEM adoption from the participant survey responses is included in *Addendum B. Continuous Energy Improvement Adoption Scoring Methodology*.

All eight participating districts provided data about continuous energy improvement adoption, and Cadmus compared the district-level participant scores against the PY6 results, as shown in Table 13-17. (Participants implementing all of the CEE's minimum activities had *full* adoption. Participants with some implemented activities had *some* adoption. Overall SEM adoption was high across all program participants, with all of the school districts having *some* or *full* adoption.

**Table 13-17: Continuous Energy Improvement Adoption Scoring**

| Continuous Energy Improvement Element | Full Adoption | | Some Adoption | |
|---|---|---|---|---|
| | PY6 | PY7 | PY6 | PY7 |
| Customer Commitment | 6 | 7 | 2 | 1 |
| Planning and Implementation | 2 | 0 | 6 | 8 |
| System for Measuring and Reporting Energy Performance | 8 | 5 | 0 | 3 |
| **Overall** | **2** | **0** | **6** | **8** |

These were the results of full or some adoption:

- Customer Commitment
  - 7 of 8 school districts met all criteria for customer commitment by setting an energy performance goal.
  - All 8 met all criteria for dedicating resources to energy efficiency projects.

[178] Consortium for Energy Efficiency (CEE). *Strategic Energy Management Minimum Elements.* 2014. Available online: http://library.cee1.org/sites/default/files/library/11283/SEM_Minimum_Elements.pdf

- Planning and Implementation
  - 3 of 8 said they had created an energy map this year.
  - Half reported they did completed an opportunity register for each school.
  - All districts created metrics and goals.
  - 5 reported that they completed an energy management assessment.
  - 3 completed an opportunity register for PY7
  - 4 updated the opportunity register during PY7
- System for Measuring and Reporting Energy Performance
  - 2 did not reassess their goals or update their project list.
  - Five of eight school districts report progress regularly to the ICSP and to others within the district.

Since the program is implemented at the school level and not the district level, Cadmus did not score adoption for the schools. School-level participants were asked some, but not all, of the same questions asked of the district-level participants.

These were the results from the survey of 15 school energy champions:

- 12 reported establishing goals, having an energy team, and having sufficient resources to continue with continuous energy improvements.
- 10 said they had not completed an energy map for any of their school buildings to identify key energy drivers and end uses.
- 13 said they were currently using the MT&R model and workbook to track energy use at their school.
- 13 said they were using the SEMP and found it *very* useful (4 of 13) or *somewhat useful* (9 of 13).

### 13.4.9.1 Program Influence

The program's objectives are designed to identify energy-savings opportunities through cultural change that in turn drives behavioral and business process changes and fosters sustainability through individual engagement.

Participants rated the level of influence of the CEI Program on the decision to implement capital, behavioral, or operational energy efficiency projects. Rating used a scale of 1 to 5 where 1 meant *no influence* and 5 meant *extremely influential,* with these results:

- 15 respondents said the program was either *extremely influential* (8 of 23) or *somewhat influential* (7 of 23) in their decision to implement capital energy efficiency projects.
- 10 of 23 respondents said the program was *extremely influential,* and 8 said it was *somewhat influential* for their decision to implement operational energy efficiency projects.
- 18 of 23 said the program was *extremely influential,* and 3 said it was *somewhat influential* on their decision to implement behavioral energy efficiency projects.
- The perception of the program's influence on capital projects showed a slight disconnect between the district and school representatives—one district said *don't know* and one school in that district reported *no influence.*

## 13.5 CONCLUSIONS AND RECOMMENDATIONS

After analyzing the findings, Cadmus offers these conclusions and recommendations.

**Conclusion**
The realization rate for savings was 98.2%, indicating that the ICSP models estimated energy savings accurately. Nevertheless, for several sites where *ex ante* and *ex post* estimates disagreed, Cadmus found that the ICSP used baseline periods that were less than 12 months or overlapped with the performance period for the pilot program. This does not meet the guidelines presented in IPMVP Option C and may lead to biased estimates of savings. (See Sections 13.2.4 and 13.3.3).

**Recommendation**
Consider maintaining the same baseline dates for all schools within a district except when there is a substantial documented operational change at the facility that would affect energy consumption.

Consider using a full year of baseline data for all schools to capture the full effect of seasonality and therefore better capture the impact of the energy-savings program.

When the program is expanded to other schools following a pilot program, the baselines at the new schools should not overlap with the pilot school CEI Program implementation period.

**Conclusion**
The ICSP reported that some districts rolled out program activities to non-pilot schools before PY6 (the pilot school year) was over. Cadmus investigated whether this may have led to "spillover" savings in PY6, and found that four school districts may have savings. This showed that the district energy managers were motivated to expand the program to their other schools to achieve more energy savings. However, because the ICSP did not quantify these savings in PY6, PPL Electric Utilities was not able to claim these savings. (See Section 13.3.3)

**Recommendation**
Consider changing the program design to engage all schools in participating districts in the first year in order to claim savings from CEI activities at all schools.

**Conclusion**
The CEI Program appears to increase cross-program participation with other PPL Electric programs. Sixty-seven percent of the schools enrolled in the CEI program participated in at least one other PPL Electric program. (See Section 13.2.5.1)

**Recommendation**
Consider utilizing the CEI program as a way to build customer relationships and encourage participation in other PPL Electric programs.

**Conclusion**
The CEI Program has performed well and was highly influential in participants' decisions to implement energy efficiency improvements. Participants reported that the program was *very influential* in their decision to implement operational and behavioral energy efficiency activities, resulting in a NTG ratio of 1.0. (See Sections 13.4.9.1, 13.3.3, 13.2.5)

**Conclusion**
The PY7 rollout from pilot (one school) to full program (all schools in the district) was well received by participants, but faced challenges in initial implementation.

The CEI Program exceeded its satisfaction targets in PY7. The program had a target of 80% satisfaction and reached 100% of participants reporting *very satisfied* or *somewhat satisfied*. Although the program reported high levels of satisfaction, the program encountered some challenges in smoothly expanding from a pilot to a full program. Program implementation included challenges in obtaining buy-in from teachers and school administrators and maintaining momentum throughout the year. Also, participants found it difficult to find time for energy efficiency activities. The ICSP and participants said that finding sufficient time and resources were the main barriers. (See Section 13.4.8)

**Recommendation**
Consider refining existing timelines or creating new timelines with suggested activities so participants could control the investment of time schools needed to implement continuous energy improvement activities. For each program activity this can mean giving an example of how long a particular action will take or when a particular action should be completed (e.g., which day of the week, which month of the year).

**Recommendation**
Consider helping the school districts communicate how the incentive money was used, and how much energy and money was saved because of participation in the program. This will help school staff recognize the program benefits, which could lead to additional buy-in from teachers and school administrators.

**Conclusion**
The schools did not achieve all minimum elements for continuous energy improvement in PY7, mainly due to infrequent updates of program planning materials such as goals, energy maps, energy assessments, and opportunity registers. Compared to PY6, more districts received scores for *full* continuous energy improvement adoption in PY7. Using the CEE minimum elements for continuous energy improvement, seven districts had *full* customer commitment, and five had *full* adoption of the monitoring, targeting, and reporting elements. The lowest adoption was for the CEE planning and implementation element, which requires regular updates to all program planning documents. (See Section 13.4.9)

**Recommendation**
Consider encouraging participants to focus more on the *continuous* aspect of continuous energy improvement by communicating the CEE minimum elements and to conduct at least a yearly review and update of all of their program documents, including energy maps, energy assessments, and opportunity registers.

### 13.5.1 Status of Recommendations for Program

Table 13-18 contains the status of each PY7 process recommendation made to PPL Electric Utilities.

**Table 13-18: Continuous Energy Improvement Program Status Report on Process and Impact Recommendations**

| Recommendations | EDC Status of Recommendation (Implemented, Being Considered, Rejected AND Explanation of Action Taken by EDC) |
|---|---|
| **Continuous Energy Improvement Program** | |
| Consider maintaining the same baseline period for all schools. | Being considered. |
| Consider using at least 12 months for school baselines. | Being considered. |
| Ensure baseline periods for schools do not overlap with implementation periods for other schools within the same district. | Being considered. |
| Encourage CEI participants to enroll in other PPL Electric programs. | Will be implemented when program is launched. |
| Provide schools with a timeline of CEI activities, and communicate how incentive money is being distributed throughout the district | Being considered. |
| Ask that participants conduct at least yearly updates to all program documents | Being considered. |

## 13.6 FINANCIAL REPORTING

A breakdown of the Continuous Energy Improvement Program finances is presented in Table 13-19.

**Table 13-19: Summary of Continuous Energy Improvement Program Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs[6] ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs (Sum of rows 2 to 4) | $0 | $29 |
| 2 | EDC Incentives to Participants | $0 | $0 |
| 3 | EDC Incentives to Trade Allies | - | - |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $0 | $29 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6, 7, 8, 9, 10 ) | $361 | $910 |
| 6 | Design & Development | $0 | $0 |
| 7 | Administration, Management, and Technical Assistance[1] | $361 | $910 |
| 8 | Marketing[2] | $0 | $0 |
| 9 | EDC Evaluation Costs | $0 | $0 |
| 10 | SWE Audit Costs | $0 | $0 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | $0 | ($0) |
| | | | |
| 12 | Total TRC Costs[3] (Sum of rows 1, 5 and 11) | $361 | $939 |
| 13 | Total NPV Lifetime Energy Benefits | $928 | $995 |
| 14 | Total NPV Lifetime Capacity Benefits | $107 | $181 |
| 15 | Total NPV O&M Saving Benefits | $0 | $0 |
| 16 | Total NPV TRC Benefits[4] | $1,035 | $1,176 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | 2.87 | 1.25 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.
[2] Includes the marketing CSP and marketing costs by program CSPs.
[3] Total TRC Costs includes Total EDC Costs and Participant Costs.
[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.
[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[6] Phase II Costs in this table are discounted back to PY5, thus will not match cumulative costs reported in the PY7 Q4 quarterly report.

# ADDENDUM A. PARTICIPANT SURVEY ATTRITION AND FINAL DISPOSITION

## Dialing Instructions

PPL Electric Utilities provided dialing instructions for conducting surveys. Telephone survey calls cannot take place on Sundays or national holidays.

Researchers called participants at different times of day and different days of the week to increase the probability of contact. Cadmus contacted all schools, and attempted to reach respondents up to five times over several days, at different times of the day, and scheduled callbacks whenever possible.

## Sample Cleaning and Attrition

Cadmus included all program participants in the survey call list. Table 13-20 lists total number of records and the outcome (final disposition) of each record.

**Table 13-20: Survey Sample Attrition Table**

| Description of Call Outcomes | School District | Schools |
|---|---|---|
| **Population** | **8** | **18** [1] |
| **Survey Sample Frame** | **8** | **18** |
| Not attempted | 0 | 0 |
| Records Attempted | 8 | 18 |
| Unavailable | 0 | 3 |
| **Completed Survey** | **8** | **15** |
| [1] Number of schools with school-level energy champion | | |

# ADDENDUM B. CONTINUOUS ENERGY IMPROVEMENT ADOPTION SCORING METHODOLOGY

The adoption scoring methodology developed by Cadmus helped to assess the extent to which a participant had implemented continuous energy improvement activities. This methodology used the CEE minimum elements to determine which behaviors constitute a fully implemented program. Table 13-21 shows the survey questions based on the three CEE minimum elements (customer commitment, policy and goals, monitoring, targeting, and reporting)

**Table 13-21: Continuous Energy Improvement Adoption Elements and Survey Questions**

| CEI Element | Survey Question(s) | Level of CEI Implementation | | |
|---|---|---|---|---|
| | | Full | Some | None |
| **1a. Policy and Goals** | ▪ How has the energy performance goal for the district changed from last year?<br>▪ Have the energy performance goals been communicated to the schools?<br>▪ Have you defined goals to improve energy performance at each school? | Have goals at each school and they have been communicated to teachers and staff or to students and parents | Any other response combination | Don't have a goal for each school (or don't know) and have not been communicated to teachers or staff or students and parents (or don't know). |
| **1b. Resources** | ▪ Do you have an energy team at your school district?<br>▪ How frequently does the energy team meet? | Have an energy team that meets quarterly or more frequently. | | No energy management team (or don't know) and or team meets less frequently than quarterly. |
| **2a. Energy Management Assessment** | ▪ Have energy management assessments for the current school year been conducted at the schools participating in the program or are they planned? | Conducted an energy management assessment at each school | Any other response combination | Did not and will not conduct an energy management assessment at each school (or don't know) |
| **2b. Energy Map** | ▪ Have you or your energy team developed an energy map for each of the participating schools and corresponding buildings in your school district to identify the key energy drivers and end uses? | Have developed an energy map | | Did not develop an energy map (or don't know) |
| **2c. Metrics and Goals** | ▪ Does the MT&R model use energy performance indicators to measure progress toward goals? | The MT&R model tracks progress toward goals. | | The MT&R model does not track progress toward goals. |
| **2d. Project Register** | ▪ Did each school create an opportunity register? | Opportunity register was developed | | An Opportunity Register was not developed |
| **2e. Employee Engagement** | ▪ Have you or your energy team conducted or planned any specific school staff engagement activities? | Conduct or plan specific school staff engagement opportunities | | Did not conduct or plan specific school staff engagement opportunities (or don't know) |
| **2f. Implementation** | ▪ Have you completed any of the potential opportunities listed in the opportunity register? | Completed one or more projects in opportunity register | | Did not complete any projects in opportunity register |
| **2g. Reassessment** | ▪ Have you reviewed the goals since they were set to ensure they still align with energy performance priorities of the program?<br>▪ How often do you update the opportunity register? | Have reviewed goals and updated the Opportunity Register regularly or occasionally | | Have not updated goals (or don't know), and almost never or never update opportunity register (or don't know) |

<table>
<tr><th rowspan="2">CEI Element</th><th rowspan="2">Survey Question(s)</th><th colspan="3">Level of CEI Implementation</th></tr>
<tr><th>Full</th><th>Some</th><th>None</th></tr>
<tr><td>3a. Measurement</td><td rowspan="3">▪ Are you currently using the monitoring, targeting and reporting or MT&R model and workbook to track your energy use?<br>▪ Are you using another type of electronic system to track your energy use over time?<br>▪ How frequently are the MT&R model and workbook reviewed?</td><td rowspan="3">Using MT&R, or something else to track energy use and the model is reviewed quarterly or more frequently</td><td rowspan="4">Any other response combination</td><td rowspan="3">Not using MT&R or other model (or don’t know) and model is reviewed less frequently than quarterly (or don’t know)</td></tr>
<tr><td>3b. Data Collection and Availability</td></tr>
<tr><td>3c. Analysis</td></tr>
<tr><td>3d. Reporting</td><td>▪ Do your continuous energy improvement require regular updates from the energy team?<br>▪ How often is energy use data shared with others at your school district?</td><td>Regular updates are provided to the ICSP and energy use data are shared regularly with others within the school district</td><td>Regular updates are not provided to the ICSP (or don’t know) and energy use data are not shared regularly with others within the school district (or don’t know)</td></tr>
</table>

# 14 SCHOOL BENCHMARKING PROGRAM

The School Benchmarking Program works with school administrators to evaluate total building energy use using the Portfolio Manager tool from the U.S. Environmental Protection Agency (EPA).[179] The program provides school administrators the information they need to evaluate short- and long-term goals and paybacks for energy efficiency investment opportunities. A turnkey ICSP, TRC Environmental Corp (TRC), manages the program, which is offered to up to 25 schools each program year. The ICSP also explains PPL Electric Utilities' rebates and incentives.

For each participating school, the Portfolio Manager tool produces a report of specific characteristics and energy indicators, including total energy use per square foot, electric utilities use per square foot, heating fuel use per square foot and per heating degree day, and energy cost per square foot and per student. Schools also receive assistance in developing action plans to reduce energy consumption.[180]

### 14.1.1 Program Objectives

The School Benchmarking Program's objectives are these:[181]

- Provide an opportunity for school districts in PPL Electric Utilities' territory to participate in benchmarking
- Train school staff to use the EPA's Portfolio Manager tool and encourage and assist schools in achieving the ENERGY STAR label (awarded if the school is in the top 25% compared to its peers)
- Educate school staff about the school's energy use, recommend how energy can be used more wisely, and explain PPL Electric Utilities' rebates and incentives
- Collaborate with the U.S. Department of Energy and the Pennsylvania Department of Environmental Protection on their benchmarking initiatives
- Promote other PPL Electric Utilities Energy Efficiency and Conservation (EE&C) programs.
- Obtain participation of up to 75 schools through 2016
- Develop and implement an LED exit sign component for participating schools and as an incentive to encourage other schools to participate in the School Benchmarking Program. These savings are claimed under the Prescriptive Equipment Program.

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179 ENERGY STAR. "Energy Strategies for Buildings & Plants." Available online: http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager

180 Participation in the School Benchmarking and Continuous Energy Improvement programs is intended to be mutually exclusive. However, past participants of the School Benchmarking Program may be recruited into the Continuous Energy Improvement Program in a later year.

181 Program objectives are stipulated on PPL Electric Utilities' revised EE&C Plan (Docket No. M-2012-2334388) approved by the Pennsylvania PUC on June 5, 2015, p.173.

**Table 14-1: PY7 School Benchmarking Program Summary**

| Sector | Phase II Reported Energy Savings (MWh/yr) | Phase II Adjusted *Ex Ante* Energy Savings (MWh/yr) | Phase II Verified Gross Energy Savings (MWh/yr) | Phase II Net-to-Gross Ratio | Phase II TRC Ratio | Phase II EDC Expenditures ($1,000) | Program Acquisition Cost ($/Annual kWh) [1] | Cost of Conserved Energy (TRC Costs/ Lifetime kWh, at Generation) [2] | Phase II Participants |
|---|---|---|---|---|---|---|---|---|---|
| Residential | - | - | - | - | N/A | - | N/A | N/A | - |
| Low-Income | - | - | - | - | N/A | - | N/A | N/A | - |
| Small C&I | - | - | - | - | N/A | - | N/A | N/A | - |
| Large C&I | - | - | - | - | N/A | - | N/A | N/A | - |
| Government/ Nonprofit/ Education | - | - | - | - | N/A | $370 | N/A | N/A | 89 |
| **Total** | **-** | **-** | **-** | **-** | **N/A** | **$370** | **N/A** | **N/A** | **89** |

[1] Total EDC costs divided by first-year kWh savings.
[2] Total TRC costs divided by levelized lifetime kWh savings.

## 14.2 Program Updates

This program was offered in PY7 and there were no program updates in PY7.

### 14.2.1 Definition of Participant

Participants are defined by unique CSP Job numbers assigned to each participating school.

## 14.3 Impact Evaluation Gross Savings

Cadmus did not complete an impact evaluation for PY7 because the program does not generate energy savings.

## 14.4 Impact Evaluation Net Savings

Cadmus and PPL Electric decided not to evaluate net savings for PY7 because the program does not generate energy savings.

## 14.5 Process Evaluation

Cadmus conducted a process evaluation at the beginning of PY6 that covered PY5. Because the program does not generate savings, Cadmus and PPL Electric decided not to complete a process evaluation for PY7.

## 14.6 Conclusions and Recommendations

Cadmus determined that through PY5 the program was working as planned. Cadmus and PPL Electric Utilities decided not to complete further evaluation activities because the program does not contribute energy savings. We did not offer any conclusions because we did not complete an evaluation.

## 14.7 FINANCIAL REPORTING

A breakdown of the School Benchmarking Program finances is presented in Table 14-2.

**Table 14-2: PY7 Summary of School Benchmarking Program Finances**

| Row | Cost Category | Actual PYTD Costs ($1,000) | Actual Phase II Costs[6] ($1,000) |
|---|---|---|---|
| 1 | Incremental Measure Costs (Sum of rows 2 to 4) | $0 | $0 |
| 2 | EDC Incentives to Participants | $0 | $0 |
| 3 | EDC Incentives to Trade Allies | - | - |
| 4 | Participant Costs (net of incentives/rebates paid by utilities) | $0 | $0 |
| | | | |
| 5 | Program Overhead Costs (Sum of rows 6, 7, 8, 9, 10 ) | $92 | $347 |
| 6 | Design & Development | $0 | $0 |
| 7 | Administration, Management, and Technical Assistance[1] | $92 | $347 |
| 8 | Marketing[2] | $0 | $0 |
| 9 | EDC Evaluation Costs | $0 | $0 |
| 10 | SWE Audit Costs | $0 | $0 |
| | | | |
| 11 | Increases in costs of natural gas (or other fuels) for fuel-switching programs | $0 | $0 |
| | | | |
| 12 | Total TRC Costs[3] (Sum of rows 1, 5 and 11) | $92 | $347 |
| 13 | Total NPV Lifetime Energy Benefits | $0 | $0 |
| 14 | Total NPV Lifetime Capacity Benefits | $0 | $0 |
| 15 | Total NPV O&M Saving Benefits | $0 | $0 |
| 16 | Total NPV TRC Benefits[4] | $0 | $0 |
| | | | |
| 17 | TRC Benefit-Cost Ratio[5] | $0 | $0 |

*Per PUC direction, TRC inputs and calculations are required in the Annual Report only and should comply with the 2013 Total Resource Cost Test Order. Please see the "Report Definitions" section of this report for more details.*

[1] Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.
[2] Includes the marketing CSP and marketing costs by program CSPs.
[3] Total TRC Costs includes Total EDC Costs and Participant Costs.
[4] Total TRC Benefits equals the sum of Total Lifetime Energy Benefits and Total Lifetime Capacity Benefits. Based upon verified gross kWh/yr and kW savings. Benefits include avoided supply costs, including the reduction in costs of electric energy, generation, transmission, and distribution capacity, and natural gas valued at marginal cost for periods when there is a load reduction. NOTE: Savings carried over from Phase I are not to be included as a part of Total TRC Benefits for Phase II.
[5] TRC Ratio equals Total NPV TRC Benefits divided by Total NPV TRC Costs.
[6] Phase II Costs in this table are discounted back to PY5, thus will not match cumulative costs reported in the PY7 Q4 quarterly report

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# APPENDICES

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# APPENDIX A | EM&V INFORMATION

## A.1 PARTICIPANT DEFINITIONS

Participant definitions discussed in each of the program chapters are summarized in Table A-1.

**Table A-1: PY7 Participant Definition by Program**

| Program | Participant Definition | Can there be more than one measure per participant? | Sample Defined by |
|---|---|---|---|
| **Appliance Recycling** | Unique CSP job ID | Yes | Freezer and refrigerators (target 85/15) |
| **Continuous Energy Improvement** | CSP job ID unique to each project | Yes | Projects (all included in analysis) |
| **Custom Incentive** | Customer project that received an incentive payment between June 1, 2015, and May 31, 2016. There were two exceptions paid in June 2016 for projects that were installed prior to May 31, 2016, where post-install metering finalized after May 31, 2016. | Yes | Large stratum are projects with reported savings > 500,000 kWh/year (all included in analysis)<br>Small stratum are projects with reported savings ≤500,000 kWh/year (random sample) |
| **E-Power Wise** | Unique CSP Job ID (receive one energy savings kit per income-eligible household) | No | Delivery method (agency or direct mail) |
| **Low-Income Energy-Efficiency Behavior and Education** | Income eligible household identified with unique CSP account ID that received at least one home energy report | No | All customers in treatment (recipient) group |
| **Low-Income WRAP** | Income eligible household; identified with unique CSP job ID | Yes | Job type (baseload, low-cost, full-cost, heat pump water heater) |
| **Master Metered Multifamily** | CSP job ID unique to each project | Yes | Random sample of projects (target 85/15) |
| **Prescriptive Equipment – Non-Lighting subcomponent** | CSP job ID unique to each project | Yes | Random sample of projects (target 85/15) |
| **Prescriptive Equipment – Lighting Subcomponent** | CSP job ID unique to each project | Yes | Defined kWh thresholds (target 90/10 lighting subcomponent) |
| **Residential Energy-Efficiency Behavior and Education** | Household identified with unique CSP account ID that received at least one home energy report | No | All customers in treatment (recipient) group |
| **Residential Home Comfort** | Unique CSP job ID | Yes | Subprograms: audits, weatherization measures, equipment rebates, manufactured housing, new construction (program target 85/15) |
| **Residential Retail – Equipment Subcomponent** | Unique CSP job ID | Yes | Rebated equipment strata (random sample prorated by reported savings, target 85/15 across all equipment) |
| **Residential Retail – Upstream Lighting Subcomponent** | Jobs are reported as weekly bulb sales by product. Number of participants determined by dividing total number of bulbs sold or distributed by a bulbs-per-participant estimate derived from general residential and small C&I population survey respondents who reported having purchased bulbs. | N/A | All records |

| Program | Participant Definition | Can there be more than one measure per participant? | Sample Defined by |
|---|---|---|---|
| **School Benchmarking** | CSP Job ID unique to each project | Yes | Projects |
| **Student and Parent Energy Efficiency Education** | Unique CSP ID defined by school and classroom; quantity per CSP ID is the number of kits distributed in the classroom | Yes | 3 classroom cohorts, 1 teacher cohort, 1 parent workshop cohort |
| **De Facto Pilot** | Unique bill account number | Yes | All records |
| **Wise Home Pilot** | Unique bill account number | Yes | 4 study groups: 2 randomized control trials, and, 2 pre-post analysis with no control group |

## A.2 PY7 EVALUATION ACTIVITIES

Table A-2 summarizes actual evaluation activities completed in PY7.

**Table A-2: PY7 Actual Evaluation Activities**

| Programs | Sectors | Records Review | Participant Surveys | Nonparticipant Surveys | Site Visits | Metering | Billing Analysis |
|---|---|---|---|---|---|---|---|
| **Appliance Recycling** | All sectors | All records | 62[1] | - | - | - | - |
| **Continuous Energy Improvement** | GNE | 8 | 23[2] | - | - | - | 42 |
| **Custom Incentive** | C&I, GNE | 28 | 24 | - | 31 | 18 large stratum 2 small stratum | |
| **E-Power Wise** | Low Income | All records | 776[3] | - | - | - | - |
| **E-Power Wise - Wise Home Pilot** | Low Income | - | 84 [4] | - | 8 [5] | - | 390 RCT (195 treatment 195 control) 48 pre-post (no control) |
| **Low-Income Energy-Efficiency Behavior and Education** | Low Income | All records | 151 (treatment) | 150 (control) | - | - | 87,376 (treatment) 26,583 (control) |
| **Low-Income WRAP** | Low Income | 30 baseload, 34 low-cost jobs, 46 full cost jobs, and 93 HPWH | 141 | - | 381 [5] | - | 2,446 baseload jobs, 411 low-cost jobs, 1,056 full-cost jobs [6] |
| **Low-Income WRAP - De Facto Heating Pilot** | Low Income | 12 | 3 | - | 11 [5] | - | 1 full-cost job [6] |
| **Master Metered Multifamily** | GNE | 20 | 200[7] | - | 20 | - | - |
| **Prescriptive Equipment – Non-Lighting Subcomponent** | Small C&I, Large C&I, and GNE | 49 | 12 | - | - | - | - |
| **Prescriptive Equipment – Lighting Subcomponent** | Small C&I, Large C&I, and GNE | 35 | 68 | - | 35 | 8 [5] | 19 |

| Programs | Sectors | Records Review | Participant Surveys | Nonparticipant Surveys | Site Visits | Metering | Billing Analysis |
|---|---|---|---|---|---|---|---|
| **Residential Energy-Efficiency Behavior and Education** | Residential | All records | - | - | - | - | 126,290 (treatment) 68,940 (control) |
| **Residential Home Comfort** | Residential | 377 | 286[1] | - | - | - | - |
| **Residential Retail – Equipment subcomponent** | Residential | 139 | 132[1] | - | - | - | - |
| **Residential Retail – Upstream Lighting Subcomponent** | Residential; small C&I | 81[8] | - | 337[9] | - | - | - |
| **School Benchmarking[10]** | GNE | - | - | - | - | - | - |
| **Student & Parent Education** | Residential | 20,264 | 25,426[11] | - | - | - | |
| **Total** | | **21,216+** | **27,388** | **487** | **486** | **28** | **313,602** |

[1] Includes surveys completed as part of the cross-program survey, which included participants of the Residential Retail, Residential Home Comfort, and Appliance Recycling programs.
[2] Includes eight surveys with school district representatives and 15 with school-level energy champions.
[3] Includes customer surveys returned from the energy-savings kits.
[4] Includes Cadmus-administered surveys (n=44) and leave-behind postcard surveys (n=40).
[5] QC site visits or metering conducted by PPL Electric Utilities, their subcontractor, or the ICSP.
[6] See Appendix J for more information about this.
[7] Includes tenant leave-behind surveys (n=44) and ICSP-administered tenant education workshop surveys (n=156).
[8] Lighting manufacturer invoice audits.
[9] Includes residential general population upstream lighting survey
[10] Cadmus did not complete an evaluation for this program in PY7.
[11] Includes ICSP-administered home energy worksheets (n=20,264); parent workshop home energy worksheets (n=1,015); ICSP-administered parent surveys (n=2,229); and ICSP-administered classroom teacher, teacher workshop, and parent workshop evaluation surveys (n=1,918).

# APPENDIX B | TRC INCREMENTAL COSTS

## B.1 PROGRAM YEAR 7 EVALUATION ACTIVITIES

For Program Year 7, the following measures had incremental measure costs that were not obtained from the SWE incremental cost database, as shown in Table B-1.

**Table B-1: PY7 Actual Evaluation Activities**

| Program | Measure | Incremental Cost | Incremental Cost Source |
|---|---|---|---|
| **Custom Incentive** | All Large C&I | $9,534,686 | PY7 program verification of all project costs. |
| **Custom Incentive** | All Small C&I | $1,753,338 | PY7 program verification of all project costs. |
| **Custom Incentive** | All GNE | $3,959,485 | PY7 program verification of all project costs. |
| **Prescriptive Equipment** | New Construction Lighting: Small C&I | $1,256,562 | Energy Trust of Oregon's average cost per square foot of $0.35 for 20% LPD reduction (used in EE&C Plan) adjusted linearly for project specific LPD reductions. Exterior lights used SWE incremental costs for LED street lighting and HID installations. |
| **Prescriptive Equipment** | New Construction Lighting: Large C&I | $2,865,307 | Energy Trust of Oregon's average cost per square foot of $0.35 for 20% LPD reduction (used in EE&C Plan) adjusted linearly for project specific LPD reductions. Exterior lights used SWE incremental costs for LED street lighting and HID installations. |
| **Prescriptive Equipment** | New Construction Lighting: GNE | $288,975 | Energy Trust of Oregon's average cost per square foot of $0.35 for 20% LPD reduction (used in EE&C Plan) adjusted linearly for project specific LPD reductions. Exterior lights used SWE incremental costs for LED street lighting and HID installations. |
| **Prescriptive Equipment** | New Construction Lighting: Agriculture | $49,097 | Energy Trust of Oregon's average cost per square foot of $0.35 for 20% LPD reduction (used in EE&C Plan) adjusted linearly for project specific LPD reductions. Exterior lights used SWE incremental costs for LED street lighting and HID installations. |
| **Prescriptive Equipment** | Retrofit Cut Sheet Lighting Fixtures (Early Replacement) | $140 | Invoice review of 20 PY5 projects with 1,168 unique measures ($35.84 labor and $104.16 fixture). |
| **Prescriptive Equipment** | Retrofit Cut Sheet Lighting Controls (Early Replacement) | $107 | Invoice review of 20 PY5 projects with 1,168 unique measures ($56.63 labor and $50.78 materials). |
| **Prescriptive Equipment** | Automatic Milker Take-Off | $4,224 | Phase II EE&C Plan costs per participant |
| **Prescriptive Equipment** | Heat Reclaimer with Pre-Cooler | $2,508 | Phase II EE&C Plan costs per participant |

| Program | Measure | Incremental Cost | Incremental Cost Source |
|---|---|---|---|
| **Prescriptive Equipment** | Heat Reclaimers without Pre-Cooler | $2,508 | Phase II EE&C Plan costs per participant |
| **Prescriptive Equipment** | Livestock Waterers | $900 | Phase II EE&C Plan costs per participant |
| **Prescriptive Equipment** | VSD Controller for Dairy Vacuum Pumps | $528 | Phase II EE&C Plan costs per participant |
| **Master Metered Multifamily Housing** | Commercial Lighting Measures | $179,949 | Non-direct installation measure costs were estimated from 34 PY7 project records with customer contributions having an average cost of $0.07 per kWh then extrapolated to total kWh. |
| **Residential Home Comfort** | HERS Base Savings | $8,917 | Source Linear Regression of two studies result; "Tolkin, Blake,Bonanno, Conant, Mauldin, Hoefgen, How Much More Does It Cost to Build an ENERGY STAR® Home? Incremental Cost Estimation Process, 2008 ACEEE Summer Study on Energy Efficiency in Buildings" and "Energy Star V3 Cost and Savings Estimates, EPA 2013" |
| **Residential Home Comfort** | Manufactured Home - Single (ENERGY STAR envelope and assumed 13 SEER ASHP) | $2,753 | NREL incremental measure costs applied to Energy Star's prototype mobile home designs |
| **Residential Retail** | Candelabra/Decorative: Lumens 150-299 | $8 | Average retail price from ICSP (Ecova) as value is less than SWE cost data. |
| **Residential Retail** | Candelabra/Decorative: Lumens 300-499 | $9 | Average retail price from ICSP (Ecova) as value is less than SWE cost data. |
| **Residential Retail** | Candelabra/Decorative: Lumens 500-699 | $12 | Average retail price from ICSP (Ecova) as value is less than SWE cost data. |
| **Residential Retail** | Candelabra/Decorative: Lumens 90-149 | $13 | Average retail price from ICSP (Ecova) as value is less than SWE cost data. |
| **Residential Retail** | General Service: Lumens 1100-1599 | $14 | Average retail price from ICSP (Ecova) minus baseline bulb cost from PY6 shelf stocking study. |
| **Residential Retail** | General Service: Lumens 1600-2600 | $17 | Average retail price from ICSP (Ecova) minus baseline bulb cost from PY6 shelf stocking study. |
| **Residential Retail** | General Service: Lumens 310-449 | $9 | Average retail price from ICSP (Ecova) minus baseline bulb cost from PY6 shelf stocking study. |
| **Residential Retail** | General Service: Lumens 450-799 | $7 | Average retail price from ICSP (Ecova) minus baseline bulb cost from PY6 shelf stocking study. |
| **Residential Retail** | General Service: Lumens 800-1099 | $7 | Average retail price from ICSP (Ecova) minus baseline bulb cost from PY6 shelf stocking study. |
| **Residential Retail** | Globe: Lumens 250-349 | $10 | Average retail price from ICSP (Ecova) as value is less than SWE cost data. |
| **Residential Retail** | Globe: Lumens 350-499 | $12 | Average retail price from ICSP (Ecova) as value is less than SWE cost data. |
| **Residential Retail** | Globe: Lumens 500-574 | $14 | Average retail price from ICSP (Ecova) as value is less than SWE cost data. |

| Program | Measure | Incremental Cost | Incremental Cost Source |
|---|---|---|---|
| **Residential Retail** | Pin-Based: Lumens 450-799 | $16 | Average retail price from ICSP (Ecova) as value is less than SWE cost data. |
| **Residential Retail** | Reflector: Lumens 1050-1489 | $14 | Average retail price from ICSP (Ecova) minus baseline bulb cost from Cadmus research of Homedepot.com and 1000bulbs.com completed in April 2016. |
| **Residential Retail** | Reflector: Lumens 1490-2600 | $17 | Average retail price from ICSP (Ecova) minus baseline bulb cost from Cadmus research of Homedepot.com and 1000bulbs.com completed in April 2016. |
| **Residential Retail** | Reflector: Lumens 250-749 | $8 | Average retail price from ICSP (Ecova) minus baseline bulb cost from Cadmus research of Homedepot.com and 1000bulbs.com completed in April 2016. |

# APPENDIX C | LOW-INCOME PARTICIPATION IN NON-LOW-INCOME PROGRAMS

PPL Electric Utilities determined the number of low-income households participating in programs that are open to all residential customers—that is, low-income participation in non-low-income (general residential) programs. These programs were Appliance Recycling, Residential Energy-Efficiency Behavior & Education, Student and Parent Energy-Efficiency Education, Residential Home Comfort, Residential Retail – Equipment, and Residential Retail – Upstream Lighting. These participant numbers were obtained according to the methodology approved by the Pennsylvania Public Utility Commission and described in the PPL Electric Utilities memo, *Method to Estimate Low-Income Savings in Non-Low-Income Programs*, dated June 1, 2011.

This analysis used survey data that included responses from participants who answered questions regarding the number of individuals in their household and estimated annual household income.[1] Table C-1 lists the number of respondents in five programs and whether they answered income and household questions.

**Table C-1: PY7 Percentage of Respondents Answering Income and Household Questions**

| Program | Completed Surveys | Income/Household Questions | |
|---|---|---|---|
| | | Respondents Who Provided Demographic Responses | Percentage Who Refused to Answer |
| Appliance Recycling | 62 | 42 | 32% |
| Behavior and Education [1] | 541 | 381 | 30% |
| Residential Home Comfort | 286 | 193 | 33% |
| Residential Retail – Equipment | 132 | 98 | 26% |
| Residential Retail – Lighting | 337 | 56 | 83% |
| **Total** | **1,178** | **642** | **46%** |

Source: Survey question, "Including yourself, how many people lived in your home full-time during the past 12 months? (If Necessary: full-time is considered more than 9 months in the past year.)" and survey question, "In 2015, was your annual household income before taxes above or below $50,000?" and survey question, "Was your annual household income before taxes above or below $25,000?" and survey questions, "Please stop me when I read your category. Was it…?"
[1] The results for this survey are from PY6. No surveys were conducted for this program in PY7.

The Student and Parent Energy-Efficiency Education Program was offered to schools in PPL Electric Utilities' service territory that offer free lunches to children from households with income below 130% of the federal poverty level (FPL), a more conservative percentage than 150%.

The Pennsylvania Department of Education publishes the percentage of student enrollment that qualifies for free lunches. Cadmus used these published data to determine the percentage of low-income participants in Student and Parent Energy-Efficiency Education Program and assumed that the percentage of students enrolled in the school free-lunch program was representative of the percentage within any

1 Cadmus, the evaluation, measurement, and verification conservation service provider (EM&V CSP) did not conduct a survey with participants of the Residential Energy-Efficiency Behavior & Education Program so the results are from the PY6 survey data and report. Results for all other programs use data from PY7 surveys.

particular classroom participating in the program. Across all participating schools with available data, an average of 45% of the students received free lunches in the 2015–2016 school year.

In PY7, participants below 150% of the federal poverty level were associated with verified gross savings of 13,667 MWh/year in non-low-income programs. PY7 participation by program and PY7 savings are summarized in Table C-2.

**Table C-2: PY7 Verified Gross Savings Attributable to Low-Income Participation in Non-Low-Income Programs**

| Program | Total Survey Respondents | Respondents Meeting FPL Guidelines | Percentage of Total Respondents | PY7 Verified Gross Impact (MWh/yr) | Savings Associated with FPL Population (MWh/yr) |
|---|---|---|---|---|---|
| Appliance Recycling | 62 | 8 | 19% | 9,320 | 1,775 |
| Behavior and Education [1] | 541 | 22 | 6% | 39,078 | 2,256 |
| Residential Home Comfort | 286 | 8 | 4% | 12,157 | 504 |
| Residential Retail – Equipment | 132 | 2 | 2% | 3,053 | 62 |
| Residential Retail – Lighting | 337 | 8 | 14% | 40,726 | 5,818 |
| Residential Retail – Lighting – Giveaway Bulbs | N/A | N/A | N/A | 1,422 | 1,422 |
| Student and Parent Energy-Efficiency Education | N/A | N/A | 45% | 4,053 | 1,829 |
| **Total** | **1358** | **48** | **6%** | **109,809** | **13,667** |

Source: Survey question, "Including yourself, how many people lived in your home full-time during the past 12 months? (If Necessary: full-time is considered more than 9 months in the past year.)" and survey question, "In 2015, was your annual household income before taxes above or below $50,000?" and survey question, "Was your annual household income before taxes above or below $25,000?" and survey questions, "Please stop me when I read your category. Was it…?"

[1] The results for this survey are from PY6. No surveys were conducted in PY7.

[2] Does not include verified savings for small commercial and industrial (C&I) upstream lighting component (cross-sector sales).

Table C-3 summarizes the low-income participation percentage in non-low-income programs for each program year in Phase II.

**Table C-3: Phase II Percentage of Low-Income Participation in Non-Low-Income Programs**

| Program | PY5 | PY6 | PY7 |
|---|---|---|---|
| Appliance Recycling | 9% | 12% | 19% |
| Behavior and Education | N/A | 5% | 6% |
| Residential Home Comfort | 3% | 2% | 4% |
| Residential Retail – Equipment | 12% | 4% | 2% |
| Residential Retail – Lighting | 9% | 19% | 14% |
| Student and Parent Energy-Efficiency Education | 33% | 40% | 45% |

Federal poverty guidelines are shown in Table C-4. The PY7 analyses used the 2015 guidelines, the PY6 analysis used the 2014 guidelines, and the PY5 analysis used the 2013 guidelines.

**Table C-4. Federal Poverty Guidelines**

| Persons in Family | PY1 | PY2 | PY3 | PY4 | PY5 | PY6 | PY7 |
|---|---|---|---|---|---|---|---|
| | 2009 Continental U.S.[1] | 2010 Continental U.S.[2] | 2011 Continental U.S.[3] | 2012 Continental U.S.[4] | 2013 Continental U.S.[5] | 2014 Continental U.S.[6] | 2015 Continental U.S. [7] |
| 1 | $10,830 | $10,830 | $10,890 | $11,170 | $11,490 | $11,670 | $11,770 |
| 2 | $14,570 | $14,570 | $14,710 | $15,130 | $15,510 | $15,730 | $15,930 |
| 3 | $18,310 | $18,310 | $18,530 | $19,090 | $19,530 | $19,790 | $20,790 |
| 4 | $22,050 | $22,050 | $22,350 | $23,050 | $23,550 | $23,850 | $24,250 |
| 5 | $25,790 | $25,790 | $26,170 | $27,010 | $27,570 | $27,910 | $28,410 |
| 6 | $29,530 | $29,530 | $29,990 | $30,970 | $31,590 | $31,970 | $32,570 |
| 7 | $33,270 | $33,270 | $33,810 | $34,930 | $35,610 | $36,030 | $36,730 |
| 8 | $37,010 | $37,010 | $37,630 | $38,890 | $39,630 | $40,090 | $40,890 |
| For Each Additional Person Add | $3,740 | $3,740 | $3,820 | $3,960 | $4,020 | $4,020 | $4,160 |

[1] U.S. Department of Health and Human Services. "2009 Poverty Guidelines." Available at: http://aspe.hhs.gov/2009-hhs-poverty-guidelines

[2] U.S. Department of Health and Human Services. "The HHS Poverty Guidelines for the Remainder of 2010 (August 2010)." Available at: http://aspe.hhs.gov/poverty/10poverty.shtml

[3] U.S. Department of Health and Human Services. "The 2011 HHS Poverty Guidelines." Available at: http://aspe.hhs.gov/poverty/11poverty.shtml

[4] Department of Health and Human Services. "The 2012 HHS Poverty Guidelines." Available at: http://aspe.hhs.gov/poverty/12poverty.shtml

[5] Department of Health and Human Services. "2013 Poverty Guidelines." Available at: http://aspe.hhs.gov/poverty/13poverty.cfm

[6] U.S. Department of Health and Human Services. "2014 Poverty Guidelines." Available at: http://aspe.hhs.gov/poverty/14poverty.cfm

[7] U.S. Department of Health and Human Services. "2015 Poverty Guidelines." Available at: https://aspe.hhs.gov/2015-poverty-guidelines#guidelines

Table C-5 shows, by program year, the verified gross MWh/year savings associated with the federal poverty level population in the general residential programs, and the verified gross MWh/year savings associated with low-income programs. It also shows the total verified gross low-income savings (MWh/year) achieved for Phase II exceeded the Phase II goal of 36,948 MWh/year.

**Table C-5. Phase II Verified Gross Low-Income Energy Savings**

| Sector | Verified Gross Low-Income Energy Savings (MWh/yr) | | | |
|---|---|---|---|---|
| **Program Year** | **PY5** | **PY6** | **PY7** | **Phase II Total** |
| Low-Income Verified Gross Savings from General Residential Programs | 9,078 | 8,829 | 13,667 | 31,574 |
| Low-Income Verified Gross Savings from Low Income Programs | 3,980 | 6,171 | 18,112 | 18,112 |
| **All Low Income Verified Gross Savings** | **13,057** | **15,001** | **31,779** | **59,837** |
| **Goal (MWh/yr)** | | | | **36,948** |
| **Progress Toward Low Income Goal** | | | | **162%** |

**PY7 Survey Questions for Federal Poverty Level Guidelines**

These questions were used to collect number of people in the household and household income. These data were used to determine low-income participation in non-low-income programs. (The letter and number sequence is taken directly from the survey instrument.)

D1. Including yourself, how many people lived in your home full-time during the past 12 months? (If Necessary: full-time is considered more than 9 months in the past year)

*1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 or more; don't know; refused*

D2. In 2015, was your annual household income before taxes above or below $50,000?

*Below $50,000 [ASK D3]; Above $50,000 [SKIP TO D6]; Exactly $50,000 [SKIP TO CLOSING]; Don't Know [SKIP TO CLOSING]; Refused [SKIP TO CLOSING]*

D3. Was your annual household income before taxes above or below $25,000?

*Below $25,000 [ASK D4]; Above $25,000 [SKIP TO D5]; Exactly $25,000 [SKIP TO CLOSING]; Don't Know [SKIP TO CLOSING]; Refused [SKIP TO CLOSING]*

D4. Please stop me when I read your category. Was it … [READ LIST]:

*Under $10,000 [SKIP TO CLOSING]; $10,000 to under $15,000 [SKIP TO CLOSING]; $15,000 to under $20,000 [SKIP TO CLOSING]; $20,000 to under $25,000 [SKIP TO CLOSING]; Don't Know [SKIP TO CLOSING]; Refused) [SKIP TO CLOSING]*

[ASK IF D3=2, "Above $25,000"]

D5. Please stop me when I read your category. Was it … [READ LIST]

*$25,000 to under $30,000 [SKIP TO CLOSING]; $30,000 to under $35,000 [SKIP TO CLOSING]; $35,000 to under $40,000 [SKIP TO CLOSING]; $40,000 to under $45,000 [SKIP TO CLOSING]; $45,000 to under $50,000 [SKIP TO CLOSING]; Don't Know [SKIP TO CLOSING]; Refused [SKIP TO CLOSING]*

[ASK IF D2=2, "Above $25,000"]

D6. Please stop me when I read your category. Was it … [READ LIST]

*$50,000 to under $60,000; $60,000 to under $75,000; $75,000 to under $100,000; $100,000 to under $150,000; $150,000 to under $200,000; $200,000 or more; Don't know; Refused*

# APPENDIX D | RESIDENTIAL LIGHTING UPSTREAM PROGRAM CROSS-SECTOR SALES

## D.1 INTRODUCTION

The upstream lighting component of PPL Electric Utilities' Residential Retail Program is intended for residential customers but, because incentives are paid directly to manufacturers, the actual participants are not known and small-business owners are assumed to make up a proportion of customers buying discounted bulbs from participating retailers. Because bulbs installed in commercial settings are subject to different assumptions that affect annual savings, in accordance with the Pennsylvania technical reference manual (TRM), Cadmus, the evaluation, measurement, and verification (EM&V) conservation service provider (CSP), conducted a study to estimate the proportion of the program bulbs purchased by commercial customers, referred to as "cross-sector sales."

## D.2 METHODOLOGY

### D.2.1 Surveys

Cadmus used data from general-population customer surveys, as well as from PPL Electric Utilities' customer records, to estimate the cross-sector sales proportion. Details regarding survey sampling and methodology can be found in the Residential Retail Process Evaluation Methodology section (Section 3.4.3) and Addendum A. Participant Survey Attrition and Final Disposition.

Cadmus surveyed PPL Electric Utilities' general residential customer population and a subset of its small commercial customer base to estimate the percentage of customers (from each population) who purchased LEDs from a participating retailer in the previous six months.[2] Both surveys were conducted in the spring of 2015 to capture responses during roughly the same period of time and to avoid any potential bias due to seasonality, pricing changes, or other time-based factors that could contribute to changes in bulb-purchasing behavior.

### D.2.2 Data Cleaning and Distribution Analysis

In reviewing and cleaning the resulting survey data, Cadmus considered responses to questions regarding business type, installation locations, and specific bulbs purchased. It excluded from the count of commercial respondents purchasing LEDs any who said they installed these bulbs in rental properties or any location other than their business. Also excluded from the count of LED purchasers were any residential respondents who appeared, based on responses to later questions, to have referred to CFLs rather than LEDs (i.e., they described the bulb shapes as "spiral" or "corkscrew" or either quoted a price consistent with a CFL or said all of their sockets had CFLs in them).

To ensure the appropriateness of applying the metrics gleaned from the small-commercial customer survey to PPL Electric Utilities' small commercial customer base, Cadmus compared the distribution of standard industrial classification (SIC) codes in the survey respondent group to the assumed population and found the distributions were similar. It excluded from the assumed customer base for this study records for customers with annual kWh usages outside of the range observed in the survey respondent group and any customers with SIC code 4841, Cable and Other Pay Television Services, because these were determined to be fixed-usage accounts, not applicable to the assumed population. After making

2 The EM&V CSP excluded customers with a GS3 rate code, as these larger businesses are not expected to purchase bulbs from retailers.

these adjustments to the population, a sum rank test of differences between the sample and the population was insignificant at 95% confidence.

### D.2.3 Calculations

Cadmus computed metrics for the percentage of customers purchasing bulbs and the average number of bulbs they purchased, then multiplied these two metrics by each surveyed population's total customer base to compute a theoretical estimate of the number of bulbs purchased during the six-month period. Although these theoretical bulb purchases were not expected to be accurate—due mainly to recall bias about when respondents thought they had made the purchase—such bias was expected to be similar between the two populations. Therefore, a relative proportion of bulbs purchased could be derived from these estimates. The computed metrics and resulting proportions are shown in Table D-1.

**Table D-1: Metrics and Calculated Proportions, by Population**

| Population | Percentage of Respondents Who Purchased LEDs from Participating Retailers | | Average Number of LEDs Purchased per Respondent | | | PPL Electric Utilities Customer Base | LEDs purchased from Participating Retailers by Small Commercial Customers | Percentage of Total (Cross-Sector Proportion) |
|---|---|---|---|---|---|---|---|---|
| | Estimate | n | Estimate | n | Std. Deviation | | (% x Avg. # x Customer Base) | |
| Small Commercial | 16% | 385 | 12.20 | 61 | 25.90 | 126,000[1] | 247,483 | 20% |
| Residential | 14% | 301 | 6.17 | 41 | 4.42 | 1,200,000 | 1,008,638 | 80% |
| **Total** | | | | | | **1,326,000** | **1,256,120** | **100%** |

[1]The small commercial customer base excludes rate codes not included in the survey sample as well as static-usage customers (telecommunications accounts; SIC code 4841, and customers outside the kWh usage range observed in the survey respondent group).

### D.2.4 Statistical Confidence and Final Recommendation for Proportional Adjustment

The cross-sector proportion was an estimate based on two variables derived from the customer survey—the percentage of respondents and the average number of bulbs purchased per respondent in each population. The percentage of purchasers in each population, based on a yes/no question, had large sample sizes (385 for commercial and 301 for residential). The average number of bulbs was derived from the responses of a subset of each population and the respondents who actually purchased bulbs (n=61 commercial, n=41 residential), and these estimates had relatively large standard deviations.

To compute a statistical confidence interval, Cadmus ran simulations of the above computations, treating the distribution of the number of bulbs per respondent as a normally distributed random variable and the percentage of purchasers as a uniform random variable. At 90% confidence, the resulting cross-sector proportion lay between 11% and 29%.

Cadmus recommended that PPL Electric Utilities continue to use 12% as the assumed proportion of program bulbs being purchased by commercial customers (as it had been doing since the original analysis in PY4). Although this was very close to the bottom end of a relatively wide confidence range, given the uncertainty in the estimation of purchase behavior based on self-report survey data and the relatively significant effect on savings, as described in Section 0, below, it was appropriate to use a conservative estimate.

## D.3 SAVINGS INPUTS AND IMPACT

The 2015 Pennsylvania TRM gives the following general equations for computing lighting energy savings:[3]

$$\Delta\, kWh/yr \;=\; \frac{Watts_{\,base} - Watts_{LED}}{1000\,\frac{W}{kW}} \times HOU_{\,effbulb} \times\, (1 + IE_{kWh}) \,\times 365\,\frac{days}{yr} \,\times ISR_{effbulb}$$

$$\Delta kW_{peak} \;=\; \frac{Watts_{\,base} - Watts_{LED}}{1000\,\frac{W}{kW}} \times CF \times\, (1 + IE_{kW}) \,\times ISR_{effbulb}$$

The assumptions regarding hours of use (HOU), coincidence factor (CF), and installation rate (ISR) varied by sector. These assumptions were deemed for the residential sector (HOU=2.8 hrs/day; CF=0.091; ISR=97%). For the bulbs assumed to be purchased by the small commercial sector, Cadmus used the hours of use and coincidence factor assumptions, by building type from Table 3-6 in the 2015 TRM.

Using these data, Cadmus computed a weighted average for each business type by mapping the business types of respondents who purchased LEDs from participating retailers to a TRM building type and using the proportion of the total LEDs reported to have been purchased by the respondents associated with each building type. These assumptions, and the distribution of LEDs purchased by respondent business type, are shown in Table D-2.

**Table D-2: Hours of Use (HOU) and Coincidence Factor (CF) Assumptions, by Building Type**

| Respondents Who Purchased LEDs from Participating Retailers | | | 2015 TRM | | |
|---|---|---|---|---|---|
| Business Type | % of Respondents | % of LEDs | HOU | CF | Source |
| Agriculture | 8% | 32% | 3,118 | 0.57 | Avg. of Ind. Manufacturing 1&2 Shifts, Office, Warehouse |
| Auto-Related | 2% | 1% | 4,056 | 0.62 | |
| Construction | 6% | 7% | 2,567 | 0.61 | |
| Education | 2% | 1% | 1,990 | 0.54 | Avg. of School/College/University |
| Grocery Store/Convenience Store | 3% | 3% | 4,660 | 0.87 | |
| Healthcare/Hospital | 3% | 2% | 3,213 | 0.73 | |
| Industrial/Manufacturing | 3% | 7% | 4,739 | 0.57 | Avg. of 1,2,3 shifts |
| Libraries | 2% | 3% | 2,566 | 0.62 | |
| Lodging/Hospitality | 5% | 2% | 4,399 | 0.50 | Avg. of Guest Rooms/Common Spaces |
| Office | 16% | 13% | 2,567 | 0.61 | |
| Other | 11% | 4% | 2,628 | 0.62 | |
| Public Services (nonfood) | 2% | 0% | 3,425 | 0.62 | |
| Religious Worship/Church | 2% | 0% | 1,810 | 0.62 | |
| Restaurant | 21% | 16% | 3,613 | 0.65 | |
| Retail | 15% | 7% | 2,829 | 0.73 | |
| | Avg., weighted by % of LEDs | | 3,208 | 0.62 | |
| | HOU/day (Avg. /365) | | 8.79 | | |

3 The 2014 TRM uses the same algorithms. Pennsylvania Public Utility Commission. *Technical Reference Manual.* June 2015. Available online: http://www.puc.state.pa.us/Electric/pdf/Act129/Act129_TRM-2015_Redlined_v2.pdf

Cadmus used survey data to compute an installation rate by dividing the total number of recently purchased bulbs that were currently installed by the total number of recently purchased bulbs. The effect of the proportional split, and the different assumptions for the residential and commercial sector, are illustrated in Table D-3.

**Table D-3: Assumptions Used and Savings Example**

| Sector | Delta W (13W A-Line LED) | HOU/day | ISR | CF | IEkWh Factor | IEkW | Per-Bulb kWh Savings | % of Bulbs | Savings per Program Bulb (kWh) | Proportion of Total Savings |
|---|---|---|---|---|---|---|---|---|---|---|
| Residential | 30 | 2.8 | 97% | 0.091 | 0.94 | 1.12 | 27.96 | 88% | 24.60 | 68% |
| Commercial | 30 | 8.79 | 89% | 0.62 | 1.12 | 1.34 | 95.61 | 12% | 11.47 | 32% |
| **Total** | | | | | | | | **100%** | **36.07** | **100%** |

## D.4 CALCULATING UNCERTAINTY FOR RESIDENTIAL RETAIL PROGRAM LIGHTING SAVINGS

In this study of discounted LEDs, the estimate included a cross-sector sales adjustment where population sizes, proportion of respondents who purchased bulbs (survey estimate), and the average number of bulbs they purchased at participating retailers (survey estimate) were combined into a ratio of the total commercial bulbs to total bulbs in both sectors. Because both the numerator and denominator of the cross-sector sales adjustment were estimated with uncertainty, the variance of the ratio had no closed-form solution and commonly used methods were not applicable.

Therefore, Cadmus used a statistical simulation study to generate 100,000 realizations of the proportion of purchasers in each sector and respective bulb quantities purchased using means and variances equal to observed survey means and variances. It calculated the cross-sector sales adjustment and energy savings for each realization and then estimated the variability in savings across the realizations.

Cadmus estimated precision for energy savings by calculating the 5$^{th}$ and 95$^{th}$ percentile of their distribution, which it then used to estimate the confidence interval around the total savings and to report precision. It set the precision of the demand savings equal to that of the energy savings because demand savings were estimated by applying a fixed multiplier to the energy savings, depending on the customer sector and the TRM used.

Based on the variance in the realizations, Cadmus estimated precision for energy and demand savings at 12%.

# APPENDIX E | GLOSSARY OF TERMS

This Glossary of Terms was provided by the SWE.

## -A-

**Administration Management and Technical Assistance Costs:** Includes rebate processing, tracking system, general administration, EDC and CSP program management, general management and legal, and technical assistance.

**Avoided Cost**: In the context of energy efficiency, the costs that are avoided by the implementation of an energy efficiency measure, program, or practice. Such costs are used in benefit/cost analyses of energy efficiency measures and programs as defined by the Pennsylvania PUC in the 2013 TRC Test Order.

## -B-

**Baseline**: Conditions that would have occurred without implementation of the subject measure or project. Baseline conditions are sometimes referred to as "business-as-usual" conditions and are used to calculate program-related efficiency or emissions savings. Baselines can be defined as either project-specific baselines or performance-standard baselines (e.g., building codes). For the purposes of Act 129, baselines are defined in the Pennsylvania TRM, in approved custom protocols, and in TRM interim approved protocols.

**Baseline Data**: The information representing the systems being upgraded before the energy efficiency activity takes place.

**Benefit/Cost Ratio**: The mathematical relationship between the benefits and costs associated with the implementation of energy efficiency measures, programs, or practices. The benefits and costs are typically expressed in dollars. This is the ratio of the discounted total benefits of the program to the discounted total costs over the expected useful life of the energy efficiency measure. The explicit formula for use in Pennsylvania is set forth in the TRC Order. Also see *Benefit-Cost Test*.

**Benefit-Cost Test**: Also called *Cost-Effectiveness Test,* defined as the methodology used to compare the benefits of an investment to the costs. For programs evaluated under Act 129, the TRC Test is the required benefit-cost test as established in the TRC Order.

**Bias**: The extent to which a measurement, sampling, or analytic method systematically underestimates or overestimates a value. Some examples of types of bias include engineering model bias; meter bias; sensor bias; an inadequate or inappropriate estimate of what would have happened absent a program or measure installation; a sample that is unrepresentative of a population; and selection of other variables in an analysis that are too correlated with the savings variable (or each other) in explaining the dependent variable (such as consumption).

## -C-

**Coefficient of Variation**: The mean (average) of a sample divided by its standard error.

**Coincident Demand**: The demand of a device, circuit, or building that occurs at the same time as the system peak demand. For purposes of Act 129 reporting, the coincident demand is during the peak period as defined in the TRM (June through August, excluding weekends and holidays between 2 and 6 PM.

**Coincidence Factor**: The ratio, expressed as a numerical value or as a percentage of connected load, of the coincident demand of an electrical appliance or facility type to the system peak.

**Completed Project:** A project in which the energy conservation measure has been installed and is commercially operable, and for which an incentive has been provided.

**Confidence**: An indication of the probability that an estimate is within a specified range of the true value of the quantity in question. Confidence is the likelihood that the evaluation has captured the true value of a variable within a certain estimated range. Also see *Precision*.

**Correlation**: For a set of observations, such as for participants in an energy efficiency program, the extent to which values for one variable are associated with values of another variable for the same participant. For example, facility size and energy consumption usually have a high positive correlation.

**Cost-Benefit and Cost-Effectiveness Analysis**: See *Benefit-Cost Test*.

**Cost-Effectiveness**: An indicator of the relative performance or economic attractiveness of an investment or practice. In the energy efficiency field, the present value of the estimated benefits produced by an energy efficiency program is compared to the estimated total costs to determine if the proposed investment or measure is desirable from a variety of perspectives (e.g., whether the estimated benefits exceed the estimated costs consistent with definitions in the TRC Order. See *Benefit-Cost Test*.

**Cost-Effectiveness Test**: See *Benefit-Cost Test*.

**Cumulative Energy Savings**: The summation of energy savings associated with multiple projects or programs over a specified period of time.

**Custom Program**: An energy efficiency program intended to provide efficiency solutions to unique situations not amenable to common or prescriptive solutions addressed by the Pennsylvania TRM. Each custom project is examined for its individual characteristics, savings opportunities, efficiency solutions, and often, customer incentives. Under Act 129, these programs fall outside of the jurisdiction of the Pennsylvania TRM, and thus the M&V protocols for each should be approved by the SWE.

## -D-

**Deemed Savings**: An estimate of energy or demand savings for a single unit of an installed energy efficiency measure that: (1) has been developed from data sources and analytical methods that are widely considered acceptable for the measure and purpose, and (2) is applicable to the situation being evaluated. Individual parameters or calculation methods can also be deemed. Deemed savings for measures implemented under Act 129 are stipulated in the Pennsylvania TRM, which undergoes an annual review and update process, as well as in the Interim TRM Measures, which are subject to interim approval by the SWE.

**Defensibility**: The ability of evaluation results to stand up to scientific scrutiny. Defensibility is based on assessments by experts of the evaluation's validity, reliability, and accuracy. Under Act 129, it is the role of the SWE to determine the defensibility of the verified savings estimates reported by each of the EDCs.

**Delta Watts**: The difference in the connected load (wattage) between existing or baseline equipment and the energy-efficient replacement equipment, expressed in Watts or kilowatts.

**Demand**: The rate of energy flow. Demand usually refers to the amount of electric energy used by a customer or piece of equipment over a defined time interval (e.g., 15 minutes), expressed in kW (equals kWh/h). Demand can also refer to natural gas usage over a defined time interval, usually as Btu/hr, kBtu/hr, therms/day, or ccf/day.

**Demand Reduction**: See *Demand Savings*.

**Demand Response**: The reduction of customer energy usage at times of peak usage in order to help system reliability, to reflect market conditions and pricing, or to support infrastructure optimization or deferral of additional infrastructure. Demand response programs may include contractually obligated or voluntary curtailment, direct load control, and pricing strategies.

**Demand Savings**: The reduction in electric demand from the demand associated with a baseline system to the demand associated with the higher-efficiency equipment or installation. Demand savings associated with energy efficiency measures implemented under Act 129 are calculated according to the approved calculation methods stipulated in the TRM or subsequently approved through alternative methods (e.g., interim measures, custom protocols).

**Demand-side Management**: Strategies used to manage energy demand including energy efficiency, load management, fuel substitution, and load shedding.

## -E-

**Energy Efficiency and Conservation (EE&C) Plan:** Plan as filed by the EDC and approved by the PUC.

**EE&C Plan Estimate for Program Year:** An estimate of the energy savings or demand reduction for the current program year as filed in the EDC EE&C plans.

**Effective Useful Life**: An estimate of the median number of years that efficiency measures installed under a program are still in place and operable. For measures implemented under Act 129, it is required that the effective useful life or 15 years, whichever is less, be used to determine measure assessments.

**Electric Distribution Company (EDC)**: In reference to Act 129, there are seven EDCs with at least 100,000 customers that are required to adopt a plan to reduce energy and demand consumption within their service territory in accordance with 66 Pa. C.S. § 2608. The seven EDCs are: Duquesne Light, Metropolitan Edison Company, Pennsylvania Electric Company, Pennsylvania Power Company, PECO Energy Company, PPL Electric Utilities and West Penn Power.

**End Use**: An appliance, activity, system, or equipment that uses energy.

**Energy Conservation**: Using less of a service in order to save energy. The term often is used unintentionally instead of *energy efficiency*.

**Energy Efficiency**: The use of less energy to provide the same or an improved level of service to the energy consumer; or the use of less energy to perform the same function.

**Energy Efficiency Measure:** An installed piece of equipment or a system, modification of equipment systems, or modified operations in customer facilities that reduce the total amount of electrical or gas energy and the capacity that otherwise would have been needed to deliver an equivalent or improved level of comfort or energy service.

**Energy Savings**: A reduction in electricity use (kWh) or in fossil fuel use in thermal unit(s).

**Evaluation**: The conduct of any of a wide range of assessment studies and other activities aimed at documenting an enhanced understanding of a program or portfolio, including determining the effects of a program, understanding or documenting program performance, program-related markets and market operations, program-induced changes in energy efficiency markets, levels of potential demand or energy savings, and/or program cost-effectiveness. Market assessments, monitoring and evaluation, and M&V are aspects of evaluation.

**Ex Ante Savings Estimate**: Forecasted savings used for program and portfolio planning purposes.

**Ex Post Savings Estimate**: Savings estimate reported by an evaluator after the energy impact evaluation has been completed.

## -F-

**Free Driver**: A program nonparticipant who adopted a particular efficiency measure or practice as a result of the evaluated program. Also see *Spillover*.

**Free-Rider**: A program participant who would have implemented the program measure or practice in the absence of the program. Free-riders can be: (1) total, in which the participant's activity would have completely replicated the program measure; (2) partial, in which the participant's activity would have partially replicated the program measure; or (3) deferred, in which the participant's activity would have completely replicated the program measure, but after the program's timeframe.

**Free-Ridership Rate**: The percent of savings attributable to free-riders.

## -G-

**Gross Impact**: See *Gross Savings*.

**Gross Savings**: The change in energy consumption and/or demand that results directly from program-related actions taken by participants in an efficiency program, regardless of why they participated.

**Gross kW**: Expected demand reduction based on a comparison of standard or replaced equipment with equipment installed through an energy efficiency program.

**Gross kWh**: Expected kWh reduction based on a comparison of standard or replaced equipment with equipment installed through an energy efficiency program.

## -H, I-

**Impact Evaluation**: An evaluation of the program-specific, directly induced quantitative changes (kWh, kW, and therms) attributable to an energy efficiency program.

**Incremental Cost**: The difference between the cost of an existing or baseline equipment or service and the cost of an alternative energy efficient equipment or service.

**Incremental Energy Savings**: The difference between the amount of energy savings associated with a project or a program in one period and the amount of energy savings associated with that project or program in a prior period.

## -J, K-

**Kilowatt (kW)**: A measure of the rate of power used during a pre-set time period (e.g., minutes, hours, days, months) equal to 1,000 Watts.

**Kilowatt-Hour (kWh)**: A common unit of electric energy; one kilowatt-hour is numerically equal to 1,000 Watts used for one hour.

## -L-

**Lifetime kW**: The expected demand savings over the lifetime of an installed measure, equal to the annual peak kW reduction associated with a measure multiplied by the expected lifetime of that measure. It is expressed in units of kW-years.

**Lifetime MWh**: The expected electrical energy savings over the lifetime of an installed measure, calculated by multiplying the annual MWh reduction associated with a measure by the expected lifetime of that measure.

**Lifetime Supply Costs**: The net present value of avoided supply costs associated with savings, net of changes in energy use that would have happened in the absence of the program over the life of the energy efficiency measure, factoring in persistence of savings. See *Avoided Cost*.

**Load Factor**: A percentage indicating the ratio of electricity or natural gas used during a given timeframe to the amount that would have been used if the usage had stayed at the highest demand the whole time. The term is also used to indicate the percentage of capacity of an energy facility, such as a power plant or gas pipeline, that is utilized for a given period of time.

**Load Management**: Steps taken to reduce power demand at peak load times or to shift some of it to off-peak times. Load management may coincide with peak hours, peak days, or peak seasons. Load management may be pursued by persuading consumers to modify behavior or by using equipment that regulates some electric consumption. This may lead to complete elimination of electric use during the period of interest (load shedding) and/or to an increase in electric demand in the off-peak hours as a result of shifting electric usage to that period (load shifting).

## -M-

**Market Assessment**: An analysis that provides an assessment of how and how well a specific market or market segment is functioning with respect to the definition of well-functioning markets or with respect to other specific policy objectives. Generally includes a characterization or description of the specific market or market segments, including a description of the types and number of buyers and sellers in the market, the key factors that influence the market, the type and number of transactions that occur on an annual basis, and the extent to which market participants consider energy efficiency as an important part of these transactions. This analysis may also include an assessment of whether a market has been sufficiently transformed to justify a reduction or elimination of specific program interventions. Market assessments can be blended with strategic planning analysis to produce recommended program designs or budgets. One particular kind of market assessment effort is a baseline study, or the characterization of a market before the commencement of a specific intervention in the market, for the purpose of guiding the intervention and/or assessing its effectiveness later.

**Measurement and Verification (M&V)**: A subset of program impact evaluations that are associated with the documentation of energy savings at individual sites or projects using one or more methods that can involve measurements, engineering calculations, statistical analyses, and/or computer simulation modeling.

**Measurement Error**: In the evaluation context, a reflection of the extent to which the observations conducted in the study deviate from the true value of the variable being observed. The error can be random (equal around the mean) or systematic (indicating bias).

**Megawatt (MW)**: A unit for measuring electricity equal to 1,000 kilowatts or one million Watts.

**Megawatt-Hour (MWh)**: A unit of electric energy numerically equal to 1,000,000 Watts used for one hour.

**Metered Data**: Data collected over time through a meter for a specific end use, energy-using system (e.g., lighting, HVAC), or location (e.g., floors of a building, a whole premise). Metered data may be collected over a variety of time intervals. Usually refers to electricity or gas data.

**Metering**: The collection of energy consumption data over time through the use of meters. These meters may collect information about an end use, a circuit, a piece of equipment, or a whole building (or facility). *Short-term metering* generally refers to data collection for no more than a few weeks. *End-use metering* refers specifically to separate data collection for one or more end uses in a facility, such as lighting, air conditioning, or refrigeration. *Spot metering* is an instantaneous measurement (rather than over time) to determine equipment size or power draw.

**Monitoring**: The collection of relevant measurement data over time at a facility, including but not limited to energy consumption or emissions data (e.g., energy and water consumption, temperature, humidity, volume of emissions, and hours of operation) for the purpose of conducting a savings analysis or to evaluate equipment or system performance.

## -N-

**Net Impact**: See *Net Savings*.

**Net Present Value**: The discounted value of the net benefits or costs over a specified period of time (e.g., the expected useful life of the energy efficiency measure).

**Net Savings**: The total change in load that is attributable to an energy efficiency program. This change in load may include, implicitly or explicitly, the effects of spillover, free-riders, energy efficiency standards, changes in the level of energy service, and other causes of changes in energy consumption or demand. Net savings are calculated by multiplying verified savings by a NTG ratio.

**Net-to-Gross (NTG)**: A factor representing net program savings divided by gross program savings that is applied to gross program impacts to convert them into net program load impacts.

**Nonparticipant**: Any consumer who was eligible but did not participate in the subject efficiency program in a given program year.

## -O-

**Off-Peak Energy kWh Savings**: The kWh reduction that occurs during a specified period of off-peak hours for energy savings (see the PA TRM Table 1-1).

**On-Peak Energy kWh Savings**: The kWh reduction that occurs during a specified period of on-peak hours for energy savings (see the PA TRM Table 1-1).

## -P-

**Participant**: A utility customer partaking in an energy efficiency program, defined as one transaction or one rebate payment in a program. For example, a customer receiving one payment for two measures within one program counts as one participant. A customer receiving two payments in two programs counts as two participants. A customer partaking in one program at two different times receiving two separate payments counts as two participants.

**Participant Costs**: Costs incurred by a customer participating in an energy efficiency program.

**Peak Demand**: The maximum level of metered demand during a specified period, such as a billing month or a peak demand period.

**Peak Load**: The highest electrical demand within a particular period of time. Daily electric peaks on weekdays typically occur in the late afternoon and early evening. Annual peaks typically occur on hot summer days.

**Percent of Estimate Committed**: The program year-to-date total committed savings as a percent of the savings targets established in each EDC EE&C Plan, calculated by dividing the PYTD total committed by the EE&C Plan program year estimate.

**Portfolio**: Can be defined as: (1) a collection of programs addressing the same market (e.g., a portfolio of residential programs), technology (e.g., motor efficiency programs), or mechanisms (e.g., loan programs); or (2) the set of all programs conducted by one or more organizations, such as a utility or program administrator, and which could include programs that cover multiple markets, technologies, etc.

**Precision**: An indication of the closeness of agreement among repeated measurements of the same physical quantity. It is also used to represent the degree to which an estimated result in social science (e.g., energy savings) would be replicated with repeated studies.

**Preliminary Program Year-to-Date (PYTD) Net Impact**: Net impacts reported in quarterly reports. These net impacts are preliminary in that they are based on preliminary realization rates.

**Preliminary Program Year-to-Date (PYTD) Verified Impact**: Verified impacts reported in quarterly reports. These verified impacts are preliminary in that they are based on preliminary realization rates.

**Preliminary Realization Rate**: Realization rates reported in quarterly reports based on the results of M&V activities conducted on the sample to date. These results are preliminary because the sample-to-date is likely not to have met the required levels of confidence and precision.

**Prescriptive Program**: An energy efficiency program focused on measures that are one-for-one replacements of the existing equipment and for which anticipated similar savings results across participants.

**Process Evaluation**: A systematic assessment of an energy efficiency program for the purposes of documenting program operations at the time of the examination and identifying and recommending improvements to increase the program's efficiency or effectiveness for acquiring energy resources, while maintaining high levels of participant satisfaction.

**Program Administrator**: Those entities that oversee the implementation of energy efficiency programs. This generally includes regulated utilities, other organizations chosen to implement such programs, and state energy offices.

**Program Year Energy Savings Target**: Energy target established for the given program year as approved in each EDC EE&C Plan.

**Program Year Sample Participant Target**: Estimated sample size for evaluation activities in the given program year.

**Program Incentive**: An incentive, generally monetary, that is offered to a customer through an energy efficiency program to encourage their participation. The incentive is intended to overcome one or more barriers that keep the customer from taking the energy efficiency action on their own.

**Program Participant**: A consumer that received a service offered through an efficiency program in a given program year. The term "service" can refer to one or more of a wide variety of services, including financial rebates, technical assistance, product installations, training, energy efficiency information, or other services, items, or conditions.

**Program Year-to-Date (PYTD)**: Beginning June 1 of the current program year through the end of the current quarter (February 28/29, May 31, August 31, or November 30).

**Program Year-to-Date (PYTD) Net Impact**: The total change in load that is attributable to an energy efficiency program from June 1 of the current program year through the end of the current quarter (February 28/29, May 31, August 31, or November 30).

**Program Year-to-Date (PYTD) Participants**: The number of utility customers participating in an energy efficiency program beginning June 1 of the current program year through the end of the current quarter (February 28/29, May 31, August 31, or November 30).

**Program Year-to-Date (PYTD) Reported Gross Impact**: The change in energy consumption and/or demand that results directly from program-related actions taken by participants in an efficiency program, regardless of why they participated, beginning June 1 of the current program year through the end of the current quarter (February 28/29, May 31, August 31, or November 30). This value is unverified by an independent third-party evaluator.

**Program Year-to-Date (PYTD) Sample Participants**: Total participant sample beginning June 1 of the current program year through the end of the current quarter (February 28/29, May 31, August 31, or November 30).

**Program Year-to-Date (PYTD) Total Committed**: The estimated gross impacts, including reported impacts and in-progress impacts, beginning June 1 of the current program year through the end of the current quarter (February 28/29, May 31, August 31, or November 30), calculated by adding PYTD reported gross impacts for projects in progress.

**Project**: An activity or course of action involving one or multiple energy efficiency measures at a single facility or site.

**Projects in Progress**: Energy efficiency and demand response projects currently being processed and tracked by the EDC, but that are not yet complete at the time of the report. See *Completed Project*.

## -Q,R-

**Realization Rate**: The term is used in several contexts in the development of reported program savings. The primary applications include the ratio of project tracking system savings data (e.g., initial estimates of project savings) to savings that: 1) are adjusted for data errors, and 2) incorporate the evaluated or verified results of the tracked savings.

**Rebate Program**: An energy efficiency program in which the program administrator offers a financial incentive for the installation of energy-efficient equipment.

**Rebound Effect**: Also called "snap back," defined as a change in energy-using behavior that yields an increased level of service that is accompanied by an increase in energy use and occurs as a result of taking an energy efficiency action. The result of this effect is that the savings associated with the direct energy efficiency action are reduced by the resulting behavioral change.

**Regression Analysis**: Analysis of the relationship between a *dependent variable* (response variable) to specified *independent variables* (explanatory variables). The mathematical model of their relationship is the *regression equation*.

**Regression Model**: A mathematical model based on statistical analysis where the dependent variable is quantified based on its relationship to the independent variables that are believed to determine its value. In so doing, the relationship between the variables is estimated statistically from the data used.

**Reliability:** The quality of a measurement process that would produce similar results on: (1) repeated observations of the same condition or event, or (2) multiple observations of the same condition or event by different observers.

**Renewable Energy**: Energy derived from resources that are naturally replenishing. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include biomass, hydro, geothermal, solar, wind, ocean thermal, wave action, and tidal action.

**Reported Gross Impact:** The change in energy consumption and/or demand that results directly from program-related actions taken by participants in an efficiency program, regardless of why they participated. This value is unverified by an independent third-party evaluator. Also referred to as "ex post" impact.

**Reporting Period**: The time following implementation of an energy efficiency activity during which results are to be determined.

**Representative Sample**: A sample that has approximately the same distribution of characteristics as the population from which it was drawn.

**Rigor**: The level of effort expended to minimize uncertainty due to factors such as sampling error and bias. The higher the level of rigor, the more confidence there is that the results of the evaluation are accurate and precise.

## -S-

**Sample**: In program evaluation, a portion of the population selected to represent the whole. Differing evaluation approaches rely on simple or stratified samples (based on some characteristic of the population).

**Sample Design**: The approach used to select the sample units.

**Sampling Error**: The error in estimating a parameter caused by the fact that all of the disturbances in the sample are not zero.

**Savings Factor (SVG):** The percent of time the lights are off due to lighting controls relative to the baseline controls system (typically a manual switch). Also referred to as the *lighting controls savings factor*.

**Simple Random Sample**: A method for drawing a sample from a population such that all samples of a given size have an equal probability of being drawn.

**Snap Back**: See *Rebound Effect*.

**Simulation Model**: An assembly of algorithms that calculate energy use based on engineering equations and user-defined parameters.

**Spillover**: Reductions in energy consumption and/or demand caused by the presence of an energy efficiency program, beyond the program-related gross savings of the participants and without financial or technical assistance from the program. There can be participant and/or nonparticipant spillover. *Participant spillover* is the additional energy savings that occur when a program participant independently installs energy efficiency measures or applies energy-saving practices after having participated in the efficiency program as a result of the program's influence. *Nonparticipant spillover* refers to energy savings that occur when a program nonparticipant installs energy efficiency measures or applies energy-saving practices as a result of a program's influence.

**Spillover Rate**: An estimate of energy savings attributable to spillover effects expressed as a percent of savings installed by participants through an energy efficiency program.

**Standard Error**: A measure of the variability in a data sample indicating how far a typical data point is from the mean of a sample. In a large sample, approximately two-thirds of observations lie within one standard error of the mean, and 95% of observations lie within two standard errors.

**Statistically Adjusted Engineering Models**: A category of statistical analysis models that incorporate the engineering estimate of savings as a dependent variable. The regression coefficient in these models is the percentage of the engineering estimate of savings observed in changes in energy usage. For example, if the coefficient of the statistically adjusted engineering term is 0.8, the customers are, on average, realizing 80% of the savings from their engineering estimates.

**Stipulated Values**: See *Deemed Savings*.

**Stratified Random Sampling**: The population is divided into subpopulations, called *strata*, that are non-overlapping and together comprise the entire population. A simple random sample of each stratum is taken to create a sample based on stratified random sampling.

**Stratified Ratio Estimation**: A sampling method that combines a stratified sample design with a ratio estimator to reduce the coefficient of variation by using the correlation of a known measure for the unit (e.g., expected energy savings) to stratify the population and allocate a sample from the strata for optimal sampling.

## -T-

**Takeback Effect**: See *Rebound Effect*.

**Total Resource Cost (TRC) Test**: A cost-effectiveness test that measures the net direct economic impact to the utility service territory, state, or region. The TRC Order details the method and assumptions to be used when calculating the TRC Test for EE&C portfolios implemented under Act 129. The results of the TRC Test are to be expressed as both a net present value and a benefit-cost ratio.

**Total Resource Cost (TRC) Test Benefits**: Benefits calculated in the TRC Test that include the avoided supply costs, such as the reduction in transmission, distribution, generation, and capacity costs, valued at a marginal cost for the periods when there is a consumption reduction. The PA TRC benefits will consider avoided supply costs, such as the reduction in forecasted zonal wholesale electric generation prices, ancillary services, losses, generation capacity, transmission capacity, and distribution capacity. The avoided supply costs will be calculated using net program savings, defined as the savings net of changes in energy use that would have happened in the absence of the program. The persistence of savings over time will also be considered in the net savings.

**Total Resource Cost (TRC) Test Costs:** The costs calculated in the TRC Test will include the costs of the various programs paid for by an EDC (or by a default service provider) and the participating customers, and costs that reflect any net change in supply costs for the periods in which consumption is increased in the event of load shifting. Note that the TRC Test should use the incremental costs of services and equipment. Thus, for example, this would include costs for equipment, installation, operation and maintenance, removal (less salvage value), and administrative tasks, regardless of who pays for them.

## -U-

**Uncertainty**: The range or interval of doubt surrounding a measured or calculated value within which the true value is expected to fall with some degree of confidence.

**Upstream Program**: A program that provides information and/or financial assistance to entities in the delivery chain of high-efficiency products at the retail, wholesale, or manufacturing level. Such a program is intended to yield lower retail prices for the products.

## -V-

**Verification**: An independent assessment of the reliability (considering completeness and accuracy) of claimed energy savings or an emissions source inventory.

**Verified Gross Impact**: Calculated by applying the realization rate to reported gross impacts. Also referred to as “ex ante” impact.

## -W-

**Watt**: A unit of measure of electric power at a point in time as capacity or demand. One Watt of power maintained over time is equal to one Joule per second. The Watt is named after Scottish inventor James Watt, and is shortened to W and used with other abbreviations, as in kWh (kilowatt-hours).

**Watt-Hour**: One Watt of power expended for one hour, or one-thousandth of a kilowatt-hour.

**Whole-Building Calibrated Simulation Approach**: A savings measurement approach (defined in the International Performance Measurement and Verification Protocol Option D and in the American Society of Heating, Refrigerating and Air-Conditioning Engineers Guideline 14) that involves the use of an approved computer simulation program to develop a physical model of the building in order to determine energy and demand savings. The simulation program is used to model the energy used by the facility before and after the retrofit. The pre- or post-retrofit models are developed by calibration with measured energy use, demand data, and weather data.

**Whole-building Metered Approach**: A savings measurement approach (defined in the International Performance Measurement and Verification Protocol Option C and in the American Society of Heating, Refrigerating and Air-Conditioning Engineers Guideline 14) that determines energy and demand savings through the use of whole-facility energy (end-use) data, which may be measured by utility meters or data loggers. This approach may involve the use of monthly utility billing data or data gathered more frequently from a main meter.

### References

PAH Associations, prepared by Paul Horowitz. Facilitated by the Northeast Energy Efficiency Partnerships. Glossary of Terms Version 1.0. A project of the Regional Evaluation, Measurement and Verification Forum. March 2009.

# APPENDIX F | DEMAND ELASTICITY STUDY

To provide estimates of freeridership for the upstream lighting component of the Residential Retail Program, Cadmus, the EM&V CSP, conducted demand elasticity modeling using bulb sales information from Ecova, the program's ICSP.

## F.1 INTRODUCTION

Lighting products that incur price changes and promotion during the program period provide valuable information regarding the correlation between sales and prices. To estimate freeridership in PY7, Cadmus used a demand elasticity model, which is the same principle as the willingness-to-pay analyses that relied on self-report survey responses. However, rather than relying on self-report data, elasticities are based on actual observed changes in purchasing behavior in response to program activity.

Demand elasticity modeling is based on the same economic principle driving program design: demand for efficient lighting is elastic and changes in price and merchandising generate changes in quantities sold (i.e., the upstream buydown approach). Demand elasticity modeling uses sales and merchandising information to achieve the following:

- Quantify the relationship of price and merchandising to sales
- Predict the likely sales level without the program's intervention (baseline sales)
- Estimate freeridership by comparing predicted baseline savings with predicted program savings

After estimating variable coefficients, Cadmus used the resulting model to predict sales that would have occurred *without* the program's price and merchandising impact and sales that would have occurred *with* the program (which should be close to actual sales with a representative model). Cadmus then multiplied predicted bulb sales by verified savings by bulb type. Freeridership was then calculated using this formula:

$$FR\ Ratio = \left(\frac{Savings\ without\ Program}{Savings\ with\ Program}\right)$$

## F.2 INPUT DATA

Because the demand elasticity approach relies exclusively on program data, a model's robustness depends on data quality. Overall, in PY7 the available data achieved a sufficient quality to support the analysis. Data quality also improved in PY7. In PY6, there were issues with consistency in tracking prices and package quantities, but these issues were not present in the PY7 data.

### F.2.1 Seasonal Anomalies

The PY7 sales data showed a pronounced decrease in sales starting in 2016, when PPL Electric Utilities decided to scale back activity because the Residential Retail Program had already reached its planned savings for Phase II. However, there was no quantitative information that could be incorporated into the model that captured the degree to which the program was being scaled back. Additionally, the scaling back also coincided with typical decreasing sales due to seasonal variation, in which Cadmus observed peak sales in the fall, a smaller peak in spring, and lower sales in winter and early summer.

In economic analysis, it is critical to separate data variations resulting from seasonality from those resulting from relevant external factors. To illustrate this, suppose prices had been reduced on umbrellas at the beginning of the rainy season. Any estimate of this price shift's impact would be skewed if the analysis did not account for the natural seasonality of umbrella sales.

The only quantitative information that Cadmus observed that reflected the scaling back of program activity was decreasing program incentives. Beginning in December of 2015 and continuing through May of 2016, the program changed incentive levels; however, these incentive levels were not the same across retailers. For example, the average incentive at one club store retailer decreased by 35% between years for A-line bulbs and by 66% for reflector bulbs; but at another club store retailer the average incentive changed very little, declining only 12% for A-line bulbs and increasing by 5% for reflector bulbs.

Because incentives and sales trends differed between retailer channels and because PPL Electric Utilities scaled back program activity in 2016, Cadmus controlled for seasonality by using retailer-specific monthly fixed effects.

Additionally, Cadmus modeled price elasticities separately for 2015 and 2016 to account for price changes that were unrelated to incentive levels.

### F.2.2 Additional Incentives

Cadmus identified several instances where the reported promotional price was significantly different than the difference between the regular retail price and the program incentive. The ICSP confirmed that the prices were correct and said that the manufacturers had provided additional incentives for several products during PY7, which accounted for the discrepancy.

The PY7 freeridership estimate assumed that the additional manufacturer incentives would not have occurred absent the program and that the program encouraged manufacturers to provide them. However, the difference in freeridership resulting from these incentives was negligible for all but the hard-to-reach stores where the original price of A-line bulbs was marked down by 51% from program incentives and 25% from manufacturer incentives.

### F.2.3 Price Variation

Overall in PY7, a substantial number of products exhibited price variation. Additionally, most retailers had multiple products that exhibited price variation.

For the demand elasticity model, Cadmus combined sales and prices across all comparable products within a given retailer store location. The average price for each bulb type within each store was the monthly sales-weighted, per-bulb price across all comparable products. Monthly sales were the sum of all sales within each store across the same group of comparable products. For example, Cadmus combined the prices and monthly sales for all 60-watt incandescent-equivalent general purpose bulbs at a single Home Depot store.

Combining sales and prices this way, rather than observing changes in price and sales for each individual model number, had the advantage of capturing any substitutions between comparable products, such as decreases in the average price per-bulb when a three-pack of an existing bulb or a new model was added to the program.

Similarly, suppose one bulb model was replaced with an updated version (with a different model number). Sales of the first model would likely drop because the retailer was running out of back-stock. Aggregating prices and sales captured variation across both products rather than trying to control for the influence on sales of factors unrelated to price (i.e., products being phased out and replaced).

Only sales with price variation or merchandising displays were included in the model. The greater the level of price variation across retailers and lamp styles, the more representative the elasticity estimates when applied to the portion of the program that did not exhibit price variation.

The program discounted bulbs in four retail channels: hard-to-reach (e.g., Habitat Restores), club (e.g., Costco), do-it-yourself (e.g., Lowe's), and mass market retailers (e.g., Target). Cadmus examined the variation across each channel and found significant variation in prices across all channels except for the hard-to-reach retailers. As shown in Table F-1, prices varied for more than 90% of total sales for club, do-it-yourself, and mass market retailers, while prices varied for only 36% of total sales for hard-to-reach retailers.

**Table F-1. PY7 Sales with Price Variation and Representativeness**

| Retail Channel | Modeled Sales | Total Sales | Percentage Represented | Percentage of Total Sales |
|---|---|---|---|---|
| Club | 310,359 | 312,997 | 99% | 25% |
| Do-It-Yourself | 382,962 | 384,590 | 100% | 31% |
| Hard-to-Reach | 145,380 | 404,651 | 36% | 33% |
| Mass Market | 128,752 | 139,900 | 92% | 11% |

Additionally, there was significant variation for most bulb types. The model included sales that represented between 76% to 79% of sales for A-line, candelabra, and reflector bulbs. Globe bulbs were less, with 37% of total sales represented in the model; however, these bulbs accounted for only about 1% of total program sales.

Overall, the model relied on products with price variations that accounted for 78% of total lamp sales in PY7.[4]

### F.2.4 Promotional Displays

The ICSP provided records of specific bulb model numbers that were featured in special promotions during PY7. These records included the dates for which the promotions took place as well as the store numbers to match to the tracking data. This detail was much improved from PY6.

Cadmus was able to match the promotions to records in the sales tracking data for each product number and store location. Ultimately, because the sales and prices for all comparable products were aggregated, Cadmus created variables that captured the proportion of each month's sales that were featured in the promotions.

### F.2.5 Model Specification

Cadmus used an econometric model to organize bulb and pricing data as a panel, with a cross-section of program bulb quantities for each unique retail location, bulb type, and baseline wattage combination modeled over time as a function of price, retail channel (club, do-it-yourself, hard-to-reach, and mass market). This study also involved testing a variety of specifications to ascertain price impacts—the main instrument affected by the program—on the demand for bulbs. Cadmus estimated the basic equation for the model as follows (for cross-section *i*, in month *t*):

4 Products with no price variation provide no information to quantify the relationship between sales and price and are therefore not included.

**Equation F-1**

$$\ln(Q_{it}) = \sum_{\pi}(\beta_{\pi} ID_{\pi,\mathrm{i}}) + \sum_{\lambda}(\beta_{\lambda} Month_{\lambda,\mathrm{t}}) + \sum_{\theta,\delta}(\beta_{\theta 1,\delta 1}[ln(P_{it}) * Year_{\delta} * \ Retail\ Channel_{\delta} * Bulb\ Type_{\delta}]) + \beta_1 Display + \beta_2 + \alpha_{it} + \varepsilon_{it}$$

Where:

| | | |
|---|---|---|
| ln | = | Natural log |
| Q | = | Quantity of bulb packs sold during the month |
| P | = | Retail price in that month |
| Store Type | = | Retailer category (do-it-yourself, mass market, hard-to-reach, club) |
| Bulb Type | = | Product category (general purpose, reflector, candelabra, globe) |
| ID | = | Dummy variable equaling 1 for each unique retail location, bulb type, and base watt; 0 otherwise |
| Month | = | Dummy variable equaling 1 for each unique program month; 0 otherwise |
| Display | = | Dummy variable equaling 1 if a product was featured in an off-shelf display in time period t |
| $\varepsilon_{it}$ | = | Cross-sectional random-error term in time period *t* |
| $\alpha\varepsilon_{it}$ | = | Time period random-error term in time period *t* |

The model specification assumed a lognormal distribution. This distribution serves as the best fit of the plausible distributions (negative binomial, poisson, negative binomial, or gamma).

Cadmus ran numerous model scenarios to identify the model with the best parsimony and explanatory power using these criteria:

- Model coefficient p-values (keeping values less than <0.1)[5]
- Explanatory variable cross-correlation (minimizing where possible)
- Model AIC (minimizing between models)[6]
- Utilizing the heteroskedastic consistent covariance matrix and clustered standard errors to account for heteroskedasticity
- Minimizing multicollinearity
- Optimizing model fit

The fit of the model can be examined by comparing the model-predicted sales with the actual sales. As shown in Figure F-1, the model-predicted sales matched very closely the actual sales with no persistent bias in a single direction (over or under-predicting), indicating that the model fit the data well. As the figure shows, the two largest discrepancies between predicted and actual sales occurred at the end of

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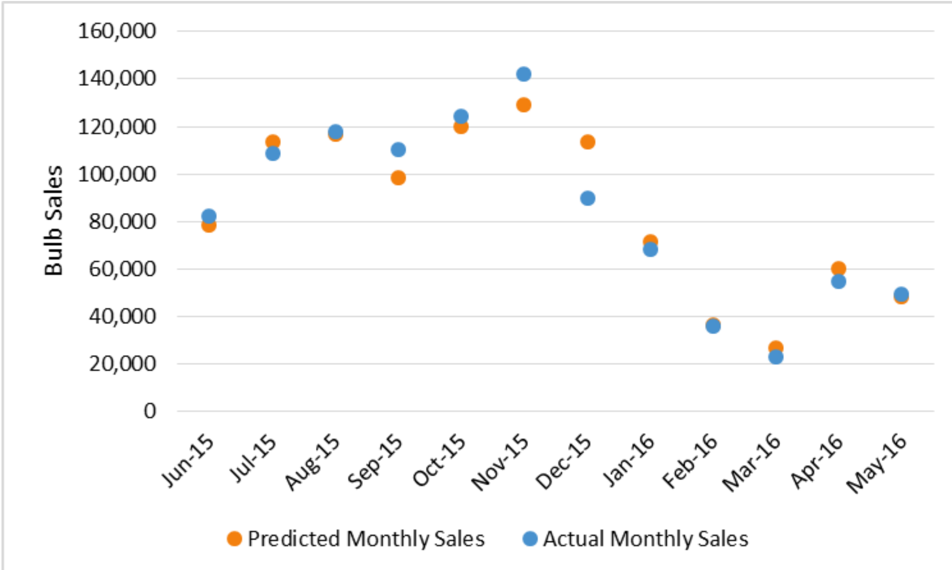
5 Where a qualitative variable had many states (such as bulb type), Cadmus did not omit variables if one of the states was not significant, but rather considered the joint significance of all states. The team used robust estimation of model standard errors to properly represent model accuracy and to guide the specification process. The error structure involved clustering around cross-sectional units.

6 Akaike's Information Criteria (AIC) was used to assess model fit, as the R-square statistic is undefined for nonlinear models. AIC also has the desirable property that it penalizes overly complex models, similar to the adjusted R-square.

2015. The model under-predicted in November of 2015 and over-predicted the following month, but overall the predictions fit actual sales well and over-predicted sales by less than 1%.

**Figure F-1. PY7 Predicted and Actual Sales by Month**




## F.3 FINDINGS

Cadmus estimated an overall net-to-gross ratio of 61% for freeridership. The model could not account for any spillover or market effects. Additionally, because the estimate was based on only one program year, Cadmus could not capture the influence of the program over time. For example, the program also featured customer engagement and education events, during which the ICSP helped customers choose among the available options of bulbs and color temperatures. However, the model could not to distinguish customers who may have been convinced to try an LED at one of these events who then returned to purchase additional bulbs in subsequent program years.

Freeridership varied by retail channel and bulb type based on the elasticity estimates within each of these (shown in Table F-2). The "All" retail channel encompasses candelabra bulbs. There was insufficient price variation to estimate elasticities within each retailer so Cadmus calculated its elasticities across all retailers.

**Table F-2. Modeled Elasticity Estimates**

| Retail Channel | Bulb Type | Elasticity Estimate | |
|---|---|---|---|
| | | 2015 | 2016 |
| All | Candelabra | -0.72 | -1.62 |
| Club | A-Line | -0.95 | -0.87 |
| | Reflector | -1.42 | -1.49 |
| Do-It-Yourself | A-Line | -2.53 | -2.26 |
| | Reflector | -1.47 | -1.42 |
| Hard-to-Reach | A-Line | -0.70 | -0.82 |
| | Globe | -0.24 | -0.19 |
| | Reflector | -1.75 | -1.72 |
| Mass Market | A-Line | -0.93 | -0.45 |
| | Globe | 0.00 | -0.25 |
| | Reflector | -2.12 | -1.95 |

Overall, demand for A-line bulbs sold at do-it-yourself retailers was the most sensitive to price changes and mass market retailer A-line bulbs were least price sensitive. Additionally, demand for reflector bulbs was more elastic across club, do-it-yourself, and mass market retailers and less elastic at hard-to-reach retailers.

Again, hard-to-reach stores had the least amount of price variation (only 36% of total bulb sales). It could be that the bulbs with price variation were not representative of all reflector bulbs sold within the hard-to-reach retail channel.

Table F-3 shows the average per bulb prices by retail channel, which includes original price, final price, and incentive levels.

**Table F-3. Net-to-Gross and Prices by Retail Channel**

| Retail Channel | Original Price per Bulb | Manufacturer Incentive per Bulb | Incentive per Bulb | Final Price per Bulb | Markdown Percentage | Freeridership | Net-to-Gross |
|---|---|---|---|---|---|---|---|
| All | $7.81 | $0.00 | $3.29 | $4.52 | 42% | 0.62 | 0.38 |
| Club | $6.61 | $0.00 | $3.49 | $3.12 | 53% | 0.49 | 0.51 |
| Do-It-Yourself | $10.33 | $0.01 | $4.57 | $5.74 | 44% | 0.28 | 0.72 |
| Hard-to-Reach | $12.24 | $2.70 | $6.10 | $3.44 | 50% | 0.33 | 0.67 |
| Mass Market | $7.93 | $0.00 | $3.35 | $4.58 | 42% | 0.63 | 0.37 |

The average per-bulb price varied by retail channel. Do-it-yourself and hard-to-reach stores had the highest per-bulb prices, largely because of differences in product mix. However, the markdown levels, the incentives as a share of the original price, were comparable across all channels, between 42% and 53%.

Additionally, freeridership and net-to-gross ratios varied by bulb type, as shown in Table F-4.

**Table F-4. Net-to-Gross and Prices by Bulb Type**

| Bulb Type | Original Price per Bulb | Manufacturer Incentive per Bulb | Incentive per Bulb | Final Price per Bulb | Markdown Percentage | Freeridership | Net-to-Gross Ratio |
|---|---|---|---|---|---|---|---|
| A-Line | $9.54 | $1.13 | $4.75 | $3.66 | 50% | 0.39 | 0.64 |
| Candelabra | $8.99 | $1.11 | $3.59 | $4.28 | 40% | 0.62 | 0.38 |
| Globe | $10.88 | $1.46 | $5.32 | $4.11 | 49% | 0.87 | 0.13 |
| Reflector | $11.79 | $0.79 | $5.12 | $5.88 | 43% | 0.41 | 0.59 |

Markdowns were also relatively similar across all bulb types. However, net-to-gross ratios varied by type. A-lines and reflectors had the highest net-to-gross ratios, accounting for roughly 90% of all program sales.

Demand for globe bulbs appeared to be inelastic, though only 37% of globe sales had price variations; therefore, the sample used to estimate elasticities may not be representative of all globe sales. In addition, globe bulbs accounted for only 1% of all program bulb sales, so the impact of globe bulbs on the overall net-to-gross ratio was very small.

Net-to-gross ratios varied between channels primarily because of differences in price elasticities and the mix of bulb types sold within each channel. Do-it-yourself and hard-to-reach stores had the highest net-to-gross ratio. Mass market retailers had the lowest.

Table F-5 details prices and net-to-gross ratios by both retail channel and bulb types.

**Table F-5. Net-to-Gross and Prices by Bulb Type and Retail Channel**

| Retail Channel | Bulb Type | Original Price per Bulb | Manufacturer Incentive per Bulb | Incentive per Bulb | Final Price per Bulb | Markdown % | Freeridership | Net-to-Gross Ratio |
|---|---|---|---|---|---|---|---|---|
| All | Candelabra | $7.81 | $0 | $3.29 | $4.52 | 42% | 0.62 | 0.38 |
| Club | A-Line | $5.21 | $0 | $2.78 | $2.43 | 53% | 0.49 | 0.51 |
| | Reflector | $9.14 | $0 | $4.80 | $4.35 | 53% | 0.37 | 0.63 |
| DIY | A-Line | $9.76 | $0.01 | $4.65 | $5.10 | 48% | 0.20 | 0.80 |
| | Reflector | $12.99 | $0 | $4.20 | $8.79 | 32% | 0.54 | 0.46 |
| Hard-to-Reach | A-Line | $12.09 | $3.03 | $6.12 | $2.93 | 51% | 0.37 | 0.63 |
| | Globe | $11.67 | $1.95 | $5.18 | $4.54 | 44% | 0.77 | 0.23 |
| | Reflector | $13.51 | $0.34 | $6.11 | $7.07 | 45% | 0.28 | 0.72 |
| Mass Market | A-Line | $7.23 | $0 | $3.12 | $4.11 | 43% | 0.61 | 0.39 |
| | Globe | $10.56 | $0 | $5.40 | $5.16 | 51% | 0.99 | 0.01 |
| | Reflector | $10.22 | $0 | $3.92 | $6.31 | 38% | 0.34 | 0.66 |

**Globes.** Of note (as shown in Table F-5), globes had 0% net-to-gross ratio at mass market retailers. As previously discussed, the proportion of globe bulbs with price variation was considerably smaller than were other bulb types. The net-to-gross ratio for globes was higher at hard-to-reach retailers, though overall sales at these retailers also had lower price variation.

With so few globe sales experiencing price variation, it was difficult to get a robust estimate of price elasticities and net-to-gross ratios. However, Cadmus typically observes lower elasticities for globes in other evaluations with greater price variation. Demand for globe bulbs may be less elastic than other bulb types because they have fewer applications. Most homes have few fixtures that require globe bulbs (e.g., vanities); because these fixtures are usually low priority, consumers tend to buy bulbs only as needed.

Cadmus considered combining globes with candelabras as a specialty category, but this would not have changed the overall impact. If combined, the elasticities for globes and candelabras would have been averaged, which would have decreased the net-to-gross ratio for candelabra bulbs. However, Cadmus' analysis found that demand for globes appeared to be relatively inelastic but sales were low enough that globes had very little impact on the overall net-to-gross ratio for PY7.

**A-line bulbs.** Another unexpected result was that the net-to-gross ratio for A-line bulbs between club and mass market retailers was half that of do-it-yourself and hard-to-reach retailers. One explanation could be the low original per-bulb price at club and mass market retailers (between $5.21 and $7.23) compared to the per-bulb price at do-it-yourself and hard-to-reach retailers ($9.76 and $12.09, respectively). Consumer expectations could be changing as the LED market matures and as club and mass market retailers are able to offer lower prices than other retailers, leading to decreasing price elasticities. The benefit is that LEDs become more cost-competitive and will require smaller incentives in the future.

Another possible explanation for lower than expected elasticities for A-line bulbs could be the increasing prevalence of low-cost, non-program-eligible LEDs during 2016.[7] Lower price elasticities would be expected because program LEDs would have to compete by offering sufficient discounts to make them comparable in price or cheaper than non-program bulbs (assuming relatively comparable quality, which may not be the case).

Finally, PPL Electric Utilities scaled back the program late in PY7 by offering fewer and lower incentives compared to 2015. If factors other than price were also scaled back in 2016, such as retailers decreasing the shelf space allocated to program bulbs or ordering fewer program bulbs to sell, Cadmus would be unable to control for such factors in the model because the program cannot account for activity beyond price and special promotions.

Overall, the net-to-gross ratio for LEDs was comparable with the results of other evaluations Cadmus has conducted during the last year, which typically showed net-to-gross ratios in the range of 60% to 70%.

To minimize freeridership in future years Cadmus recommends monitoring the LED market to focus on retail channels or bulb types with minimal competition from lower-priced, non-program LEDs. Additionally, the ISCP could work with retailers to incorporate additional special promotions into the program, which can increase sales without requiring increased incentives.

## F.4 PRECISION

Once the final model specification had been developed, Cadmus calculated "block bootstrap" standard errors to determine the sensitivity of the net-to-gross ratios. To develop bootstrap standard errors, Cadmus drew 598 new samples (with replacements drawn at the cross-section level) from the original data, estimating coefficients with each sample and calculating a new net-to-gross ratio. Using this method, the 5$^{th}$ and 95$^{th}$ percentiles in these net-to-gross ratios represented the lower and upper bounds of the 90$^{th}$ confidence interval, as shown in Table F-6.

**Table F-6. Net-to-Gross Ratio and Confidence Interval**

| NTG | 5% Lower Bound Confidence Interval | 95% Upper Bound Confidence Interval | CV | Relative Precision at 90% Confidence |
|---|---|---|---|---|
| 61% | 56% | 65% | 4% | 11% |

7 Cadmus is researching the prevalence of non-program LEDs and their impact on the market in PPL Electric Utilities' service territory for PY8.

# APPENDIX G | ENERGY-EFFICIENCY BEHAVIOR & EDUCATION PROGRAM SAVINGS COUNTED IN OTHER ENERGY-EFFICIENCY PROGRAMS

Savings in two programs, the Residential and the Low-Income Energy-Efficiency Behavior & Education Program, reflected both behavioral changes, such as turning off lights in unoccupied rooms and adjusting thermostat settings, and investments in energy-efficient products, such as high-efficiency furnaces and LEDs. In PY7, some customers who installed efficiency products because of home energy reports may have received rebates from PPL Electric Utilities through other Act 129 programs. Customers could also have received rebates in previous program years following receipt of their first home energy report, and these efficiency products could have continued to yield savings in PY7. In these cases, the Energy-Efficiency Behavior & Education Program billing analysis would capture the savings from both the home energy reports as well as from the rebate program, causing them to be double-counted.

To avoid claiming the additional amount of cross-program savings caused by the home energy report program (in both of the Energy-Efficiency Behavior & Education Programs and the other programs), Cadmus subtracted cross-participation savings from the residential portfolio and low-income portfolio savings. To do this, Cadmus conducted an uplift analysis to estimate the impacts of the Energy-Efficiency Behavior & Education Program on participation in PPL Electric Utilities' residential efficiency programs and the energy savings from that participation.[8]

In PY7, Cadmus updated its uplift methodology to conform to the Phase III Evaluation Framework.[9] This new method did not conflict with the method described in the Phase II Evaluation Framework but was useful because Cadmus looked at cross-program participation in PY7 and compared these data to all Energy-Efficiency Behavior & Education Program treatment and control group customers across time, starting with the launch of each wave.

This section estimates the impacts of the Residential Energy-Efficiency Behavior & Education Program and the Low-Income program on participation in PPL Electric's residential efficiency programs and the energy savings from participation. Cadmus refers to any difference in the rate of participation and savings as "participation uplift" and "savings uplift."

In PY7, the total Residential Behavior & Education Program savings from efficiency program participation was 2,127 MWh/yr (or 5.4% of the program's PY7 savings). The total uplift savings for the Low-Income Behavior & Education Program was 223 MWh/yr (2.1%). Cadmus subtracted these savings from the residential and low-income portfolios, not from the Behavior & Education Program.[10]

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8 Cadmus conducted an uplift analysis for downstream rebate programs, in which participation was tracked at the individual customer level, in EEMIS. Cadmus did not estimate the impact of the Behavior & Education Program on participation in upstream PPL Electric Utilities lighting programs.

9 Pennsylvania Public Utility Commission. *Evaluation Framework for Pennsylvania Act 129 Phase III Energy Efficiency and Conservation Programs.* August 29, 2016. See section 6.1.1.8, pg 128.

10 One advantage of subtracting these double-counted savings at the portfolio level instead of from the Energy Efficiency Behavior & Education Program directly is that doing so does not *penalize* the behavioral program for encouraging treatment customers to participate in other programs, which is a positive benefit of the program.

## G.1 APPROACH FOR ESTIMATING HOME ENERGY REPORTS SAVINGS FROM PARTICIPATION IN PPL ELECTRIC RESIDENTIAL REBATE PROGRAMS

Estimating home energy report savings from PPL Electric's efficiency program participation is facilitated by the experimental design of the Residential and the Low-Income Energy-Efficiency Behavior & Education Programs, hereby referred to collectively as the Energy-Efficiency Behavior & Education Program.

To illustrate, suppose that there is an equal number of customers in the treatment and control groups and that information exists about the benefits of installing Measure A, which is promoted by the utility. Customers in the treatment and control groups are assumed to have received the same marketing and incentives from the utility for the program promoting Measure A. Because customers were randomly assigned to the treatment and control groups, the Energy-Efficiency Behavior & Education Program's effect on installation of Measure A can be estimated as the difference between the groups in the installation of the measure, and the savings from any difference in installation rates of Measure A can be attributed to the behavioral program. If the difference in installations is $\Delta n_A$ and the per-unit deemed savings are $s_A$, then the Behavior & Education Program savings from installation of Measure A would be $\Delta n_A * s_A$.

## G.2 DOWNSTREAM REBATE PROGRAMS

For measures promoted by utility programs and tracked at the customer level, Cadmus estimated the participation and savings uplift. Cadmus matched Energy-Efficiency Behavior & Education Program treatment and control group customers in each wave to the energy efficiency program participation tracking data in EEMIS, starting in the month when treatment began (the first home energy report was delivered) through the end of PY7.[11]

Homes in the Energy-Efficiency Behavior & Education Program treatment and control groups could participate in six downstream PPL Electric rebate programs from PY2 through PY7: Appliance Recycling, E-Power Wise,[12] Low-Income WRAP, Low-Income WRAP Wise Homes Pilot,[13] Residential Home Comfort,[14] and Residential Retail (equipment component).

### G.2.1 Participation Uplift

After matching tracking data to the Energy-Efficiency Behavior & Education Program participants, Cadmus calculated participation uplift. Cadmus defined participation uplift as the difference in the percent of treatment group customers participating in at least one rebate program and the percent of control group customers participating in at least one rebate program.

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11 Each measure's record in EEMIS includes its evaluated *ex post* annual savings, the program to which it belongs, and the date that the measure was installed.

12 The E-Power Wise program in the participation rate uplift calculations includes the Wise Homes pilot. For the savings uplift calculations, the two sub-components are shown split-out.

13 The Low-Income WRAP program in the participation rate uplift calculations includes the De Facto Heating program, though they are shown split-out in the savings uplift tables.

14 In EEMIS, the Residential Home Comfort program tracked participation by its sub-components: Direct Install & Audit, Ductless Mini-Split, New Homes & Whole House, Pool Pumps, and Residential HVAC. For the purposes of the split-out participation rate uplift calculations, Cadmus counted each subcomponent as a separate opportunity for participation. However, for the program total participation rate uplift, Cadmus removed duplicates of customer account IDs in order to get counts of customers who participated in at least one rebate program, thereby not double counting the Residential Home Comfort program participation overall.

The control group customers' participation rate reflected the baseline participation rate, capturing the business-as-usual effect of marketing and word-of-mouth impacts on customers' participation in other PPL Electric Utilities' Act 129 programs in the absence of the Behavior & Education Program's effects. This baseline participation rate is defined as the number of control group customers who participated in at least one other Act 129 program in PY7 divided by the total number of control group customers. If this cross-program participation rate was greater for treatment group customers, then the home energy reports had an additive effect in encouraging these treatment group customers to participate in the other programs, and therefore participation uplift would be positive and vice versa.

The following tables show the PY7 participation rate uplift results for each wave of the residential and the low-income programs by all other rebate programs.

- Table G-1, Table G-2, and Table G-3 provide participation rate uplift results by program for the three residential waves. Participation uplift was positive for the three residential program waves, ranging from 5.7% to 11.7%. The residential program as a whole achieved a combined percent participation rate of 12.4%.
- Table G-4 and Table G-5 provide participation rate uplift results by program for the two low-income waves. Low-Income Wave 1 had positive participation uplift, while Low-Income Wave 2 had negative participation uplift. For the latter, control group customers participated in other programs about 4% more frequently than did treatment group customers. In aggregate, however, the low-income program total participation uplift was positive at 6.2%.

**Table G-1: Participation Rate Uplift: Residential Program Legacy Wave 1**

| Program | Baseline Participation Rate in PY7 (per 1,000 Customers)* | Participation Uplift in PY7 (Treatment Effect on Participation Rate, per 1,000 Customers) | Percentage Participation Uplift in PY7 |
|---|---|---|---|
| Appliance Recycling | 7.4 | 1.3 | 18.0% |
| E-Power Wise | 1.5 | 0.004 | 0.3% |
| Low-Income WRAP | 0.7 | 0.3 | 48.6% |
| Low-Income WRAP Wise Homes Pilot | 0.1 | 0.0001 | 0.3% |
| Residential Home Comfort Direct Install & Audit | 0.9 | 0.2 | 27.6% |
| Residential Home Comfort Ductless Mini Split | 0.9 | 0.1 | 6.2% |
| Residential Home Comfort New Homes & Whole House | 0.03 | -0.03 | -100.0% |
| Residential Home Comfort Pool Pumps | 0.6 | 0.5 | 91.0% |
| Residential Home Comfort Residential HVAC | 9.7 | -1.4 | -14.8% |
| Residential Retail Equipment | 5.0 | 0.7 | 13.2% |
| **Program Total** | **26.0** | **1.5** | **5.7%** |

**Table G-2: Participation Rate Uplift: Residential Program Legacy Wave 2**

| Program | Baseline Participation Rate in PY7 (per 1,000 Customers)* | Participation Uplift in PY7 (Treatment Effect on Participation Rate) | Percentage Participation Uplift in PY7 |
|---|---|---|---|
| Appliance Recycling | 9.0 | 1.6 | 17.3% |
| E-Power Wise | 3.4 | 0.4 | 12.9% |
| Low-Income WRAP | 0.6 | 0.4 | 73.0% |
| Low-Income WRAP Wise Manufactured Homes Pilot | 0.1 | -0.03 | -54.7% |
| Residential Home Comfort Direct Install & Audit | 1.2 | 1.0 | 81.2% |
| Residential Home Comfort Ductless Mini Split | 2.2 | 0.2 | 10.0% |
| Residential Home Comfort New Homes & Whole House | 0.1 | -0.03 | -54.7% |
| Residential Home Comfort Pool Pumps | 1.0 | -0.4 | -41.1% |
| Residential Home Comfort Residential HVAC | 11.0 | 0.2 | 2.3% |
| Residential Retail Equipment | 7.0 | 0.5 | 6.9% |
| **Program Total** | **34.1** | **4.0** | **11.6%** |

**Table G-3: Participation Rate Uplift: Residential Program Expansion Wave**

| Program | Baseline Participation Rate in PY7 (per 1,000 Customers)* | Participation Uplift in PY7 (Treatment Effect on Participation Rate) | Percentage Participation Uplift in PY7 |
|---|---|---|---|
| Appliance Recycling | 7.1 | 2.8 | 39.9% |
| E-Power Wise | 0.8 | 0.5 | 64.5% |
| Low-Income WRAP | 0.6 | 0.1 | 22.4% |
| Low-Income WRAP Wise Manufactured Homes Pilot | 0.0 | 0.1 | - |
| Residential Home Comfort Direct Install & Audit | 1.6 | 0.3 | 20.3% |
| Residential Home Comfort Ductless Mini Split | 2.8 | -1.0 | -36.3% |
| Residential Home Comfort Pool Pumps | 0.3 | 0.3 | 116.4% |
| Residential Home Comfort Residential HVAC | 7.5 | 1.4 | 19.0% |
| Residential Retail Equipment | 7.1 | -1.2 | -17.5% |
| **Program Total** | **26.6** | **3.1** | **11.7%** |

**Table G-4: Participation Rate Uplift: Low-Income Program Wave 1**

| Program | Baseline Participation Rate in PY7 (per 1,000 Customers)* | Participation Uplift in PY7 (Treatment Effect on Participation Rate) | Percentage Participation Uplift in PY7 |
|---|---|---|---|
| Appliance Recycling | 3.9 | 1.7 | 43.7% |
| E-Power Wise | 18.2 | -1.1 | -6.2% |
| Low-Income WRAP | 9.5 | 1.2 | 12.1% |
| Low-Income WRAP Wise Manufactured Homes Pilot | 0.1 | 0.2 | 140.9% |
| Residential Home Comfort Direct Install & Audit | 0.1 | 0.3 | 216.9% |
| Residential Home Comfort Ductless Mini Split | 0.4 | 0.1 | 35.2% |
| Residential Home Comfort Pool Pumps | 0.0 | 0.01 | - |
| Residential Home Comfort Residential HVAC | 0.6 | 0.2 | 42.0% |
| Residential Retail Equipment | 1.6 | 0.2 | 9.9% |
| **Program Total** | **32.4** | **3.2** | **9.9%** |

**Table G-5: Participation Rate Uplift: Low-Income Program Wave 2**

| Program | Baseline Participation Rate in PY7 (per 1,000 Customers)* | Participation Uplift in PY7 (Treatment Effect on Participation Rate) | Percentage Participation Uplift in PY7 |
|---|---|---|---|
| Appliance Recycling | 3.3 | -0.5 | -16.6% |
| E-Power Wise | 15.5 | -0.1 | -0.7% |
| Low-Income WRAP | 13.7 | 0.1 | 0.4% |
| Low-Income WRAP Wise Manufactured Homes Pilot | 0.2 | -0.2 | -100.0% |
| Residential Home Comfort Direct Install & Audit | 0.1 | -0.1 | -100.0% |
| Residential Home Comfort Ductless Mini Split | 0.2 | 0.04 | 17.1% |
| Residential Home Comfort Residential HVAC | 0.3 | -0.1 | -37.5% |
| Residential Retail Equipment | 1.0 | -0.1 | -6.3% |
| **Program Total** | **33.2** | **-1.4** | **-4.1%** |

## G.2.2 Savings Uplift

As explained above, in addition to calculating participation uplift, Cadmus also calculated *savings* uplift to determine whether treatment group customers also *saved* more than control group customers from downstream energy efficiency program participation.

Many measures had expected useful lives (EULs) that were longer than one year and continued to generate energy savings in future program years; if the Energy-Efficiency Behavior & Education Program resulted in positive savings uplift in a previous program year, then those cross-program savings would continue to be counted in each subsequent program year's billing analysis. What is more, the Energy-Efficiency Behavior & Education Program can result in new savings uplift every program year, in addition to prior program year's savings uplift that continue to persist.

To determined uplift savings, Cadmus prorated *ex post* savings for each cross participant's rebated measures based on three criteria:

- ***The month in which the customer installed the measure.*** Uplift savings began to accumulate during this month.
- ***The measure's sensitivity to weather.*** Cadmus allocated a proportion of annual *ex post* savings to each month the measure was installed. The measure's sensitivity to weather and if it was heating- or cooling-sensitive factored into this proportion.
- ***The measure's EUL.***[15] Uplift savings ceased once the measure had expired according to its EUL.

After accounting for the above criteria, Cadmus calculated the total uplift savings that occurred or persisted in each program year since the wave's first treatment month. Cadmus then summed the savings uplift across all program years to estimate the total amount of double-counted savings reflected in the PY7 billing analysis results.

Table G-6: through Table G-10 show each wave's savings uplift by each program for each program year. The values in the treatment and control columns are the average annual savings (kWh/yr) from other Act 129 programs per customer in that group. The columns labeled "Δ" represent the difference (or delta) in savings rates between the treatment and control groups—the program's savings uplift in that program year. Each column is also summed across all programs to show the program year's total uplift. The PY7 columns show the per-customer uplift savings.

To calculate total uplift savings that were subtracted from the portfolio savings, Cadmus multiplied the sum of the "Δ" by the total number of treatment group customers active in that program year.

- The tables for the three residential waves below indicate that in addition to having positive participation uplift, they also experienced positive savings uplift in PY7, ranging from 1.9% to 9.3% of the waves' total savings. The total double-counted savings across the three residential waves was 2,127 MWh in PY7, or 5.4% of the total program's savings.
- The savings uplift for the two low-income waves also showed similar trends to their participation uplift: Low-Income Wave 1 had positive savings uplift of 2.5% of its PY7 savings total and Low-Income Wave 2 had negative savings uplift of -2.3% of its total savings. Combined, however, the two low-income waves had a total of 223 MWh of savings uplift in PY7, or about 2.1% of the program's total savings.

15 Cadmus defined a measure's EUL using the EEMIS field, cross-referenced by assumptions made in cost effectiveness TRC calculations. Cadmus also looked into customers' account-inactive date when determining the month in which a measure stops generating savings.

**Table G-6: Savings Uplift by Program and Program Year: Residential Legacy Wave 1[1]**

| Program | PY2 | | | PY3 | | | PY4 | | | PY5 | | | PY6 | | | PY7 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ |
| Appliance Recycling | 12.3 | 9.7 | 2.6 | 44.2 | 33.9 | 10.3 | 68.3 | 54.9 | 13.4 | 85.6 | 71.7 | 13.9 | 95.5 | 81.3 | 14.2 | 108.8 | 93.2 | 15.6 |
| E-Power Wise | 0.2 | 0.4 | -0.1 | 0.5 | 0.7 | -0.2 | 0.8 | 1.0 | -0.2 | 1.1 | 1.2 | -0.2 | 1.5 | 1.7 | -0.2 | 2.2 | 2.5 | -0.3 |
| Efficient Equipment Incentive Program | 24.7 | 24.8 | 0.0 | 58.9 | 56.9 | 2.0 | 77.2 | 72.6 | 4.6 | 86.7 | 80.9 | 5.8 | 89.6 | 83.4 | 6.3 | 92.2 | 85.2 | 7.1 |
| Low-Income WRAP | 2.1 | 2.2 | -0.1 | 7.2 | 7.4 | -0.2 | 10.9 | 10.8 | 0.1 | 12.0 | 12.5 | -0.5 | 13.9 | 14.6 | -0.7 | 16.0 | 15.6 | 0.4 |
| Renewable Energy Program | 2.4 | 3.3 | -0.9 | 4.0 | 5.6 | -1.6 | 4.2 | 5.9 | -1.7 | 4.4 | 6.1 | -1.7 | 4.6 | 6.1 | -1.6 | 4.8 | 6.3 | -1.5 |
| Residential Energy Assessment & Weatherization | 1.5 | 0.7 | 0.8 | 6.0 | 3.0 | 3.0 | 10.3 | 5.9 | 4.5 | 11.8 | 7.3 | 4.5 | 12.3 | 7.5 | 4.8 | 12.7 | 7.7 | 4.9 |
| Residential Home Comfort Direct Install & Audit | - | - | - | - | - | - | - | - | - | 0.3 | 0.2 | 0.1 | 1.6 | 0.9 | 0.7 | 2.4 | 1.9 | 0.5 |
| Residential Home Comfort Ductless Mini Split | - | 0.0 | 0.0 | - | 0.0 | 0.0 | - | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.5 | 0.6 | -0.1 | 2.4 | 3.6 | -1.2 |
| Residential Retail Equipment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 1.9 | 1.8 | 0.0 | 5.1 | 4.4 | 0.7 | 8.6 | 7.1 | 1.5 |
| Residential Home Comfort Pool Pumps | - | - | - | - | - | - | - | - | - | 0.2 | 0.2 | 0.1 | 0.7 | 0.5 | 0.1 | 1.7 | 1.2 | 0.5 |
| Residential Home Comfort Residential HVAC | - | - | - | - | - | - | - | - | - | 1.2 | 1.2 | 0.0 | 5.1 | 5.0 | 0.1 | 11.8 | 11.6 | 0.2 |
| E-Power Wise-Wise Manufactured Homes Pilot | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.0 | 0.0 | 0.0 |

| Program | PY2 | | | PY3 | | | PY4 | | | PY5 | | | PY6 | | | PY7 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ |
| Residential Home Comfort New Homes & Whole House | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.0 | 0.0 |
| **Sum** | **43.2** | **41.0** | **2.2** | **120.8** | **107.6** | **13.2** | **171.8** | **151.2** | **20.6** | **205.2** | **183.2** | **22.0** | **230.3** | **206.0** | **24.3** | **263.5** | **236.0** | **27.5** |

[1] The units in this table are average per-customer annual savings across all treatment or control group customers, per program.

**Table G-7: Savings Uplift by Program and Program Year: Residential Legacy Wave 2**

| Program | PY2 | | | PY3 | | | PY4 | | | PY5 | | | PY6 | | | PY7 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ |
| Appliance Recycling | 0.2 | 0.3 | -0.1 | 20.2 | 19.2 | 1.1 | 46.2 | 39.4 | 6.8 | 65.6 | 57.6 | 8.0 | 76.9 | 68.8 | 8.1 | 92.8 | 83.1 | 9.7 |
| E-Power Wise | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.0 | 1.1 | 0.9 | 0.1 | 1.2 | 1.1 | 0.2 | 1.9 | 1.9 | 0.1 | 3.6 | 3.5 | 0.1 |
| Efficient Equipment Incentive Program | 0.2 | 0.2 | 0.0 | 18.1 | 17.4 | 0.7 | 39.8 | 38.0 | 1.8 | 51.5 | 47.8 | 3.7 | 53.3 | 49.2 | 4.2 | 54.9 | 50.8 | 4.1 |
| Low-Income WRAP | 0.0 | 0.1 | 0.0 | 5.5 | 6.8 | -1.3 | 13.2 | 14.1 | -0.9 | 15.2 | 16.0 | -0.8 | 16.7 | 18.0 | -1.3 | 18.5 | 19.4 | -0.9 |
| Residential Energy Assessment & Weatherization | 0.1 | 0.0 | 0.0 | 5.9 | 2.8 | 3.1 | 12.5 | 6.0 | 6.6 | 17.0 | 7.4 | 9.6 | 17.5 | 7.3 | 10.1 | 18.0 | 7.7 | 10.3 |
| Residential Home Comfort Direct Install & Audit | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.4 | 0.2 | 2.2 | 1.8 | 0.4 | 4.0 | 3.2 | 0.9 |
| Residential Home Comfort Ductless Mini Split | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | -0.1 | 0.4 | 0.6 | -0.2 | 1.9 | 1.6 | 0.3 | 10.0 | 10.0 | 0.0 |
| Residential Retail Equipment | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 | 2.9 | 2.7 | 0.2 | 7.2 | 7.0 | 0.2 | 11.9 | 12.5 | -0.6 |
| Residential Home Comfort Pool Pumps | - | - | - | - | - | - | - | - | - | 0.2 | 0.3 | -0.1 | 0.6 | 1.2 | -0.6 | 1.2 | 2.0 | -0.8 |
| Residential Home Comfort | - | - | - | - | - | - | - | - | - | 2.2 | 2.9 | -0.6 | 7.8 | 9.2 | -1.3 | 17.7 | 19.9 | -2.2 |

| Program | PY2 | | | PY3 | | | PY4 | | | PY5 | | | PY6 | | | PY7 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ | Trtmt | Ctrl | Δ |
| Residential HVAC | | | | | | | | | | | | | | | | | | |
| E-Power Wise-Wise Manufactured Homes Pilot | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.0 | 0.0 | 0.0 |
| Residential Home Comfort New Homes & Whole House | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.0 | 0.0 | 0.0 |
| **Sum** | **0.5** | **0.5** | **0.0** | **50.3** | **46.5** | **3.8** | **113.0** | **98.6** | **14.3** | **156.7** | **136.7** | **20.0** | **186.1** | **165.9** | **20.2** | **232.7** | **212.1** | **20.6** |

**Table G-8: Savings Uplift by Program and Program Year: Residential Expansion Wave**

| Program | PY6 | | | PY7 | | |
|---|---|---|---|---|---|---|
| | Treatment | Control | Δ | Treatment | Control | Δ |
| Appliance Recycling | 1.4 | 1.2 | 0.3 | 13.5 | 10.3 | 3.2 |
| E-Power Wise | 0.1 | 0.0 | 0.0 | 0.5 | 0.5 | 0.0 |
| Low-Income WRAP | 0.3 | 0.2 | 0.1 | 1.4 | 1.1 | 0.3 |
| Residential Home Comfort Direct Install & Audit | 0.5 | 0.3 | 0.2 | 2.3 | 1.4 | 0.9 |
| Residential Home Comfort Ductless Mini Split | 0.2 | 0.2 | 0.0 | 6.3 | 8.3 | -2.0 |
| Residential Retail Equipment | 0.7 | 0.6 | 0.2 | 4.4 | 4.3 | 0.1 |
| Residential Home Comfort Pool Pumps | 0.0 | 0.0 | 0.0 | 0.9 | 0.2 | 0.7 |
| Residential Home Comfort Residential HVAC | 1.1 | 0.7 | 0.4 | 8.6 | 7.2 | 1.4 |
| E-Power Wise- Wise Manufactured Homes Pilot | - | - | - | 0.1 | - | 0.1 |
| **Sum** | **4.4** | **3.2** | **1.2** | **38.0** | **33.4** | **4.6** |

**Table G-9: Savings Uplift by Program and Program Year: Low-Income Wave 1**

| Program | PY6 | | | PY7 | | |
|---|---|---|---|---|---|---|
| | Treatment | Control | Δ | Treatment | Control | Δ |
| Appliance Recycling | 0.8 | 0.6 | 0.1 | 7.5 | 5.6 | 1.9 |
| E-Power Wise | 1.2 | 1.3 | -0.1 | 9.5 | 10.3 | -0.8 |
| Low-Income WRAP | 4.6 | 4.2 | 0.4 | 19.7 | 17.5 | 2.2 |
| Residential Home Comfort Direct Install & Audit | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.1 |
| Residential Home Comfort Ductless Mini Split | 0.0 | 0.1 | 0.0 | 1.3 | 0.7 | 0.6 |
| Residential Retail Equipment | 0.0 | 0.1 | -0.1 | 0.4 | 0.5 | -0.1 |
| Residential Home Comfort Residential HVAC | 0.0 | 0.3 | -0.3 | 0.5 | 0.9 | -0.4 |
| E-Power Wise- Wise Manufactured Homes Pilot | - | - | - | 0.1 | 0.0 | 0.1 |
| Low-Income Wrap De Facto Heating | - | - | - | 0.04 | - | 0.04 |
| **Sum** | **6.7** | **6.6** | **0.0** | **39.2** | **35.6** | **3.7** |

**Table G-10: Savings Uplift by Program and Program Year: Low-Income Wave 2**

| Program | PY7 | | |
|---|---|---|---|
| | Treatment | Control | Δ |
| Appliance Recycling | 2.2 | 3.1 | -0.9 |
| E-Power Wise | 5.5 | 5.9 | -0.5 |
| Low-Income WRAP | 10.3 | 8.8 | 1.6 |
| Residential Home Comfort Direct Install & Audit | - | 0.01 | -0.01 |
| Residential Home Comfort Ductless Mini Split | 0.1 | 1.2 | -1.0 |
| Residential Retail Equipment | 0.1 | 0.3 | -0.1 |
| Residential Home Comfort Residential HVAC | 0.06 | 0.04 | 0.02 |
| E-Power Wise- Wise Manufactured Homes Pilot | - | 0.1 | -0.1 |
| **Sum** | **18.3** | **19.4** | **-1.0** |

## G.3 Upstream Lighting Programs (LEDs)

In PY7, PPL Electric Utilities mailed 45,000 free LED bulbs to high-energy use Low-Income Energy-Efficiency Behavior & Education Program participants as part of the Residential Retail Program. In total, this amounted to 1,305 MWh in savings that were allocated to the Residential Retail Program (see this program's chapter for details on the giveaway LED bulb savings). However, since the customers who received the giveaway LEDs were also part of the Low-Income Energy-Efficiency Behavior & Education Program billing analysis, savings from the giveaway LEDs are being double-counted in the Low-Income Energy-Efficiency Behavior & Education Program. To account for this, Cadmus deducted 1,305 MWh from the PY7 low-income savings as additional uplift savings.

# APPENDIX H | METHODOLOGY FOR DETERMINING SAVINGS FROM ENERGY-SAVINGS KITS

This appendix explains the criteria used to assign survey *ex post* savings for kit products for the Student and Parent Energy-Efficiency Education Program and the E-Power Wise Program in PY7.

## H.1 INTRODUCTION

Cadmus used an individual respondent-level savings methodology to calculate the program savings associated with kit products. It applied survey-verified savings only to respondents who met certain criteria for fuel type and who answered questions on surveys. Additionally, E-Power Wise participants required responses on the enrollment cards for Cadmus to apply savings.

Cadmus assigned specific survey-verified savings to each respondent for each product using these variables:

- Whether or not the respondent answered the product-specific question (regardless of the answer)
- Home characteristics recorded on the respondent's kit survey and/or enrollment card (i.e., gas or electric heat)
- Respondent's answers to the installation and behavior questions

For the E-Power Wise Program, Cadmus also calculated the energy savings associated with participant behavior changes. The updated behavior savings custom measure protocol (CMP) for the E-Power Wise Program can be found in Appendix I.

No survey *ex ante* savings were assigned to products corresponding to questions that respondents did not answer. These are excluded because Cadmus did not know why the customer did not answer the question, customers may have installed the item, or customers may not have installed the item. Rather than over- or underestimating savings by assuming installation, these products were not included in the calculation of the *ex post* savings. Likewise, Cadmus did not apply survey *ex ante* savings to calculate the overall realization rate for products corresponding to any questions the respondents did not answer.

### H.1.1 Estimating Realization Rates and *Ex Post* Savings for the Program

Cadmus calculated the program total *ex post* savings and realization rate using the following steps:

- Calculate survey *ex ante* and survey-verified savings for each customer and product based on survey responses
- Add survey *ex ante* and survey-verified savings within each stratum to calculate total savings values
- Divide the stratum-total survey-verified savings by the stratum total survey *ex ante* to estimate the stratum realization rate
- Multiply the stratum realization rate to the stratum total TRM-adjusted *ex ante* savings to estimate the stratum total *ex post* savings
- Add stratum total *ex post* savings together to estimate the program total *ex post* savings
- Divide the program-total *ex post* savings estimate by the program-total *ex ante* savings to estimate the program realization rate

Because the kit included one survey with questions about each item, survey responses for products could be correlated within customers. Cadmus accounted for the correlations by rolling savings up to the customer level prior to calculating realization rates and precision. It calculated confidence and precision for the *ex post* savings and realization rate estimates in each stratum and for the programs as a whole.

## H.2 ENERGY-SAVINGS KIT PRODUCT SAVINGS METHODOLOGY

The PY7 survey-verified savings depended on various criteria for each product group.

For **LEDs, LED nightlights**, and **smart strips**, survey-verified savings depended on these criteria, as shown in Table H-1:

- The respondent returned a survey.
- The respondent answered the product question.
- The respondent answered the question about installing the product.

**Table H-1: PY7 Methodology – LED Example**

<table>
<tr><th>Question from Kit Survey</th><th>Question Answered? (Yes/No)</th><th>Possible Answers</th><th>Verification Action Conducted</th></tr>
<tr><td rowspan="4">How many LEDs from your kit did you install?</td><td rowspan="3">Yes</td><td>Both</td><td>Respondent receives survey-verified savings for both LEDs</td></tr>
<tr><td>One</td><td>Respondent receives survey-verified savings for one LED</td></tr>
<tr><td>None</td><td>Respondent survey-verified savings of zero for both LEDs</td></tr>
<tr><td>No</td><td>N/A</td><td>N/A; respondent does not receive survey-verified savings</td></tr>
</table>

For **furnace whistles**, survey-verified savings depended on these criteria, as shown in Table H-2:

- The respondent returned a survey.
- The respondent answered the product question.
- The respondent was categorized into 2015 TRM deemed heating load hours by zip code of respondent's city.
- The respondent answered the question about installing the furnace whistle.

**Table H-2: PY7 Methodology – Furnace Whistle Example**

<table>
<tr><th>Question from Kit Survey</th><th>Question Answered? (Yes/No)</th><th>ZIP Code Mapping (by City) to Determine Heating Load Hours</th><th>Possible Answers</th><th>Verification Action Conducted</th></tr>
<tr><td rowspan="4">Did you install your new FilterTone Alarm from your Kit?</td><td rowspan="3">Yes</td><td rowspan="4">Allentown, Erie, Harrisburg, Philadelphia, Pittsburgh, Scranton, Williamsport</td><td>Yes, I installed it</td><td>Respondent receives survey-verified savings based on zip code mapping to closest city</td></tr>
<tr><td>Yes, I plan to install it</td><td>Respondent receives survey-verified savings of zero[1]</td></tr>
<tr><td>No</td><td>Respondent receives survey-verified savings of zero</td></tr>
<tr><td>No</td><td>N/A</td><td>N/A; respondent does not receive survey-verified savings</td></tr>
<tr><td colspan="5">[1] Respondents received survey-verified savings of zero for planned actions because timing for installation was unverified and may have occurred outside of the program year or not at all.</td></tr>
</table>

For **low-flow showerheads** and **kitchen aerators**, survey-verified savings depended on these criteria, as shown in Table H-3:

- The respondent returned a survey.
- The respondent answered the product question.
- The respondent indicated that the home has electric water heat on the kit survey or enrollment card.
- The respondent designated a housing type on the enrollment card or kit survey (different savings applied to single-family and multifamily households).
- The respondent answered the survey question about installing the product.

**Table H-3: PY7 Methodology – Showerhead Example**

<table>
<tr><th rowspan="2">Question from Kit Survey</th><th rowspan="2">Question Answered? (Yes/No)</th><th colspan="2">Enrollment Card Information</th><th rowspan="2">Possible Answers</th><th rowspan="2">Verification Action Conducted</th></tr>
<tr><th>Water Heating Fuel Type</th><th>Housing Type</th></tr>
<tr><td rowspan="5">Did you install the new high-efficiency showerhead from your kit?</td><td rowspan="4">Yes</td><td rowspan="5">Electric[1]</td><td rowspan="5">Single-family, multifamily</td><td rowspan="2">Yes, I installed it</td><td>Respondent receives survey-verified savings based on single-family housing type</td></tr>
<tr><td>Respondent receives survey-verified savings based on multifamily housing type</td></tr>
<tr><td>Yes, I plan to install it</td><td>Respondent receives survey-verified savings of zero [2]</td></tr>
<tr><td>No</td><td>Respondent receives survey-verified savings of zero</td></tr>
<tr><td>No</td><td>N/A</td><td>N/A; respondent does not receive survey-verified savings</td></tr>
<tr><td colspan="6">[1] Savings were assigned only to respondents with electric water heating.<br>[2] Respondents did not receive savings for planned actions because timing for installation was unverified and may have occurred outside of the program year or not at all.</td></tr>
</table>

# APPENDIX I | E-POWER WISE BEHAVIOR SAVINGS METHODOLOGY

This appendix describes the methodology for calculating the behaviorally based savings resulting from energy education provided in the E-Power Wise Program. The appendix provides the inputs and calculations used in PY7.

## I.1 BEHAVIOR SAVINGS METHODOLOGY

Electric consumption impacts associated with changes in behavior by customers who participated in the E-Power Wise Program were estimated from calculations derived from a combination of engineering estimates, secondary research, and survey data. For PY7, Cadmus updated the inputs to reflect the 2015 Pennsylvania TRM engineering calculations.

The three household actions affecting behavior change savings were these:

- Lowering the water heater temperature
- Changing the volume of laundry washed in cold water
- Adjusting the home thermostat according to the heating/cooling season

The following sections provide details about the algorithms used to estimate savings for these behavior changes.

### I.1.1 Water Heater Temperature Reduction

The E-Power Wise Program encouraged participants to reduce their water heater temperature setting to save energy. Cadmus updated the algorithm used to estimate savings for this action to follow the 2015 Pennsylvania TRM engineering calculations,[16] which is provided in Equation I-1. The first term in this equation corresponds to the savings from tank losses and the second term corresponds to savings from the clothes washer as a result of changing the water heater setting. Equation I-2 is the algorithm Cadmus used to determine demand savings for water heater temperature reduction.

**Equation I-1**

$$\Delta\, kWh/yr = \frac{A_{tank} \times \left(T_{hot\ i} - T_{hot\ f}\right) \times 8760\frac{hrs}{yr}}{R_{tank} \times \eta_{elec} \times 3412\frac{Btu}{kWh}} + \frac{V_{HW} \times \left(8.3\frac{lb}{gal}\right) \times \left(365\frac{days}{yr}\right) \times \left(1\frac{Btu}{°F \cdot lb}\right) \times \left(T_{hot\ i} - T_{hot\ f}\right)}{\left(3412\frac{Btu}{kWh}\right) \times EF_{WH}}$$

**Equation I-2**

$$\Delta\text{kWpeak} = ETDF \times \Delta\, kWh/yr$$

Equation I-1 and Equation I-2 were applied to survey respondents who indicated they had an electric water heater. Respondents who indicated they did not have an electric water heater received zero electric savings. Furthermore, Cadmus applied the clothes washer portion of savings (corresponding to the second term in the equation) only to participants who had a washing machine in their home or apartment. Respondents who washed their laundry at an on- or off-site laundry facility were not eligible to receive the clothes washer portion of water heater temperature reduction savings.

16 Pennsylvania Public Utility Commission. *Pennsylvania Technical Reference Manual.* June 2015. Available online: http://www.puc.state.pa.us/Electric/pdf/Act129/Act129_TRM-2015_Redlined_v2.pdf

Table I-1 provides a description of the variables in Equation I-1 and Equation I-2.

**Table I-1: Protocol Inputs for Water Heater Temperature Reduction Algorithm Inputs**

| Variable Name | Variable Description | Unit | Variable Type | Value | Data Source |
|---|---|---|---|---|---|
| $EF_{WH}$ | Energy factor of water heater | Fraction | Variable | 0.904 | 2015 PA TRM: Table 2-62 |
| $R_{tank}$ | R value of water heater tank | $\frac{hr \cdot °F \cdot ft^2}{Btu}$ | Variable | 8.3 | 2015 PA TRM: Table 2-62 |
| $A_{tank}$ | Surface area of water heater tank | $Ft^2$ | Variable | 24.99 | 2015 PA TRM: Table 2-62 |
| $\eta_{elec}$ | Thermal efficiency of electric heater element | Decimal | Fixed | 0.98 | 2015 PA TRM: Table 2-62 |
| $V_{HW}$ | Volume of hot water used per day by clothes washer | Gallons/day | Fixed | 7.32 | 2015 PA TRM: Table 2-62 |
| $T_{hot\_i}$ | Temperature setpoint of water heater initially | °F | Variable | 130 | 2015 PA TRM: Table 2-62 |
| $T_{hot\_f}$ | Temperature setpoint of water heater after setback | °F | Variable | 119 | 2015 PA TRM: Table 2-62 |
| $ETDF$ | Energy to demand factor | $\frac{kW}{kWh/yr}$ | Fixed | 0.00008047 | 2015 PA TRM: Table 2-62 |

Table I-2 provides the per-respondent savings applied to eligible participants.

**Table I-2: Water Heater Temperature Reduction Savings**

| Unit | Tank Loss | Clothes Washer | Total |
|---|---|---|---|
| kWh | 86.77 | 79.09 | 165.86 |
| kW | 0.0070 | 0.0064 | 0.0134 |

## I.1.2 Washing Machine Cold Water Usage

Participants could change the percentage of the laundry they washed in cold water in response to education provided in the E-Power Wise Program. Cadmus updated the algorithm used to estimate savings from this action to follow the 2015 Pennsylvania engineering calculations, provided in Equation I-3. No demand savings were associated with this action.

**Equation I-3**

$$\Delta\, kWh/yr = \frac{V_{HW} \times \left(8.3\frac{lb}{gal}\right) \times \left(365\frac{days}{yr}\right) \times \left(1\frac{Btu}{°F\cdot lb}\right) \times \left(T_{hot\ i} - T_{hot\ f}\right)}{\left(3412\frac{Btu}{kWh}\right) \times EF_{WH}} * (\%CWpre\ -\ \%CWpost)$$

Table I-3 provides a description of the variables in Equation I-3.

**Table I-3: Washing Machine Behavior Change Algorithm Inputs**

| Variable Name | Variable Description | Unit | Variable Type | Value | Data Source |
|---|---|---|---|---|---|
| $EF_{WH}$ | Energy Factor of water heater | Fraction | Variable | 0.904 | 2015 PA TRM: Table 2-62 |
| $V_{HW}$ | Volume of hot water used per day by clothes washer | Gallons/day | Fixed | 7.32 | 2015 PA TRM: Table 2-62 |
| $T_{hot\_i}$ | Temperature setpoint of water heater initially | °F | Variable | Varies | 2015 PA TRM: Table 2-62 |
| $T_{hot\_f}$ | Temperature setpoint of water heater after setback | °F | Variable | 55 | 2015 PA TRM: Table 2-62 |
| $\%CWpre$ | Volume of hot water used per day by clothes washer | % | Variable | Varies | Survey |
| $\%CWpost$ | Temperature setpoint of water heater initially | % | Variable | Varies | Survey |

Participants were eligible to receive savings from washing more loads of laundry in cold water if they had an electric water heater and used either an on-site laundry facility or a washing machine in their home or apartment. Participants who did not have an electric water heater or who used an off-site laundry facility were not eligible to receive washing machine behavior change savings.

Cadmus applied a different $T_{hot\_i}$ depending on whether or not a participant lowered the water heater temperature setting. The resulting savings are provided in Table I-4.

**Table I-4: Washing Machine Behavior Change Savings**

| (%CWpre - %CWpost | $\Delta\, kWh/yr$ Without Water Heater Temperature Reduction: Thot_i (°F) = 130 | $\Delta\, kWh/yr$ With Water Heater Temperature Reduction: Thot_f (°F) = 119 |
|---|---|---|
| 0% | 0.00 | 0.00 |
| 25% | 134.81 | 115.03 |
| 50% | 269.61 | 230.07 |
| 75% | 404.42 | 345.10 |
| 100% | 539.22 | 460.13 |
| -25% | -134.81 | -115.03 |
| -50% | -269.61 | -230.07 |
| -75% | -404.42 | -345.10 |
| -100% | -539.22 | -460.13 |

### I.2.3 Adjusting Thermostat for Heating and Cooling Season

The E-Power Wise Program recommended to participants that they raise their summer thermostat setpoint for cooling and lower their winter thermostat setpoint for heating to save energy. Cadmus used Equation I-4, Equation I-5, and Equation I-6 to calculate the cooling and heating savings.

Equation I-4 and Equation I-5 first determined the average annual energy use of a residential HVAC system and then applied a savings factor for the thermostat adjustment. The savings factor was based on the evaluation results of the Iowa 2013 Energy Wise Program.[17]

**Equation I-4**

$$\Delta kWh_{cool} = \left[\frac{CAPY_{cool}}{1000\,\frac{W}{kW}} \times \frac{1}{SEER \times Eff_{duct}} \times EFLH_{cool}\right] \times ESF_{tstat-cool}$$

**Equation I-5**

$$\Delta kWh_{heat} = \left[\frac{CAPY_{heat}}{1000\,\frac{W}{kW}} \times \frac{1}{HSPF \times Eff_{duct}} \times EFLH_{heat}\right] \times ESF_{tstat-heat}$$

**Equation I-6**

$$\Delta \mathrm{kWpeak} = CF \times \Delta kWh_{cool}$$

[17] Cadmus. *Iowa 2013 Energy Wise Program.* June 24, 2014. Prepared for Iowa Utility Association.

Table I-5 provides a description of the variables in Equation I-4, Equation I-5, and Equation I-6. Respondents with electric heating and/or cooling systems were eligible for savings. Cadmus used the equivalent full load hours (EFLH) corresponding to the location of the participant's home (determined using zip code mapping).

**Table I-5: Thermostat Setting Behavior Change Algorithm Inputs**

| Variable Name | Variable Description | Unit | Variable Type | Value | Data Source |
|---|---|---|---|---|---|
| $CAPY_{cool}$ | Capacity of cooling system | Btu/hr. | Default | 32,000 | 2015 PA TRM: Table 2-39 |
| $CAPY_{heat}$ | Capacity of heating system | Btu/hr. | Default | 32,000 | 2015 PA TRM: Table 2-39 |
| $SEER$ | Seasonal energy efficiency ratio | Btu/Wh | Default | 11.9 | 2015 PA TRM: Table 2-39 |
| $HSPF$ | Heating seasonal performance factor | Btu/Wh | Default | 3.413 | 2015 PA TRM: Table 2-39 |
| $Eff_{duct}$ | Duct system efficiency | None | Default | 0.8 | 2015 PA TRM: Table 2-39 |
| $EFLH_{cool}$ | Equivalent full load hours for cooling | Hours/ year | Variable | Allentown = 48<br>Erie= 389<br>Harrisburg= 551<br>Philadelphia= 591<br>Pittsburgh = 432<br>Scranton = 417<br>Williamsport = 422 | 2015 PA TRM: Table 2-39 |
| $EFLH_{heat}$ | Equivalent full load hours for heating | Hours/ year | Variable | Allentown = 1,193<br>Erie = 1,349<br>Harrisburg = 1,103<br>Philadelphia = 1,060<br>Pittsburgh = 1,209<br>Scranton= 1,296<br>Williamsport = 1,251 | 2015 PA TRM: Table 2-39 |
| $CF$ | Demand coincidence factor | None | Fixed | 0.7 | 2015 PA TRM: Table 2-10 |
| $ESF_{tstat-cool}$ | Energy savings factor for the thermostat adjustment during the cooling season | None | Fixed | 5% | Iowa 2013 Energy Wise Program Evaluation. Average of savings across all evaluated years. |
| $ESF_{tstat-heat}$ | Energy savings factor for the thermostat adjustment during the heating season | None | Fixed | 5% | Iowa 2013 Energy Wise Program Evaluation. Average of savings across all evaluated years. |

# APPENDIX J | ACT 129 WRAP BILLING ANALYSIS

Cadmus conducted two analyses using two different models—monthly fixed effects model and customer-specific model—to estimate the savings for baseload, low-cost, and full-cost jobs. It then used these models to cross-check estimates.

Cadmus analyzed the baseload job model using two program years of participant usage data from PY4 and PY5. It analyzed the low-cost and full-cost job model using one program year of participant usage data from PY4.[18]

Because different datasets were used for baseload jobs and for low-cost and full-cost jobs, Cadmus assessed the models for each dataset separately.

- For baseload jobs, Cadmus used the *ex post* evaluated energy savings estimates from the monthly fixed-effects model; this model was more precise than the customer-specific model.
- For low-cost and full-cost jobs, it used the *ex post* evaluated energy savings estimates from the customer-specific model which was more precise than the monthly fixed-effects model for full-cost jobs. The full-cost jobs provided the bulk of the savings between full-cost and low-cost jobs; therefore, the full cost job savings estimate's precision drove the model selection.

The method and analyses are described below.

## J.1 METHODOLOGY

**Baseload jobs.** To estimate the *ex post* evaluated savings per baseload job for jobs provided in PY7, Cadmus conducted a customer usage analysis of Phase I PY4 and Phase II PY5 participants from July 2011 through March 2015. The analysis involved consumption histories for 3,339 accounts where a baseload job was provided.

**Low-cost and full-cost jobs.** To estimate the *ex post* evaluated savings per low-cost and full-cost job for jobs provided in PY7, Cadmus conducted a customer usage analysis of Phase I PY4 participants from July 2011 through March 2014. No low-cost or full-cost jobs were implemented in PY5; therefore, Cadmus analyzed only one program year of data.[19] The analysis involved consumption histories for 656 accounts for which a low-cost job was provided, and 1,556 accounts for which a full-cost job was provided.

Cadmus reviewed all 5,551 consumption histories and excluded 1,637 records for the reasons listed in Table J-1. To conduct a customer usage analysis, it is necessary to have a minimum of nine months of pre- and post-installation energy consumption data. Cadmus conducted a billing history screen examining the monthly consumption history for each customer, plotting each participant's monthly pre- and post-

[18] The billing analysis typically uses participant usage data from the two most recent previous program years that have sufficient usage data to conduct an analysis. For PY7, the two previous program years with sufficient usage were PY4 and PY5. However, Cadmus could not use PY5 participant usage data for low-cost and full-cost job savings estimates because only baseload jobs were installed in PY5. Thus, Cadmus used the PY4 and PY5 usage data for the baseload job billing analysis and the PY4 data for the low-cost and full-cost job billing analysis.

[19] The full-cost job savings estimate was based on usage from more than 500 PY4 homes, consistent with the Phase II Evaluation Framework. The low-cost job savings estimate was based on PY4 usage data from 411 homes; however, the resulting savings per job were not statistically different from the low-cost job savings estimate calculated by Cadmus for use in PY8 from PY4 and PY6 participant usage data. (Complete PY6 usage data was not available when PY7 *ex ante* estimates were developed.) Therefore, Cadmus retained the low-cost savings estimate based on PY4 usage data for *ex post* estimates for PY7, consistent with the PA Mass Market Protocol. (Navigant Consulting, Inc., et al. *PA Mass Market Protocol: Savings Verification Methodology for Whole-Building Retrofit Measures in Low-Income Programs.* August 9, 2013.)

installation usage. Approximately one-third (39%) of the 1,637 excluded accounts had insufficient pre- or post-installation energy consumption data.

**Table J-1: Phase 1 PY4 and Phase II PY5 Consumption Analysis Attrition Table**

| Attrition Reason | Baseload | | Low-Cost | | Full-Cost | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Number of Baseload Sites | Percentage of All Baseload Sites | Number of Low-Cost Sites | Percentage of All Low-Cost Sites | Number of Full-Cost Sites | Percentage of All Full-Cost Sites | Number of Sites | Percentage of All Sites |
| **Full Participant Number** | **3,339** | **100%** | **656** | **100%** | **1,556** | **100%** | **5,551** | **100%** |
| Insufficient Pre/Post Billing Data | 237 | 7% | 116 | 18% | 276 | 18% | **629** | **11%** |
| Low Usage (Annual Usage < 1,200 kWh) | 9 | 0% | 0 | 0% | 0 | 0% | **9** | **0%** |
| Account Changed Usage by More than 70% | 15 | 0% | 9 | 1% | 7 | 0% | **31** | **1%** |
| Outliers | 524 | 16% | 100 | 15% | 183 | 12% | **807** | **15%** |
| Heat Pump Water Heater Installed | 107 | 3% | 20 | 3% | 34 | 2% | **161** | **3%** |
| **Final Analysis Participant Number** | **2,447** | **73%** | **411** | **63%** | **1,056** | **68%** | **3,914** | **71%** |

To avoid confounding the customer usage analysis, Cadmus removed approximately half (52%) of the accounts because of outliers, vacancies, seasonal usage, and equipment changes in the pre- or post-installation periods. Finally, it excluded records for heat pump water heater installations (10%) so that the savings represented only those from the baseload, low-cost, and full-cost jobs.

The customer usage analysis had a final dataset of 3,914 participants.

Cadmus weather-normalized each customer's monthly kWh consumption for both the pre- and post-installation periods following these steps:

1. Obtained daily average temperature data from January 2010 through March 2015 for the National Oceanic and Atmospheric Administration (NOAA) weather stations that represented all the zip codes associated with PPL Electric Utility's service territory
2. From daily temperatures, determined the 65°F reference temperature heating degree days (HDDs) and cooling degree days (CDDs) for each station
3. Determined the nearest weather station for each zip code using a zip code mapping for all United States weather stations
4. Matched usage data periods with the CDDs and HDDs from the associated weather stations

Cadmus used both a monthly fixed-effects model and customer-specific model to estimate energy savings for all homes receiving baseload, low-cost, or full-cost jobs. The monthly fixed-effects and customer-specific models produced similar savings estimates. Both methods were in compliance with the Evaluation Framework and the PA Mass Market Protocol.[20,21]

**Baseload jobs.** For baseload jobs in PY4 and PY5, the estimate produced by the monthly fixed-effects model combined participant usage data and had slightly better precision for the baseload job estimate where the majority of program savings were anticipated; therefore, these estimates were used as the *ex post* evaluated savings per job.

**Low-cost and full-cost jobs.** For low-cost and full-cost jobs, the estimate produced by the monthly customer-specific model for the PY4 participant usage data had slightly better precision for the full-cost job estimates. Since the majority of program savings were achieved with the full-cost jobs, Cadmus used the estimates from the customer-specific model as the *ex post* evaluated savings per job.

The estimates from the fixed-effects model are provided in Section J.1.1, along with additional details about the modeling approaches. The customer-specific model is discussed in Section J.1.2.

### J.1.1 Fixed-Effects Overall Models

Fixed-effects modeling is a method of estimating parameters from a panel dataset. Panel data is from a (usually small) number of observations over time on a (usually large) number of cross-sectional units, such as individuals, households, firms, or governments. The fixed-effects estimator is obtained by ordinary least squares on the deviations from the means of each unit or time period. This approach is relevant when one expects the averages of the dependent variable to be different for each cross-sectional unit, or for each time period, but expects the variance of the errors to be similar.[22]

To obtain overall model savings for the direct-install measures and major measure groups, Cadmus used the following fixed-effects model specification:

$$\boldsymbol{ADC_{it}} = \alpha_i + \beta_1 * \boldsymbol{HDD_{it}} + \beta_2 * \boldsymbol{CDD_{it}} + \beta_3 * \boldsymbol{POST_{it}} + \varepsilon_{it}$$

Where, for customer ‘i’ in usage month ‘t’:

- $ADC_{it}$ = the average daily kWh consumption in the pre- and post-period
- $\alpha_i$ = the average pre-period base load kWh usage for each customer; this is part of the fixed-effects specification
- $\beta_1$ = the average pre-period kWh usage per HDD
- $HDD_{it}$ = the average daily base-65 HDD for the nearest weather station based on location
- $\beta_2$ = the average pre-period kWh usage per CDD
- $CDD_{it}$ = the average daily base-65 CDD for the nearest weather station based on location
- $\beta_3$ = the average daily kWh savings for the direct-install measure or major measure group

20 GDS Associates, Inc., et al. *Evaluation Framework for Pennsylvania Act 129 Phase II Energy Efficiency and Conservation Programs*. June 1, 2014. pp. 50-52. Available online: http://www.puc.pa.gov/Electric/pdf/Act129/SWE_PhaseII-Evaluation_Framework060114.pdf

21 Navigant Consulting, Inc., et al. *PA Mass Market Protocol: Savings Verification Methodology for Whole-Building Retrofit Measures in Low-Income Programs*. August 9, 2013.

22 More details about this concept can be found online. Accessed September 2016: About.com. Economics. “Fixed Effects Estimation.” http://economics.about.com/library/glossary/bldef-fixed-effects-estimation.htm.

$POST_{it}$ = an indicator variable that is 1 in the post-installation period and 0 in the pre-installation period

$\varepsilon_{it}$ = the model error term

The following calculation shows how Cadmus derived the final savings estimates from the model coefficients:

$$\beta_3 * 365 = \text{Annual overall kWh savings for direct install or major products}$$

The model parameters and parameter estimates for the direct install products' overall model are provided in Table J-2 through Table J-4. Cadmus estimated a separate intercept for each customer; because of space constraints, only the average of the intercepts for each job type is provided in these tables.

**Table J-2: Fixed-Effects Model Parameters and Estimates – Baseload Jobs**

| Variable | Degrees of Freedom | Parameter Estimate | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|
| HDD | 1 | 0.62 | 0.02 | 36.05 | <.0001 |
| CDD | 1 | 1.58 | 0.03 | 47.69 | <.0001 |
| POST | 1 | -3.29 | 0.13 | -25.38 | <.0001 |

**Table J-3: Fixed-Effects Model Parameters and Estimates – Low-Cost Jobs**

| Variable | Degrees of Freedom | Parameter Estimate | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|
| HDD | 1 | 0.89 | 0.05 | 17.72 | <.0001 |
| CDD | 1 | 1.38 | 0.07 | 20.49 | <.0001 |
| POST | 1 | -3.37 | 0.32 | -10.38 | <.0001 |

**Table J-4: Fixed-Effects Model Parameters and Estimates – Full-Cost Jobs**

| Variable | Degrees of Freedom | Parameter Estimate | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|
| HDD | 1 | 1.96 | 0.04 | 47.23 | <.0001 |
| CDD | 1 | 2.13 | 0.05 | 40.04 | <.0001 |
| POST | 1 | -3.73 | 0.25 | -15.14 | <.0001 |

### J.1.2 Customer-Specific Models

Cadmus used customer-specific models (also known as the Princeton Scorekeeping Method, or PRISM models) to develop a second set of estimates. These models provide an alternative weather-normalization methodology to compare with the fixed-effects savings estimates. In general, the customer-specific models provided savings estimates that were very similar to those produced by the fixed-effects models.

The advantage of the customer-specific models is that they weather-normalize the pre- and post-installation periods for each customer. The disadvantage of the models is that they do not provide easily obtained measure-level savings estimates.

Cadmus fixed the heating and cooling reference temperatures (τ or tau) at 65°F. In this approach, account-level models are run for the pre- and post-periods.

Cadmus specified the heating and cooling PRISM model as follows:

$$ADC_{it} = \alpha_i + \beta_1 * AVGHDD_{it} + \beta_2 * AVGCDD_{it} + \varepsilon_{it}$$

Where for each customer 'i' and month't':

| | | |
|---|---|---|
| $ADC_{it}$ | = | the average daily kWh consumption in the pre- or post-program period |
| $\alpha_i$ | = | the participant intercept; this represents the average daily kWh baseload |
| $\beta_1$ | = | the model space heating slope |
| $AVGHDD_{it}$ | = | the base-65 average daily HDDs for the specific location |
| $\beta_2$ | = | the model space cooling slope |
| $AVGCDD_{it}$ | = | the base-65 average daily CDDs for the specific location |
| $\varepsilon_{it}$ | = | the error term |

From the model above, Cadmus computed the weather-normalized annual consumption (NAC) as follows:

$$NAC_i = \alpha_i * 365 + \beta_1 * LRHDD_i + \beta_2 * LRCDD_i + \varepsilon_i$$

Where for each customer 'i':

| | | |
|---|---|---|
| $NAC_i$ | = | the normalized annual kWh consumption |
| $\alpha_i$ | = | the intercept that is the average daily or baseload for each participant; this represents the average daily baseload from the model |
| $\alpha_i * 365$ | = | the annual baseload kWh usage (non-weather sensitive) |
| $\beta_1$ | = | the heating slope; in effect, this is the usage per heating degree from the model above |
| $LRHDD_i$ | = | the annual, long-term HDDs of a typical month year (TMY3) in the 1991-2005 series from NOAA, based on home location |
| $\beta_1 * LRHDD_i$ | = | the weather-normalized, annual weather-sensitive (heating) usage, also known as HEATNAC |
| $\beta_2$ | = | the cooling slope; in effect, this is the usage per cooling degree from the model above |
| $LRCDD_i$ | = | the annual, long-term CDDs of a TMY3 in the 1991-2005 series from NOAA, based on home location |
| $\beta_2 * LRCDD_i$ | = | the weather-normalized, annual weather-sensitive (cooling) usage, also known as COOLNAC |
| $\varepsilon_i$ | = | the error term |

A NAC is modeled for both the pre- and post-installation period, and these values are denoted as PRENAC and POSTNAC, respectively. From these values, the customer-specific savings is given by PRENAC – POSTNAC, referred to as DNAC. Cadmus calculated overall average savings values for baseload, low-cost, and full-cost jobs and compared them to the estimates calculated using the fixed-effects panel model. These comparison estimates are shown in Table J-5.

**Table J-5: PY7 Act 129 WRAP Comparison of Model Estimates**

| Analysis Group | Number of Sites in the Analysis | Fixed-Effects Model | | Customer-Specific Model | |
|---|---|---|---|---|---|
| | | Average Annual kWh Savings | Precision at 90% Confidence Level | Average Annual kWh Savings | Precision at 90% Confidence Level |
| PY4 and PY5 Baseload Participants | 2,446 | **1,200**[1] | 6.48% | 1,196 | 6.53% |
| PY4 Low-Cost Participants | 411 | 1,230 | 15.8% | **1,228**[1] | 16.9% |
| PY4 Full-Cost Participants | 1,056 | 1,362 | 10.9% | **1,476**[1] | 10.4% |

[1] These estimates were used as *ex post* verified savings.

# APPENDIX K | FUEL SWITCHING ANALYSIS: FOSSIL FUELS TO ELECTRICITY

## K.1 FUEL-SWITCHING REPORTING

On October 26, 2009, the Pennsylvania Public Utility Commission (PUC) entered an opinion and order approving PPL Electric Utilities' Act 129 plan. In the order, the PUC required PPL Electric Utilities to track and report the frequency of customers switching to electric appliances from non-electric appliances.

This appendix summarizes results from the analysis of data collected by PPL Electric Utilities from PY7 rebate forms, as well as responses to questions about fuel switching from surveys fielded by Cadmus, the EM&V CSP, to participants. This analysis was designed to:

- Determine the percentage of participants who switched fuels when they installed program-rebated equipment
- Learn why customers switched fuels
- Assess whether the rebate program had a significant impact on fuel-switching behavior

## K.2 FUEL-SWITCHING EQUIPMENT

Three programs in PPL Electric Utilities' Phase II portfolio include equipment that could involve fuel switching. These program—the Residential Retail, Residential Home Comfort, and Prescriptive Equipment—offered the following:

- Heat pump water heaters were the only potential fuel-switching equipment rebated through the Residential Retail Program.
- The Residential Home Comfort Program offered air source heat pumps and ductless mini-split heat pumps.
- Prescriptive Equipment rebated commercial ductless heat pumps.

Table K-1 shows the types, quantities, and percentages of equipment reported in PY7.

**Table K-1: Potential Fuel-Switching Equipment in PY7**

| Equipment | Quantity | Percentage of Total Number of Potential Fuel Switching Equipment Rebates | Participants | Percentage of Total Receiving Rebates |
|---|---|---|---|---|
| Air Source Heat Pump | 3,527 | 35% | 3,527 | 55% |
| Ductless Mini-Split Heat Pump | 5,075 | 51% | 1,582 | 25% |
| Heat Pump Water Heater | 1,235 | 12% | 1,235 | 19% |
| Commercial DHP | 99 | 1% | 99 | 2% |
| **Total** | **9,936** | **100%** | **6,443** | **100%** |

## K.3 TRACKING DATA

Cadmus reviewed data collected by the ICSP and recorded in EEMIS, PPL Electric Utilities' database tracking system. These data came from rebate forms that included questions asking if natural gas service was available to the customer's home and what the new electric equipment replaced. Although not all participants provided answers to these questions, there were responses for at least 75% of tracking data records. The exception was records for ductless mini-split heat pumps, where responses to the question regarding replaced equipment were available for only 65% of records. Data regarding the availability of natural gas were not available for commercial ductless heat pumps.

Table K-2 shows the availability of natural gas. Table K-3 through Table K-5 show equipment replaced.

**Table K-2: Availability of Natural Gas**

| Equipment | Yes | No |
|---|---|---|
| Air Source Heat Pump | 6% | 94% |
| Ductless Mini-Split Heat Pump | 15% | 85% |
| Heat Pump Water Heater | 7% | 93% |
| Commercial Ductless Heat Pump | Not available | |

**Table K-3: Equipment Replaced by Residential Heat Pumps**

| | Permanent Electric Heat | Other | Oil Furnace | Propane Furnace | No Previous Heating System | Natural Gas Furnace |
|---|---|---|---|---|---|---|
| Air Source Heat Pump | 49% | 32% | 8% | 2% | 2% | 1% |
| Ductless Mini-Split Heat Pump | 32% | 22% | 15% | 2% | 9% | 4% |
| **Total** | **40%** | **26%** | **12%** | **2%** | **6%** | **3%** |

**Table K-4: Equipment Replaced by Commercial Ductless Heat Pumps**

| | Non-Electric Heat | New Space | Ductless Heat Pump | Electric Resistance | No Heat |
|---|---|---|---|---|---|
| Commercial Ductless Heat Pump | 46% | 28% | 11% | 11% | 3% |

**Table K-5: Equipment Replaced By Heat Pump Water Heaters**

| | Electric | Oil | Propane | Natural Gas | No Previous Water Heating |
|---|---|---|---|---|---|
| Heat Pump Water Heater | 89% | 6% | 2% | 1% | 1% |

The analysis revealed that:

- 11% of customers who received a rebate for one of the potential fuel-switching units (n=8,883; not including commercial ductless heat pumps) had natural gas service to their homes.
- Only 5% of the 5,216 customers who answered questions regarding both natural gas service and the equipment they replaced had natural gas service and switched from non-electric equipment (excluding the "other" response category, for fuels not specified in tracking data).
- 4% replaced natural gas
- 1% replaced oil

Additionally, of all non-electric equipment replaced (not including commercial ductless heat pumps, for which Cadmus did not know the fuel type of the non-electric heat replaced)—regardless of whether the customer had natural gas service (n=3,302)—these were the results:

- 29% replaced oil equipment
- 7% replaced natural gas
- 5% of customers replaced propane
- 60% of customers replaced other fuel sources (not specified in tracking data)

## K.4 SURVEY DATA

In addition to reviewing EEMIS tracking data, Cadmus included questions in participant surveys about fuel-switching behavior. Questions were asked of 211 customers who received a rebate for air source heat pumps, ductless mini-splits or heat pump water heaters were included in the cross-program participant survey. This survey included other measures where fuel switching is not applicable, and did not include commercial ductless heat pumps. The distribution of completed surveys, by potential fuel-switching equipment, is shown in Table K-6.

**Table K-6. Completed Surveys, by Equipment**

| Equipment | Customers Surveyed | Percentage of Total |
|---|---|---|
| Air Source Heat Pump | 70 | 33% |
| Ductless Mini-Split Heat Pump | 71 | 34% |
| Heat Pump Water Heater | 70 | 33% |
| **Total** | **211** | **100%** |

## K.5 SURVEY METHODOLOGY

Questions about fuel-switching equipment were included in the cross-program participant survey. Sample attrition is in Table K-7.

The cross-program survey collected data for several purposes. The primary purpose was to obtain a preliminary estimate of low-income participation in programs that were not specifically targeting the low-income sector (i.e., programs that did not require income verification). In addition, Cadmus used this survey to update the net savings analysis for heat pump water heaters because the incentive structure for this equipment was modified in PY7. The surveys also included questions to assess possible fuel-switching behavior, program satisfaction, satisfaction with PPL Electric Utilities, and basic demographic data.

The sample frame excluded any customers who had participated in surveys within the last three months or requested not to be contacted. From this sample frame, Cadmus selected a random sample (probability sampling) and stratified by program.

Potential sources of bias in the surveys include nonresponse, recall, and social desirability biases. These sources of bias were mitigated by applying random sampling whenever possible and using survey design and survey data collection best practices. Surveys were designed to include questions that were not leading or ambiguous, were not double-barreled, and provided clear interviewing and programming instructions so that they could be implemented consistently across interviewers and surveys. Cadmus also attempted to reach respondents four times over several days at different times of the day and scheduled callbacks whenever possible.

Cadmus fielded the phone surveys during July of 2016.

**Table K-7: Survey Sample Attrition**

| Cross-Program: Residential Retail Participants | | | |
|---|---|---|---|
| Description | Heat Pump Water Heater Count | Air Source Heat Pump Count | Ductless Mini-Split Heat Pump Count |
| **Total Population (Number of Participants Q1-Q4) [1]** | **1,151** | **3,417** | **1,388** |
| Removed incomplete or bad phone number, inactive customer, completed survey in past year, on "do not call" list, selected for a different survey, duplicate contact | 110 | 358 | 158 |
| **Random Sample Selection** | 1,041 | 1,400 | 1,230 |
| **Sent to Survey Subcontractor** | 1,041 | 1,400 | 1,230 |
| **Records Not Attempted [2]** | 669 | 801 | 602 |
| **Records Attempted** | 372 | 599 | 628 |
| Nonworking number | 33 | 12 | 11 |
| Business/wrong number | 5 | 8 | 3 |
| Refusal | 60 | 69 | 89 |
| Language barrier | 0 | 2 | 0 |
| Ineligible; PPL Electric Utilities or market research employment | 3 | 7 | 5 |
| Ineligible; did not participate in program | 0 | 0 | 0 |
| No answer/answering machine/phone busy | 68 | 309 | 302 |
| Nonspecific or specific callback scheduled | 131 | 115 | 138 |
| Partially completed survey | 2 | 7 | 9 |
| **Completed Survey** | **70** | **70** | **71** |

[1] The population from which the survey samples were drawn is slightly lower than the total PY7 population shown in Table K-1 because incremental tracking records were received after the survey was conducted.
[2]These records were not needed because the overall survey target for the cross-program survey was reached before they were attempted.

## K.6 SURVEY FINDINGS

Of these 211 customers responding to the surveys, 11% had natural gas available in their home, and 0.9%, switched from natural gas. Without regard to natural gas service, 0.9% of the 211 customers said they replaced gas, 7.6% replaced oil, and 1.9% replaced propane.

Although there are differences between the results from the tracking data and the survey responses about the rates of switching to electricity from natural gas, propane or oil, both tracking and survey data indicate that less than 5% of customers switch to electric equipment from natural gas equipment.

Of the 22 customers who replaced a gas, oil, or propane system, only one reported doing so to get a rebate. Neither of the two customers who replaced gas equipment said they did so to get a rebate. The most common reason given, of all 22 customers, was to replace equipment that did not work right (nine respondents), followed by the desire to install more efficient equipment (five respondents).

## K.7 CONCLUSION

Based on the results of the phone survey and the tracking-data analysis, Cadmus concluded that a small fraction (approximately 4%) of residential customers who participated in PPL Electric Utilities' Act 129 rebate programs switched from natural gas to electric fuel. In addition, the fuel-switching behavior of these customers did not appear to have been motivated by PPL Electric Utilities' rebate. The number of commercial customers who switched from non-electric heat to electricity was higher, but these switches were uncommon, making up only 1% of the potential fuel-switching behavior.

### *PY7 Survey Questions for Fuel Switching*

These questions were used to determine the reason participants switched from a nonelectric measure to an electric one. (The sequence is taken directly from the survey instrument.)

A1. Is natural gas available in your home?
*Yes, No, Don't know, Refused*

A2. Did your new [MEASURE] replace an existing gas, oil, or propane heating system?
Yes, gas; Yes, oil; Yes, propane; No [SKIP TO NEXT SECTION]; Don't know; Refused

[ASK IF A2=1, 2, OR 3 (gas, propane or oil)]

**A3.** What was the reason you replaced your gas, oil, or propane water heater with the [MEASURE]?
**[RECORD ALL THAT APPLY]**
*Didn't work right / old and in need of replacement; Broken/failed; To get a rebate; To get more efficient equipment; Save money on utility bill; Other [SPECIFY]; Don't know; Refused*

[ASK IF A3≠1]

A4. Just to make sure I understand, was the [MEASURE] you replaced old and in need of replacement?
*Yes, No, Don't know, Refused*

[ASK IF A3≠2]

A5. And was the [MEASURE] in working condition when you replaced it?
*Yes, No, Don't know, Refused*

A6. Other than what we've discussed, were there any other factors that influenced your decision to replace your water heater with the [MEASURE]?
*Yes, [ASK A6a]—What were the factors ? [RECORD RESPONSE]; No; Don't know; Refused*

# APPENDIX L | FUEL SWITCHING PILOT ANALYSIS: ELECTRICITY TO FOSSIL FUELS

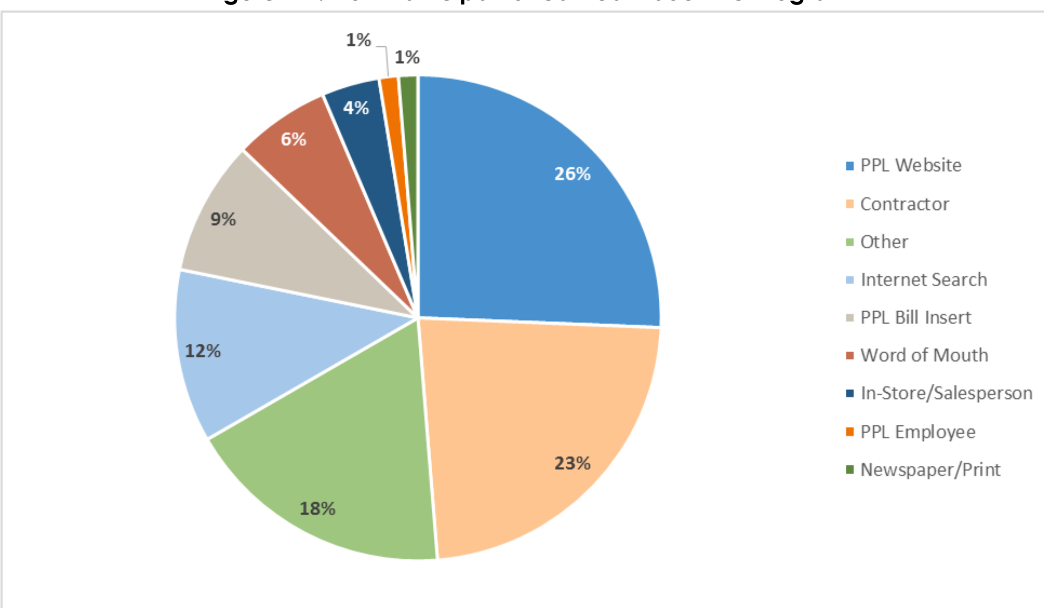
In PY7, PPL Electric Utilities continued the fuel switching pilot program, which was offered for the first time in PY5. This program offered rebates to customers who used electric space or water heat and installed new efficient non-electric space or water heating equipment. Rebates were available through three programs—Residential Home Comfort, Residential Retail, and Prescriptive Equipment. In PY7, only customers in the Residential Retail and Residential Home Comfort programs participated. The distribution of rebated equipment is shown in Table L-1.

**Table L-1: PY7 Fuel Switching Equipment Rebated**

| Program | Equipment | PY7 Rebates |
|---|---|---|
| Residential Home Comfort | Fuel Switching Central Heat Gas | 16 |
| Residential Home Comfort | Fuel Switching Central Heat Propane | 7 |
| Residential Retail | Fuel Switching Water Heater Gas | 33 |
| Residential Retail | Fuel Switching Water Heater Propane | 34 |
| **Total** | | **90** |

The rebate forms included a question asking where the applicant learned about the program. The implementation conservation service providers (ICSPs) collected the rebate forms and recorded the data in EEMIS, PPL Electric Utilities' database tracking system. The distribution of responses collected from rebate forms is shown in Figure L-1. Data were available for 78 of the 90 fuel switching participants.

**Figure L-1. How Participants Learned About the Program**




Of the 90 participants, only 14 were available for a follow-up phone survey conducted by Cadmus. Of these, seven installed a propane water heater, five installed a gas water heater, and two installed a propane heating system. Five survey respondents learned of the pilot program from PPL Electric Utilities' website, four from a retailer or vendor, and three from an installer or contractor. Two of the 14 respondents learned of the program from a PPL Electric Utilities bill insert or newsletter.

The survey asked respondents about their reasons for replacing existing equipment. Nine of the 14 respondents said they replaced their water heater or heating system because it was broken or in need of replacement, three wanted better performance, three wanted an on-demand water system, and four wanted equipment that was more energy-efficient. Their reasons are listed in Table L-2.

**Table L-2: Reasons for Replacing Equipment[1]**

| Replacement Reason | Responses |
|---|---|
| Didn't work right/old and in need of replacement/broken/failed | 9 |
| To get more energy-efficient equipment | 4 |
| Wanted on-demand system | 3 |
| Wanted better performance | 3 |

[1] N=14, multiple responses allowed.
Source: Question D2 "What was the reason you replaced the electric water heater/electric heating system?"

When asked why the respondent decided to switch fuels from electricity to gas when purchasing equipment, six respondents gave reasons related specifically to the cost of electricity or their heating bill, three said their electric heating system was less efficient than a fossil-fuel system, and three said they wanted on-demand hot water. One respondent switched because gas became available in the area.

Respondents were split on whether the rebate offered through the pilot was important to their decision to install the equipment, as shown in Table L-3. However, when asked what would have happened if they had not received the rebate from PPL Electric Utilities, nine out of 14 respondents said they would have purchased the same equipment without it (one of the nine had already purchased the equipment). One each said they would have purchased a less expensive unit, purchased a less efficient unit, postponed the purchase at least one year, or repaired the old system.

**Table L-3: Importance of Rebate to Replacement Decision**

| Response | Number of Respondents |
|---|---|
| Very important | 5 |
| Somewhat important | 3 |
| Not too important | 2 |
| Not at all important | 4 |
| **Total** | **14** |

Source: Question D7 "Please think back to when you were considering the purchase of your ___. How important was getting a rebate from PPL Electric in your decision to install the___? Was it …?"

Respondents were also asked to rate how much influence specific aspects of the program had on their decision to purchase the equipment. The distribution of responses is shown in Table L-4.

Based on the results of the phone survey, Cadmus concluded that the availability of the pilot program has had a marginal impact on the customer's decision to switch from electric to non-electric equipment.

**Table L-4: Influence on Decision to Purchase Equipment**

| Level of Influence | Rebate Amount (n=14) | PPL Electric Utilities' Marketing (n=14) | PPL Electric Utilities' Information about Energy Efficiency (n=14) | Information about Energy Efficiency from a Salesperson (n=14) | Information about Energy Efficiency from a Contractor (n=14) | Opportunity to Change [Heating/Water Heating] Equipment through PPL Electric Utilities' Program (n=14) |
|---|---|---|---|---|---|---|
| 1 – No Influence | 4 | 5 | 6 | 4 | 5 | 4 |
| 2 | 1 | 1 | 0 | 0 | 0 | 0 |
| 3 | 3 | 0 | 2 | 1 | 1 | 1 |
| 4 | 1 | 1 | 0 | 2 | 3 | 1 |
| 5 – Extremely Influential | 2 | 3 | 2 | 3 | 2 | 3 |
| Don't know/Refused | 1 | 2 | 2 | 2 | 2 | 2 |

Source: Question G2a/b/c "I'm going to read a list of items about PPL Electric's rebate program. Please rate each item on how much influence it had on your decision to purchase the [MEASURE_NAME]. Please use a scale from 1 to 5, with 1 meaning "no influence," and 5 meaning the item was "extremely influential" in your decision."

# APPENDIX M | RESIDENTIAL AND LOW-INCOME ENERGY-EFFICIENCY BEHAVIOR & EDUCATION PROGRAM IMPACT ANALYSIS

## M.1 DATA DEVELOPMENT

The Residential Energy-Efficiency Behavior and Education Program impact evaluation involved the analysis of three population waves: Legacy Wave 1, Legacy Wave 2, and the Expansion Wave. These population waves were defined by when they received their first home energy reports:

- Legacy Wave 1: PY1, April or May 2010
- Legacy Wave 2: PY3, June 2011
- Expansion Wave: PY6, October or December 2014

The Low-Income Energy-Efficiency Behavior and Education Program impact evaluation involved the analysis of two population waves:

- Low-Income Wave 1: PY6, October or December 2014
- Low-Income Wave 2: PY7, June 2015

Cadmus, the EM&V CSP, collected customer billing and program participation data for each wave and prepared the data for analysis. The monthly customer bills covered the 12 months preceding the delivery of the first energy report and all post-treatment months through the end of PY7.

To prepare the data for analysis, Cadmus first dropped residential customers who received energy reports but were not part of the program randomized control trial. For example, some PPL Electric Utilities employees received reports but were not randomly assigned to receive them. Cadmus also dropped customers who were assigned to the treatment or control group but for whom a report could not be generated or delivered to the home. The ICSP included a flag in the program customer database to indicate any customers who should be excluded from the impact analysis.

Table M-1 and Table M-2 show details on the analysis sample data.

**Table M-1: Data Preparation Summary: Residential Energy-Efficiency Behavior & Education Program**

| | Number of Observations from Billing Data | | |
|---|---|---|---|
| | **Legacy Wave 1** | **Legacy Wave 2** | **Expansion Wave** |
| Bills used in estimation | 6,138,426 | 4,094,056 | 1,145,074 |
| | **Total Number of Customer Accounts in the Final Dataset** | | |
| Customer accounts in full analysis dataset | 96,668 | 75,950 | 60,105 |
| | **Number of Customer Accounts Active in PY7[1]** | | |
| Customer accounts remaining in PY7 | 75,049 | 62,348 | 57,833 |
| Treatment group | 37,472 | 42,907 | 45,911 |
| Control group | 37,577 | 19,441 | 11,922 |
| [1] Number of customer accounts when first reports in PY7 were delivered. | | | |

**Table M-2: Data Preparation Summary: Low-Income Energy-Efficiency Behavior and Education Program**

| | Number of Observations from Billing Data | |
|---|---|---|
| | Low-Income Wave 1 | Low-Income Wave 2 |
| Bills used in estimation | 1,555,644 | 330,774 |
| | Number of Customer Accounts | |
| Customer accounts in estimation | 91,182 | 31,249 |
| | Number of Customer Accounts in PY7[1] | |
| Customer accounts in estimation | 89,967 | 30,272 |
| Treatment group | 66,760 | 20,616 |
| Control group | 16,926 | 9,657 |
| [1] Number of customer accounts when first reports in PY7 were delivered. | | |

The data cleaning and customer account inactivity resulted in an unbalanced panel of 75,049 treatment and control group customers in Legacy Wave 1, 62,348 customers in Legacy Wave 2, 57,833 customers in the Expansion Wave, 89,967 customers in Low-Income Wave 1, and 30,272 customers in Low-Income Wave 2 as of the beginning of PY7. The panel was unbalanced because some customer accounts had closed since the program started treatment for each wave. The number of customer accounts still active in PY7 reflects this attrition.

Cadmus collected weather data from the weather station closest to each home and estimated the heating degree days (HDDs) and cooling degree days (CDDs) for each customer billing cycle. After merging the weather and billing data, Cadmus allocated the billing cycle electricity consumption, HDDs, and CDDs to calendar months.

## M.2 VERIFICATION OF BALANCED TREATMENT AND CONTROL GROUPS

A key assumption of the impact analysis is that homes eligible for the program were randomly assigned to the program treatment or control group. In Phase I, the ICSP randomly assigned customers to the program treatment or control group for Legacy Wave 1 and Legacy Wave 2. As part of Phase I of the Act 129 impact evaluation of the Residential Energy Efficiency Behavior and Education Program, Cadmus verified that the treatment and control groups for the Legacy Wave 1 and Legacy Wave 2 populations had equal pre-treatment energy use. Results of statistical tests can be found in the reports for PY2, PY3, and PY4. They are also presented in Table M-3 through Table M-7.

In Phase II, Cadmus randomly assigned eligible customers to the expansion group treatment or control group, as well as the two low-income waves. At the time of the randomization, Cadmus also performed statistical tests to verify the equivalence of the two groups. Results of the tests are shown below.

Cadmus found that all waves were equivalently balanced and had been successfully randomized: no significant differences existed between the pre-treatment consumption of treatment and control groups in each wave.

**Table M-3: Equivalency Test for Legacy Group 1**

| | Treatment Group | Control Group | Difference | T-test statistic (p value) |
|---|---|---|---|---|
| Average annual electricity use per customer (kWh) | 18,530 | 18,465 | 66 | 0.15 |
| Number of customers | 37,472 | 37,577 | -105 | |

**Table M-4: Equivalency Test for Legacy Group 2**

| | Treatment Group | Control Group | Difference | T-test statistic (p value) |
|---|---|---|---|---|
| Average annual electricity use per customer (kWh) | 27,393 | 27,490 | -97 | 0.16 |
| Number of customers | 42,907 | 19,441 | 23,466 | |

**Table M-5: Equivalency Test for Expansion Group**

| | Treatment Group | Control Group | Difference | T-test statistic (p value) |
|---|---|---|---|---|
| Average annual electricity use per customer (kWh) | 23,205 | 23,205 | 0 | 1.00 |
| Number of customers | 45,911 | 11,922 | 33,989 | |

**Table M-6: Equivalency Test for Low-Income Group 1**

| | Treatment Group | Control Group | Difference | T-test statistic (p value) |
|---|---|---|---|---|
| Average annual electricity use per customer (kWh) | 11,894 | 11,843 | 51 | 0.37 |
| Number of customers | 66,760 | 16,926 | 49,834 | |

**Table M-7: Equivalency Test for Low-Income Group 2**

| | Treatment Group | Control Group | Difference | T-test statistic (p value) |
|---|---|---|---|---|
| Average annual electricity use per customer (kWh) | 8,172 | 8,248 | -76 | 0.45 |
| Number of customers | 20,616 | 9,657 | 10,959 | |

## M.3 ENERGY SAVINGS MODEL SPECIFICATION

To estimate the program energy savings, Cadmus employed regression analysis of monthly customer bills. To check the robustness of savings results, Cadmus tested and compared two general model specifications: difference-in-differences (D-in-D) fixed effects and post-only.

Both models estimated treatment effects by comparing consumption between treatment and control group customers in a specified block of time after treatment had begun and in the baseline consumption period before treatment began. While the fixed effects model included the pre-treatment period bills and interacted the treatment indicator with a post-treatment indicator, the post-only model included control variables for pre-usage then dropped the pre-period bills from the analysis.

Ultimately, the two models yielded savings estimates that were within each other's confidence intervals, meaning that their results were not statistically different. Cadmus reported the results of the post-only model, as was done in PY6 and as recommended in the SWE's PY6 annual report.[23]

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[23] Pennsylvania Public Utility Commission. *Act 129 Statewide Evaluator Annual Report.* Prepared by GDS Associates, Inc., Research into Action, and Apex Analytics, LLC. Final Report, March 8, 2016. Available online: http://www.puc.state.pa.us/Electric/pdf/Act129/SWE_PY6-Final_Annual_Report.pdf

### M.3.1 The Difference-in-Differences Fixed Effects Model

The D-in-D fixed effects model compared treatment customers' differences between pre- and post-treatment usage to the pre-post differences of the control group. The model assumed that average daily energy consumption (kWh) of home 'i' in month 't' would be produced as:

**Equation M-1**

$$ADC_{it} = \beta_1 \, PART_i * POST_{it} + W'\gamma + \alpha_I + \tau_t + \varepsilon_{it}$$

Where:

$\beta_1$ = Coefficient representing the conditional average treatment effect of the program on electricity use (average kWh per home per day); this is the home energy reports' effect on energy use

PART = Indicator variable for program participation (equaling 1 if the home was in the treatment group and 0 otherwise)

POST = Indicator variable for whether the month is pre- or post-treatment; this variable equals 1 in months following the first program intervention and 0 otherwise

W = Vector using heating degree day and cooling degree day variables to control for the impacts of weather on energy use

$\gamma$ = Vector of coefficients representing the average impact of weather variables on energy use

$\alpha_i$ = Average energy use in home 'i' that is not sensitive to weather or time; the analysis controlled for non-weather-sensitive and time-invariant energy use with home fixed effects

$\tau_t$ = Average energy use in month 't' reflecting unobservable factors specific to the month; the analysis controlled for these effects with month-by-year fixed effects

$\varepsilon_{it}$ = Error term for home 'i' in month 't'

### M.3.2 Post-Only Model

The post-only model used the approach described by Allcott and Rogers,[24] which involves regression analysis of post-treatment customer bills on a program treatment group indicator variable, month-by-year fixed effects, pre-treatment consumption, and pre-treatment consumption interacted with the month-by-year fixed effects. The regression included pre-treatment consumption to control for differences between customers in average energy use, then dropped the pre-treatment bills from the final dataset.

Specifically, Cadmus estimated the average daily savings per customer using the following regression model of electricity use:

**Equation M-2**

$$adc_{it} = \alpha + \beta \, Part_{it} + \rho_H \, HDD_{it} + \rho_C \, CDD_{it} + \mu_{my} + Pre\text{-}adc_i' \, \gamma + Pre\text{-}adc_i \times \mu_{my} \, '\theta + \varepsilon_{it}$$

24 Allcott, Hunt, and Todd Rogers. 2014. "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation." *American Economic Review*, 104(10): 3003-37.

Where:

| | | |
|---|---|---|
| $adc_{it}$ | = | Average daily electricity consumption of home 'i' in month 't' of the post-treatment period |
| $\alpha$ | = | Intercept corresponding to average daily consumption per customer across customers and months. |
| $Part_{it}$ | = | Indicator variable for receiving a home energy report (= 1 if the home was in the treatment group and received an energy report in month t or in a previous month; = 0 otherwise). |
| $\beta$ | = | Coefficient indicating the conditional average treatment effect of the program (the average daily kWh savings per customer). |
| $HDD_{it}$ | = | Average daily heating degrees for customer i in month t. |
| $\rho_H$ | = | Coefficient indicating the average effect of HDD on consumption. |
| $CDD_{it}$ | = | Average daily cooling degrees for customer i in month t. |
| $\rho_C$ | = | Coefficient indicating the average effect of CDD on consumption. |
| $\mu_{my}$ | = | Month-by-year fixed effects to capture consumption effects specific to month. |
| $Pre\text{-}adc_i$ | = | Vector of variables summarizing energy use during 12 months before treatment, including annual average daily consumption, summer average daily consumption, and winter average daily consumption. |
| $\gamma$ | = | Vector of coefficients indicating the average effect of pre-treatment consumption on post-treatment consumption. |
| $\theta$ | = | Vector of coefficients indicating the average effect of pre-treatment consumption on post-treatment consumption in post-treatment month *m* of year y. |
| $\varepsilon_{it}$ | = | Error term for home 'i' in month 't.' |

Note that Cadmus ran the models separately for each wave. Also, in both models, Cadmus estimated a separate average treatment effect (β) for each program year that the wave had been active. This involved interacting the PART or PART*POST variables with separate participation-year (e.g., Part x PY2, … Part x PY7). According to the Pennsylvania TRM, home energy reports have a measure life of one year.

## M.4 PY7 BEHAVIOR AND EDUCATION REGRESSION ANALYSIS ESTIMATES

Table M-8 and Table M-9 show the side-by-side estimates of the average daily savings per customer for each of the residential and low-income waves from the estimation of both the D-in-D fixed effects model (Equation M-2) and the post-only model (Equation M-2). The savings are shown also by each program year. All of the models were estimated by ordinary least squares (OLS), and Huber-White robust standard errors were adjusted for correlation over time in a customer's consumption.[25]

[25] Bertrand, Marianne, E. Duflo, and S. Mullainathan. *How Much Should We Trust Difference-in-Differences Estimates.* Quarterly Journal of Economics, 119 (1), pp. 249-275. 2004.

**Table M-8: Conditional Average Program Treatment Effects for the Residential Energy-Efficiency Behavior and Education Program as Estimated by Both Model Specifications [1]**

| | Legacy Wave 1 | | Legacy Wave 2 | | Expansion Wave | |
|---|---|---|---|---|---|---|
| | D-in-D Fixed Effects | Post-Only | D-in-D Fixed Effects | Post-Only | D-in-D Fixed Effects | Post-Only |
| Participant x PY1[2] | 0.24<br>(0.065) | 0.17<br>(0.044) | - | - | - | - |
| Participant x PY2 | 0.67<br>(0.054) | 0.67<br>(0.052) | - | - | - | - |
| Participant x PY3 | 0.91<br>(0.068) | 0.88<br>(0.062) | 0.95<br>(0.090) | 1.02<br>(0.079) | - | - |
| Participant x PY4 | 1.00<br>( 0.075) | 1.00<br>(0.073) | 1.16<br>(0.110) | 1.22<br>(0.107) | - | - |
| Participant x PY5 | 0.87<br>(0.085) | 0.89<br>(0.083) | 1.16<br>(0.128) | 1.22<br>(0.127) | - | - |
| Participant x PY6 | 0.88<br>(0.089) | 0.89<br>(0.088) | 1.15<br>(0.139) | 1.22<br>(0.138) | 0.58<br>(0.143) | 0.59<br>(0.126) |
| Participant x PY7 | 0.85<br>(0.090) | 0.83<br>(0.085) | 1.04<br>(0.142) | 1.10<br>(0.135) | 0.73<br>(0.121) | 0.69<br>(0.104) |
| Pre-treatment consumption[3] | No | Yes | No | Yes | No | Yes |
| Month-by-Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Weather | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 7,303,248 | 6,138,426 | 5,007,938 | 4,094,056 | 1,874,364 | 1,145,074 |

[1] Table shows estimates of average daily savings (kWh) per home for PY2 to PY7. See text for estimation details. Huber-White standard errors clustered on homes in parentheses.
[2] Legacy Wave 1 started treatment in the last two months of PY1. Therefore its savings estimates for PY1 do not reflect the effects of a full program year.
[3] Since the D-in-D fixed effects model included the pre-treatment bills in the final dataset, it did not need to include control variables for pre-treatment consumption. This difference in the number of total bills (N) between the two model specifications' final datasets is reflected in the final row of the table.

**Table M-9: Conditional Average Program Treatment Effects for the Low-Income Energy-Efficiency Behavior and Education Program as Estimated by Both Model Specifications [1]**

| | Low-Income Wave 1 | | Low-Income Wave 2 | |
|---|---|---|---|---|
| | D-in-D Fixed Effects | Post-Only | D-in-D Fixed Effects | Post-Only |
| Participant x PY6 | 0.07<br>(.086) | 0.12<br>(0.084) | - | - |
| Participant x PY7 | 0.42<br>(0.078) | 0.42<br>(0.064) | 0.13<br>(0.091) | 0.14<br>(0.069) |
| Pre-treatment consumption | No | Yes | No | Yes |
| Month-by-Year Fixed Effects | Yes | Yes | Yes | Yes |
| Weather | Yes | Yes | Yes | Yes |
| N | 2,740,298 | 1,555,644 | 705,418 | 330,774 |

[1] Table shows estimates of average daily savings (kWh) per home for PY2 to PY7. See text for estimation details. Huber-White standard errors clustered on homes in parentheses.
[2] Low-Income Wave 1 started treatment in the second quarter of PY6. Therefore its savings estimates for PY6 do not reflect the effects of a full program year.
[3] Since the D-in-D fixed effects model included the pre-treatment bills in the final dataset, it did not need to include control variables for pre-treatment consumption. This difference in the number of total bills (N) between the two model specifications' final datasets is reflected in the final row of the table.

All waves showed savings across all program years. The savings estimates were precisely estimated and statistically significant at the 5% level. Both the D-in-D fixed effects and post-only models yielded savings estimates that were statistically equivalent to each other.

Table M-10 and Table M-11 show the estimated annual treatment effects as a percentage of annual consumption for each population wave, again by the two model specifications.

**Table M-10. Percentage Treatment Effects: Residential Energy-Efficiency Behavior and Education Program as Estimated by Both Model Specifications[1]**

| | Legacy Wave 1 | | Legacy Wave 2 | | Expansion Wave | |
|---|---|---|---|---|---|---|
| | D-in-D Fixed Effects | Post-Only | D-in-D Fixed Effects | D-in-D Fixed Effects | Post-Only | Expansion Post-Only |
| Participant x PY1 | 0.59% | 0.42% | - | - | - | - |
| | (0.002) | (0.001) | | | | |
| Participant x PY2 | 1.29% | 1.29% | - | - | - | - |
| | (0.001) | (0.001) | | | | |
| Participant x PY3 | 1.91% | 1.84% | 1.42% | 1.53% | - | - |
| | (0.001) | (0.001) | (0.001) | (0.001) | | |
| Participant x PY4 | 2.00% | 1.99% | 1.63% | 1.72% | - | - |
| | (0.001) | (0.001) | (0.002) | (0.002) | | |
| Participant x PY5 | 1.71% | 1.74% | 1.55% | 1.63% | - | - |
| | (0.002) | (0.002) | (0.002) | (0.002) | | |
| Participant x PY6 | 1.79% | 1.79% | 1.60% | 1.69% | 0.83% | 0.84% |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| Participant x PY7 | 1.86% | 1.81% | 1.63% | 1.71% | 1.35% | 1.27% |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |

[1] Table shows estimates of average daily savings per home as a percentage of consumption. See text for estimation details. Huber-White standard errors clustered on homes in parentheses.

**Table M-11. Percentage Treatment Effects: Low-Income Energy-Efficiency Behavior and Education Program as Estimated by Both Model Specifications[1]**

| | Low-Income 1 Fixed Effects | Low-Income 1 Post-Only | Low-Income 2 Fixed Effects | Low-Income 2 Post-Only |
|---|---|---|---|---|
| Participant x PY6 | 0.20% | 0.34% | - | - |
| | (0.002) | (0.002) | | |
| Participant x PY7 | 1.48% | 1.47% | 0.64% | 0.69% |
| | (0.003) | (0.002) | (0.005) | (0.004) |

[1] Table shows estimates of average daily savings per home as a percentage of consumption. See text for estimation details. Huber-White standard errors clustered on homes in parentheses.

Each wave exhibited ramping of saving during the initial program years.

## M.5 Annual Net Program Energy Savings

Cadmus estimated total savings in PY7 for each wave's population. As noted above, because of the one-year measure life for home energy report in Pennsylvania, PPL Electric Utilities can claim only the savings in PY7 that occurred after the first reports were sent.

Cadmus used estimates of the average daily kWh savings per home to estimate the PY7 net savings. Specifically, the program savings were estimated as the product of the average daily kWh savings per home and the number of customer treatment days, as shown in Equation M-3.

**Equation M-3**

$$\text{PY7 Net savings} = -\beta \sum_j \text{Treatment Days in PY7}_j$$

Where:

B = The average daily kWh savings during PY7 after the first reports were received from regression Equation M-2.

$\text{Treatment Days}_j$ = The number of treatment days for treatment group customer j in PY7. This is the number of days remaining in PY7 after receiving the first PY7 energy report.

Table M-12 and Table M-13 show the estimate of PY7 total savings and average annual savings per customer with 90% confidence intervals for each wave.

**Table M-12: PY7 Residential Energy Efficiency Behavior & Education Program Energy Savings Estimates**

| Program Net Savings in PY7 | | | |
|---|---|---|---|
| | **Point Estimate (MWh)** | **90% Confidence Interval Lower Bound** | **90% Confidence Interval Upper Bound** |
| Legacy Wave 1 | 11,090.8 | 9,220.1 | 12,961.5 |
| Legacy Wave 2 | 16,807.1 | 13,408.9 | 20,205.4 |
| Expansion Wave | 11,180.0 | 8,401.1 | 13,958.9 |
| **Total Program** | **39,077.9** | **25,007.1** | **53,148.7** |
| **Average Per-Customer Net Savings in PY7** | | | |
| | **Point Estimate (kWh)** | **90% Confidence Interval Lower Bound** | **90% Confidence Interval Upper Bound** |
| Legacy Wave 1 | 296 | 246 | 346 |
| Legacy Wave 2 | 392 | 313 | 471 |
| Expansion Wave | 244 | 183 | 304 |
| **Total Program** | **309** | **246** | **373** |

**Table M-13: PY7 Low-Income Energy Efficiency Behavior & Education Program Energy Savings Estimates**

| Program Net Savings in PY7 | | | |
|---|---|---|---|
| | **Point Estimate (MWh)** | **90% Confidence Interval Lower Bound** | **90% Confidence Interval Upper Bound** |
| Low-Income Wave 1 | 9,693.9 | 7,291.7 | 12,096.0 |
| Low-Income Wave 2 | 928.1 | 144.4 | 1,711.8 |
| **Total Program** | **10,622.0** | **6,003.5** | **15,240.4** |
| **Average Per-Customer Net Savings in PY7** | | | |
| | **Point Estimate (kWh)** | **90% Confidence Interval Lower Bound** | **90% Confidence Interval Upper Bound** |
| Low-Income Wave 1 | 145 | 109 | 181 |
| Low-Income Wave 2 | 45 | 7 | 83 |
| **Total Program** | **122** | **85** | **158** |

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